Phenom Cogn Sci (2008) 7:501–527
DOI 10.1007/s11097-008-9086-2

Are our emotional feelings relational? A neurophilosophical investigation of the James–Lange theory

Georg Northoff

Published online: 23 January 2008

Abstract The James–Lange theory considers emotional feelings as perceptions of physiological body changes. This approach has recently resurfaced and modified in both neuroscientific and philosophical concepts of embodiment of emotional feelings. In addition to the body, the role of the environment in emotional feeling needs to be considered. I here claim that the environment has not merely an indirect and thus instrumental role on emotional feelings via the body and its sensorimotor and vegetative functions. Instead, the environment may have a direct and non-instrumental, i.e., constitutional role in emotional feelings; this implies that the environment itself in the gestalt of the person–environment relation is constitutive of emotional feeling rather than the bodily representation of the environment. Since the person–environment relation is crucial in this approach, I call it the relational concept of emotional feeling. After introducing the relational concept of emotional feeling, the present paper investigates the neurophilosophical question whether current neuroimaging data on human emotion processing and anatomical connectivity are empirically better compatible with the "relational" or the "embodied" concept of emotional feeling. These data lend support to the empirical assumption that neural activity in subcortical and cortical midline regions code the relationship between intero- and exteroceptive stimuli in a relational mode, i.e. their actual balance, rather than in a translational mode, i.e., by translating extero- into interoceptive stimulus changes. Such intero-exteroceptive relational mode of neural coding may have implications for the characterization of emotional feeling with regard to phenomenal consciousness and intentionality. I therefore conclude that the here advanced relational concept of emotional feeling may be considered neurophilosophically more plausible and better compatible with current neuroscientific data than the embodied concept as presupposed in the James–Lange theory and its modern neuroscientific and philosophical versions.

G. Northoff (✉)
Department of Psychiatry, University of Magdeburg, Leipziger Strasse 44, 39120 Magdeburg, Germany
e-mail: georg.northoff@medizin.uni-magdeburg.de

Keywords Emotion · Feelings · Neurophilosophy · Embodiment

Introduction

The well-known James–Lange theory determined feelings as perceptions of physiological body changes in the autonomic, hormonal, and motor systems. Once we become aware of physiological bodily changes induced by danger, we feel fear and subjectively experience emotional feelings. James (1884, 190) consequently considered bodily changes as central to emotional feelings; "we feel sorry because we cry, angry because we strike, afraid because we tremble, and not that we cry, strike, or tremble, because we are sorry, angry, or fearful, as the case may be" (James 1884, 190). Modern empirical versions of this theory resurface in current neuroscientific models of emotion as, for instance, in Damasio and others (Craig 2003, 2004, 2005; Bechara 2004; Niedenthal 2007). Conceptually, the embodied approach to emotion emphasizes the crucial role of the body in emotional feeling. If the body and its vegetative and sensorimotor function play a crucial role in constituting emotional feelings, the body can no longer be considered in a merely objective way but rather as subjective and experienced – the mere Koerper as objective body must be distinguished from the lived body as subjectively experienced body in emotional feeling (Colombetti and Thompson 2005, 2007; Colombetti 2008)[1].

The emphasis on the body raises the question for the role of the environment in constituting emotional feelings. The body stands in direct contact with the environment via its sensorimotor functions which are emphasized in recent body-based, e.g., embodied concepts of emotional feelings (see Niedenthal et al. 2005; Niedenthal 2007). The body is supposed to represent the environment in sensorimotor terms and it is these bodily representations that are considered crucial in constituting emotional feelings. The environment may have then an indirect and modulatory role via the body in the constitution of the emotional feelings. One could also imagine that the environment has a direct and constitutive role in emotional feeling; the environment may then directly constitute emotional feeling independent of the body's sensorimotor (and vegetative) functions. In this case, emotional feelings should be constituted directly by the respective person's relation to the environment rather than indirectly via bodily representations. Since the person–environment relation is crucial here, I call such approach the relational concept of emotional feeling [see Northoff 2004 for a general outline of such relational approach and Ben-Ze'ev (1993) for the characterization of perception as relational].

The general aim of the present paper is to briefly outline the characteristics of such relational concept of emotional feeling and to investigate its empirical plausibility with respect to current neuroscientific data. More specifically, the first

[1] It should also be pointed out that feelings cannot be considered to be conscious perceptions of the neural activity in those brain regions that induce emotion as for instance LeDoux assumes. We cannot become conscious of neural activity in the first-order emotion regions (see also Bennett and Hacker 2003, 208) since we remain principally unable to perceive our brain's neural activity as such which I recently called "autoepistemic limitation" (Northoff 2004; Northoff and Musholt 2006).

aim is to characterize the relational concept of emotional feeling which will be done in the first part where I introduce the embodied concept of emotional feeling and its extension in the here advanced relational concept. The second aim is to investigate current human imaging data on emotion processing and anatomical connectivity and to point out whether they lend supportive evidence to the relational concept of emotional feeling. I describe various studies on human imaging and anatomical connectivity in the second part and discuss their implications for an empirically plausible concept of emotional feeling. The third aim of the paper is to briefly discuss some neurophilosophical implications of the relational concept for how to characterize emotional feeling in terms of phenomenal consciousness and intentionality which will be done in the third and last part of the paper.

Concept of "relational" feeling

Embodied approach to emotional feelings

Darwin already believed that motor behaviour like facial expression, postures, etc. conveys an organism's response toward events and objects in the environment. This is very much in line with the observation that emotion-specific motor behaviour is accompanied by subjective experience, i.e., emotional feeling, of the respective emotion and that inhibition of motor behaviour interferes with emotion processing (see Niedenthal 2007). This indicates that sensorimotor function seems to be involved in constituting emotional feeling and emotions; in other terms, constitution of emotional feelings is based upon sensorimotor function which is called embodiment. Embodiment means that modality-specific and concrete resources, i.e., sensorimotor function (as distinguished from higher-order cognitive functions that remain abstract and amodal), are used in constituting emotional feelings (see Niedenthal et al. 2005). This means that personal significance and meaning as crucial characteristics of emotional feeling (see below for details) are represented in the body's sensorimotor (and vegetative) functions. Empirical examples of such sensorimotor, i.e., bodily-based and thus embodied approach to emotion are the well-known James–Lange theory and current approaches by Damasio and Panksepp. The well-known James–Lange theory determined feelings as perceptions of physiological body changes thus basing them on sensorimotor and vegetative functions. Modern versions of this theory resurface in current neuroscientific models of emotion as, for instance, in Damasio and others (Craig 2003, 2004, 2005; Bechara 2004). Though he points out some differences like the inclusion of the brain and virtual activation of the network in an 'as if body loop' (Damasio 1999, 287–9), Damasio considers emotion and feeling in close relation to perception of one's bodily changes. Physiological bodily changes are supposed to be registered through interoceptive afferences in specific brain regions, the so-called first-order neural structures, that include brain stem/midbrain regions (PAG, Tectum, etc.), the amygdala and the orbitomedial prefrontal cortex. These regions account for the induction of emotion which, according to Damasio, remain unconscious so that one may speak of "having an emotion" at this level. Only if the unconscious emotions are meta-represented in second-order neural structures like the cingulate gyrus,

thalamic nuclei, the somatosensory cortex, and the superior colliculi, feeling as the conscious representation of emotion, the "feeling of an emotion" can emerge (Damasio 1999, 260–6). These second-order neural structures allow us to perceive what has been registered about one's physiological body changes in first-order neural structures and it is this perception that induces emotional feelings which Damasio calls "feeling an emotion". Another approach that heavily draws especially on motor resources (as distinguished from Damaiso who more strongly emphasizes sensory function) is the one by Panksepp who speaks of primary affective consciousness which he associates with subcortical regions like the PAG that are characterized by strong motor connections and sensorimotor convergence (Panksepp 1998, 2005). According to him emotional feeling is constituted on the basis of subcortical motor function as the core nucleus of emotion (see below for some more details and Sheets-Johnstone 1999; Ellis 2005 and Panksepp 1998 for the emphasis of the intrinsic relationship between motor function and emotional feelings).

Embodied concepts of emotional feelings must be distinguished from neuroscientific approaches that assume emotional feelings to be disembodied by associating them with amodal and abstract cognitive representation (for instance, linguistic function or working memory) rather than sensorimotor- (and vegetative-) based bodily representation. For example, Rolls et al. (1999; Rolls 2000) assumes that higher-order linguistic thought processing is essential for the occurrence of consciousness and consequently for the emergence of feelings. LeDoux (1996, 2002) considers working memory to be crucial for consciousness which allows to meta-represent emotions thereby inducing subjective experience of them, i.e., emotional feeling; for instance, a person feeling disgust knows that it has that particular emotion by means of its working memory and is therefore assumed to be conscious of its associated brain's activity and it is this conscious awareness that is supposed to induce emotional feeling (LeDoux 1996, 2002). Though these approaches differ in various aspects, they all have in common that they account for emotional feeling by higher-order processing higher-order functions with amodal and abstract cognitive representation.

Most recently, the embodied approach to emotional feeling has also been conceptualized in philosophy which especially emphasizes the role of the body in subjective experience. Once the body is supposed to be central in constituting and representing emotional feelings including their personal significance and meaning for the respective person, the body cannot be regarded as impersonal and objective. The body can no longer be considered only in Third-Person Perspective as mere "objective index" of one's emotional state and as mere physical object or what has been called Koerper which then remains impersonal and can therefore be characterized by what Colombetti (2008) called "corporeal impersonalism". The body as Koerper has to be distinguished from the body which we experience subjectively in First-Person Perspective and which is the background of all subjective experience of emotional feeling. The subject of experience, our self or I, is situated within its body which as such constitutes the centre of experience, the subjective experiential basis, from which the subject experiences and encounters the world. It is the subjective experience of our body in First-Person Perspective that has been characterized in phenomenological philosophy as the "lived body" or "Leib" (Merleau-Ponty 1962; Gallagher 2005). Rather than merely objectively indicating

the importance of environmental events by physiological indices, as it is presupposed in the body as Koerper, the "lived body" or Leib constitutes and mediates the personal significance and meaning of environment events and their specific relationship to the respective experiencing subject. In other terms, the body as "lived body" or Leib becomes personally significant and meaningful to the experiencing subject[2] for which it becomes the "subjective experiential base". The Koerper's "corporeal impersonalism" is subsequently replaced by what Colombetti (2007) calls "corporeal personalism" of the "lived body" or Leib.

Relational approach to emotional feeling

The body as "lived body" or as Leib presupposes intrinsic relationship of the body to the respective environment; the body is integrated within the environment, it is part of it, and, at the same time, it connects and links the experiencing subject to its environmental context. The "lived body" is not merely interacting with its environment which would still presuppose separation and distinction from the environment as separate constituents. In this case, the body would merely represent the environment and it is this representation of the environment in sensorimotor terms that forms the basis of the constitution of emotional feelings. The question however is whether the environment is involved in constituting emotional feelings only indirectly via its representation in the body's sensorimotor function or rather directly in the form of its relation to the body. The former case assumes bodily representation to be crucial in constituting emotional feeling whereas the latter claims emotional feeling to be essentially relational which I want to pursue in the following in further detail.

Hurley (1998, 10, 341–2, 362–4) distinguishes between instrumental and non-instrumental dependence (see also Colombetti 2008 who also applies this distinction) with regard to the relationship between input and output in perceptual content. If the relationship between input and output is indirect and thus merely instrumental, changes in percpetual content are dependent upon changes in the input; every change in motor output has to modulate sensory input in order to have an impact on perceptual content implying that the output can not change independently of the input: "This kind of dependence of perceptual content on output is merely instrumental. It operates via changes in input; changes in output are a means to changes in input." (Hurley 1998, 10). What does this mean with regard to emotional feelings and their relation to the environment? Presupposing instrumental dependence, the environment can impact emotional feelings only indirectly via the body, i.e., by being represented either in the body's sensorimotor (and vegetative)

[2] Prinz (2004, 57) also argues for the semantic dimension of the body, our body is not only somatic but also semantic since it is the body itself that is supposed to represent the environment in its physiological bodily changes. He here presupposes a naturalized concept of representation which makes its delegation to higher-order cognitive faculties superfluous. This however also implies that he does not consider subjective experience and feeling to be central for emotion which in turn implies that feelings remain disembedded since the environment as a merely representational but not constitutive role. Furthermore it implies that his concept presupposes a different meaning of embodiment when he speaks of "embodied emotion" since his notion of embodiment refers only to the Koerper but not to the subjectively experienced body, the "lived body".

functions or in those brain regions that register the body's sensorimotor (and vegetative) functions. The latter approach is, for instance, advocated by the proponents of Damasio's theory of emotional feeling where the relation between body and environment remains at best modulatory (and contributing but not as constitutive); this is nicely reflected in a quote from a recent paper about emotion and consciousness: "Here, we follow the common view that emotion and consciousness emerge as a result of neuronal activity in the brain, but some accounts view emotions or consciousness as relationships between an organism and its environment (here we acknowledge such relationships as contributing but not as constitutive)" (Tsuchiya and Adolphs 2007, 159; see also Bechara and Naqvi 2004).

Non-instrumental dependence, in contrast, is described by Hurley as direct dependence of perceptual content on motor output independent of sensory input; even if the sensory input remains the same and fixed, perceptual content can vary depending on motor output. This means that motor output has direct access to perceptual content independent of sensory input and that it therefore no longer operates indirectly via sensory input as in instrumental dependence; instead, perceptual content may vary in orientation on motor output independent of sensory input and thus directly. What does such non-instrumental or constitutional, as I will call it in the following (see also Colombetti 2008), dependence imply for the relationship between body and environment in emotional feeling? If the relationship between emotional feeling and environment is direct and therefore constitutional, i.e., non-instrumental, changes in the environment should be able to impact and constitute emotional feelings independently of the body's sensorimotor representation. The environment itself may then directly involved in constituting emotional feelings which is empirically paradigmatically exemplified in a recent study on reward (Fliessbach et al. 2007). Two subjects a and b were simultaneously scanned while receiving rewards. While the reward for the subject a was fixed, the one for subject b was varied; this and the converse case, increasing rewards for subject a and fixed rewards for subject b, allowed to investigate its impact of the environment, i.e., subject b, on subject a. Interestingly, emotional feelings and neural activity in reward circuitry in subject a did not so much depend on the size of the reward it received but rather on the relation of or balance to its own reward when compared to the one received by subject b. If, for instance, subject a received 60$ and subject b only 30$, subject a showed happiness and increased reward circuitry activation. If, in contrast, subject b received 120$ with subject a still receiving 60$, subject a no longer showed happiness and increased neural activity in reward circuitry. Though sensorimotor input was exactly the same for subject a in both cases (only subject's b reward amount changed), playing the same game and receiving the same reward, emotional feelings and neural activity in reward circuitry differed in dependence on the amount of reward subject b received when compared to the amount subject a received. This means that, to put it into conceptual terms, emotional feelings and neural activity in subject a were not merely instrumentally dependent upon the environment (since then changes in subject b could have impact subject a only if they had changed subject's a reward) but rather instrumentally or constitutionally. More specifically, it is the relationship between person and environment, the actual difference or balance between subjects's a and b rewards, that seemed to determine emotional feelings and neural activity. It is such constitutional, i.e., non-instrumental,

dependence of emotional feelings on the environment and its relationship to the person that I will characterize as the relational concept of emotional feelings[3].

The relational approach shifts the focus of attention from the body, as in the embodied approach, to the role of the environment in emotional feelings. Rather than modulating emotional feelings indirectly via bodily representations, the environment is supposed to be involved directly in constituting emotional feelings. How does the person–environment relation account for the variety of different specific emotional feelings? The lack of specificity concerning distinct emotions has often been criticized in feeling theories like the James–Lange theory (see also Niedenthal et al. 2005). Autonomic bodily changes like arousal are rather unspecific reactions that do not allow to distinguish between distinct emotions. This criticism has been furnished by the Schacter and Singer (1962) experiments demonstrating that subjects with autonomous nervous system stimulation, as induced by epinephrine, experienced the resulting arousal as either anger or euphoria in dependence on the respective context (they were placed in a room with either an angry or happy actor). The conclusion is often drawn that physiological bodily changes and arousal themselves remain unspecific and cannot contribute to determine specific emotions); determination and distinction of specific feelings can consequently not be based upon physiological bodily changes but must be found elsewhere. This argument of the lack of specificity of bodily representations has been countered in different ways by referring to motor, cognitive, or neural representation. Zajonc (1998, 2000), for instance, claims that the motor system allows for extremely subtle distinctions which means that even a number of limited bodily states can support a very large number of representational distinctions of distinct emotional feelings. Rather than referring to motor capacities, cognitive theories, e.g., appraisal theories, (Solomon 2004; and also Schacter and Singer) resort to cognitive representations and higher-order cortical brain functions which may allow for a much more fine-grained distinction between different emotional feelings. Damasio (1999, 2003a, b) suggested a middle way between motor and cognitive representation by focusing on those subcortical brain regions that register physiological bodily states which may allow for a wider representational spectrum than the muscles and viscera themselves that are actually represented in the respective neural states. All these approaches have in common that they still presuppose representation of emotional feelings, be it motor, cognitive or neural-subcortical.

The relational approach, in contrast, claims that the wide variety of different emotional feelings may ultimately be traced back to the relation between person and

[3] The here advanced relational concept may be considered an extension of the embodied approach by Colombetti and Thompson, who also emphasize the situated, extended and thus embedded nature of emotional feeling. Since the main focus here is on the neurophilosophical aspect, I cannot go into the philosophical details about the relational approach (see below for the discussion of some philosophical implications and Northoff 2004 for a general outline). See also Ben-Ze'ev (1993, 81–99) who advocates a relational approach to perception and, in some part, also to emotion (see Ben-Ze'ev 2000).

environment rather than to motor, cognitive, or neural-subcortical representation. Since an abundant variety of different person–environment relations are possible, different emotional feelings can be constituted. The question for the specificity of emotional feelings is thus traced back to the possible (and impossible) person–environment relations rather than to the representational capacities of specific functions, be they motor, cognitive or physiological-registering. How does the person–environment relation constitute emotional feeling? I gave the example of the reward above where it is clearly apparent that there seems to be some kind of matching between both subjects' reward amounts. What is matching? Only briefly indicating, matching concerns comparison of one's reward with the one of the respective other subject and it is the balance between the two subjects' rewards that seems to constitute emotional feelings and to determine which kind of feeling is constituted. The study demonstrated that even if the sensory and motor input remain fixed, emotional feeling and the underlying neural activity may depend on the respective environment context, i.e., the other subject's reward amount. Such comparison between the two subject's reward couples the two subjects together which may result in what Edelman and Tononi (2000) described as selective-adaptive coupling. What is selective-adaptive coupling? Generally spoken, "selective-adaptive coupling" provides mutual contact between brain, body, and environment – Noe (2004, 35, 37) therefore speaks of "episodes of contact with the world". One hallmark of such selective-adaptive coupling (for further detail see Northoff 2004) is what above I called constitutional, i.e., non-instrumental, dependence of emotional feeling on the person–environment relation. If, in contrast, there would only be instrumental dependence of emotional feelings on the environment, the coupling could neither be selective, which raises the problem of specificity of emotional feeling as discussed above, nor adaptive, which would put the evolutionary role of emotional feeling into question.

If emotional feelings are intrinsically relational, i.e., depending upon the person–environment relation rather than some representational capacities in motor, cognitive or neural-subcortical function, one would expect different feelings to reflect different kinds of person–environment relationships. Ratcliffe (2005, 2008) does indeed assume exactly this and assumes what, relying on Heidgerrian phenomenology, he calls existential feelings. Existential feelings include feelings of homeliness, belonging, separation, unfamiliarity, power, control, being part of something, being at one with nature, and "being there". These feelings have in common that they describe "ways of finding ourselves in the world" which metaphorically circumscribes what I called the person–environment relation. In other terms, what Ratcliffe calls existential feeling presupposes what I here advance as relational concept of emotional feeling. How are existential and emotional feelings related to each other? Ratcliffe is aware that existential feelings are not to be fully identified with emotional feelings; he claims that emotional feelings presuppose and are based upon existential feelings as, for instance, the emotional feeling of sadness presupposes the existential feeling of separation. If so, emotional feelings require a relational approach in much the same way as existential feelings so that any kind of feeling be it existential or emotional may best be characterized by a relational approach, e.g., as constituted by and non-instrumentally or constitutionally dependent upon the person–environment relation.

Neurophilosophical hypothesis

I here described two approaches to emotional feelings, the embodied one that characterized emotional feelings by bodily representations, and the relational one where emotional feelings are traced back to the person–environment relation. From a purely philosophical perspective, both approaches may not be considered mutually exclusive but rather as complementary with the relational one extending the embodied one which however, due to space limitation, cannot be discussed in theoretical detail here. While from a neurophilosophical perspective, the question can be raised whether current empirical data are more supportive of the embodied or the relational approach. Do current data on the neuroscience of emotion lend more empirical evidence to a purely bodily-based and thus embodied concept of emotional feeling or to a relation-based concept where the person–environment relation is supposed to be constitutive of emotional feeling? In order to investigate this issue, one has to consider the distinction between intero- and exteroceptive stimuli in emotional feeling. Empirically, stimuli from one's body are designated as interoceptive whereas stimuli from the environment are described as exteroceptive. This implies that an interoceptive- and thus bodily-based concept of emotional feeling should empirically be characterized by predominant (and probably exclusive) recruitment of interoceptive stimuli and those brain regions that register physiological bodily states during emotional feelings while exteroceptive stimuli should play at least no constitutive role and may exert at best some modulatory impact. If, in contrast, emotional feelings can empirically rather be linked to specific relations between intero- and exteroceptive stimuli than to interoceptive stimulus changes (and independent of exteroceptive stimuli), empirical data may rather lend support to the relational approach.

A discussion of all neuroscientific data on emotion processing would be beyond the scope of this paper. I focus on two specific issues, human imaging data and anatomical connectivity. Concerning human imaging, I discuss studies that specifically focus on the subjective experience of bodily states, i.e., interoceptive awareness. If interoceptive awareness involves only interoceptive stimuli in isolation remaining independent of exteroceptive stimuli, empirical data may lend support to the body-based and embodied approach to emotional feelings. If, in contrast, interoceptive awareness involves exteroceptive stimuli by relating them to interoceptive ones, empirical data may rather assumed to lend support to the relational approach. Accordingly, depending on the kind of recruited regions, that may either be intero- or exteroceptive, human imaging during interoceptive awareness may lend some empirical plausibility to either the embodied or the relational concept of emotional feeling. Anatomical connectivity may also yield some insight into the empirical plausibility of either concept. A body-based and embodied concept of emotional feeling presupposes more or less segregated anatomical connections and processing between intero- and exteroceptive stimuli which, at best, may interfere at some node points for extero-interoceptive translation and to exert modulatory or instrumental (but not constitutive) effects. Whereas a relational approach to emotional feeling requires that intero- and exteroceptive stimuli are always already processed in relation to each other for which, in turn, close anatomical connectivity between intero- and exteroceptive processing at all

levels is necessary. Accordingly, the pattern of anatomical connectivity may provide some clue which concept of emotional feeling is empirically more plausible.

Brain imaging, anatomical connectivity, and the relational concept of emotional feeling

Brain imaging of interoceptive awareness

Recent imaging studies using fMRI investigated neural activity during interoceptive stimulus processing like evocation of blood pressure changes during isometric and mental tasks, heart beat changes and perception, anticipatory skin conductance during gambling, and heart rate modulation during presentation of emotional faces (Critchley 2005 for a review; Pollatos et al. 2007a, b; Craig 2002, 2003, 2004). These studies observed neural activity changes in the right insula, the anterior cingulate cortex extending from supragenual to dorsal regions (SACC/DACC), and the amygdala. This led to the assumption that specifically the right insula and the SACC/DACC integrally represent autonomic and visceral responses that are transferred from the spinal cord through the midbrain, the hypothalamus and the thalamocortical pathway to the right insular cortex (Craig 2002, 2003, 2004; Critchley 2005). Based on these results, these regions are assumed to be involved in re-presenting the autonomic and visceral state of the body and thus interoceptive processing. Craig (2002, 2003, 2004) assumes specifically the right insula to be crucially involved which receives autonomic and visceral afferences from lower centres (see above) and re-represents the interoceptive body state in an integrated way. This allows the insula to give rise of a "mental image of one's physical state" which, according to Craig, provides the basis for subjective awareness of emotional feeling and one's self as "material me".

If these regions mediate interoceptive processing, the question for their role in the subjective experience of bodily and thus interoceptive changes as the basis for emotional feeling arises. Critchley et al. (2004) led subjects evaluate whether the own heart beat was synchronous or asynchronous with an auditory feedback note which allowed to compare interoceptive- and exteroceptive-directed attention. Interoceptive attention to the own heartbeat increased activity in the right insula (and the SACC/DACC and the somatomotor cortex) while exteroceptive attention to the tone suppressed activity in the very same region. Activity in the right insula also correlated with both the performance in the heartbeat detection task and subjective anxiety symptoms which also correlated with each other. These findings suggest close relationship between interoceptive awareness and emotional feeling. Other studies demonstrated the modulation of these interoceptive stimulus changes by exteroceptive stimuli. Using fMRI, Critchley (2005), for instance, investigated regional neural activity changes during presentation of happy, sad, angry and disgusted faces. They observed heart rate changes to be dependent upon the emotional category with sad and angry faces inducing the strongest heart rate changes. Emotional face-responsive regions like the right (and left) insula, the SACC/DACC, the midbrain/brain stem and the right amygdala were also found to be correlating with the changes in heart rate magnitude. These results indicate that

different emotions may be mediated by differential interoceptive response patterns which may be mediated by neural activity in the right insula, the SACC/DACC, the midbrain/brain stem, and the amygdala. According to the authors themselves, these results provide support for the hypothesis that interoceptive stimulus processing may be involved in differentiating between different types of emotional feelings.

The group around Pollatos conducted a series of studies on heartbeat perception and emotional feeling. Pollatos et al. (2007a) investigated attention towards heartbeats and cardiovascular arousal; regions implicated in both conditions included the right insula, the somatomotor cortex, the SACC/DACC, and the dorsomedial prefrontal cortex (DMPFC). They observed activity in the right insula and the DACC to be correlating with the degree of interoceptive awareness while negative feelings correlated with the BOLD response of the interoceptive awareness condition in the DACC and DMPFC. Using EEG, they distinguished between good and poor heartbeat perceivers. Good heartbeat perceivers (Pollatos et al. 2005, 2007a, b) showed higher arousal ratings as well as higher P300 amplitudes and slow-wave latency ranges than poor heartbeat perceivers during presentation of emotional pictures. Taken together, these studies show behaviourally a close relationship between interoceptive awareness, arousal and emotional feeling while neuroanatomically, they confirm the involvement of the right insula, the SACC/DACC and the DMPFC in mediating the relationship between interoceptive awareness and emotional feeling.

Interoceptive awareness and its relation to exteroceptive processing

The question is whether the above described data support an embodied concept of emotional feeling with exteroceptive stimuli being merely modulatory and instrumental or epiphenomenal. Or whether the data might be interpreted rather in favour of a relational concept of feelings with interoceptive stimuli in relation to exteroceptive stimuli being constitutive and thus central. Presupposing the James–Lange theory, most of the above cited authors have interpreted their data in favour of the interoceptive-based concept. However, I will argue that there are strong arguments which make the data rather compatible with what I call the intero-exteroceptive relational concept of emotional feeling. I argue that there seems to be a mismatch between empirical data and their interpretation in current imaging studies on emotional feelings and interoceptive processing which I want to support by making the three following points.

First, all paradigms employed did not investigate interoceptive stimuli in isolation from exteroceptive stimuli but rather in relation to them. Critchley et al. (2004), for instance, investigated heart beat perception in relation to auditory tones as exteroceptive stimuli while Pollatos et al. (2005, 2007a, b) directly compared both conditions with each other. Neural activity changes assumed to be specific for interoceptive awareness thus reflect a relation or dynamic balance between intero- and exteroceptive processing rather than mirroring isolated interoceptive stimulus processing remaining (more or less) independent of exteroceptive stimulus processing. Dynamic modulation of right insula activity as observed by Critchley may thus reflect a dynamic balance between intero- and exteroceptive attention in the heartbeat-auditory tone detection task rather than pure interoceptive heartbeat

stimulus processing. Such intero-exteroceptive relational concept would thus assume that the above mentioned regions like the right insula, the SACC/DACC and the DMPFC are rather responsive to changes in intero-exteroceptive balance than to isolated interoceptive changes remaining independent of exteroceptive changes.

Second, neither of the above mentioned studies addressed the question of emotional valence that indicates whether a feeling is positive or negative (see also Colombetti 2005 for a discussion of the concept of emotional valence). Pollatos et al. (2005, 2007b) did not observe any significant difference between good and poor heartbeat perceivers in terms of their emotional valence ratings while both groups did differ in emotional arousal. Interoceptive awareness may thus be linked to emotional arousal and subjective experience of emotional intensity while it apparently does not seem to determine the valence of the emotional feeling. Regions that have been associated with emotional valence, as distinguished from emotional arousal, include the medial orbitofrontal cortex (MOFC), the subgenual and pregenual anterior cingulate cortex (PACC), and the ventromedial prefrontal cortex (VMPFC; Kringelbach 2005; Craig 2002; Critchley 2005; Phan et al. 2002; Grimm et al. 2006). Interestingly, these regions are densely and reciprocally connected with the right insula, the SACC/DACC and the DMPFC that are supposed to represent the body's interoceptive state. (Ongur and Price 2000). The connectivity pattern thus argues strongly in favour of the intero-exteroceptive relational concept of emotional feeling which seems to make isolated interoceptive processing and thus an interoceptive-based concept of emotional feeling rather unlikely. What however is needed to further support this point are investigations of both regional activity and connectivity patterns during intero- and exteroceptive stimulus processing (see Hurliman et al. 2005 for some first support).

Third, Pollatos et al. (2005, 2007b) investigated the temporal course with EEG during heartbeat perception task. They observed that good heartbeat perceivers showed higher heart-evoked potentials and stronger dipole strength in cortical sources that included the SACC/DACC, the right insula, the DMPFC and the secondary somatosensory cortex when compared to poor heartbeat perceivers. Interestingly, they also observed the dipole sources in the SACC/DACC and DMPFC to occur earlier (around 280 ms) than the ones in the insula and the somatosensory cortex (around 370 ms). A similar temporal distribution is suggested by Tsuchiya and Adolphs (2007) who assume involvement of subcortical regions like brain stem nuclei and hypothalamus that mediate interoceptive stimuli to occur after and later than activation in higher regions like the DMPFC. If the interoceptive-based model is true, one would rather expect the opposite temporal pattern with early insula and somatosensory involvement, indicating interoceptive processing, and late SACC/DACC and DMPFC involvement. Late SACC/DACC and DMPFC involvement may then reflect some abstract internal cognitive evaluation of interoceptive stimulus processing with consecutive top–down modulation of interoceptive brain regions as interpreted by advocates of the interoceptive-based concept (Craig 2002; Tsuchiya and Adophs 2007). What is the role of the SACC/DACC and the DMPFC? These higher cortical regions have been associated with processing of higher-order exteroceptive stimuli particularly those that are highly self-related to the organism (Northoff et al. 2006; Northoff and Bermpohl 2004). The fact that these regions are apparently implicated from early on in interoceptive awareness gives some though

indirect support to the assumption that exteroceptive stimuli are involved early in interoceptive processing. Such early involvement indicates that the role of exteroceptive stimulus processing goes beyond mere modulation of interoceptive processing which would be better compatible with late involvement. In other terms, early involvement of these regions may indicate that interoceptive stimulus processing is coded in relation to exteroceptive stimuli going beyond mere modulation of the former by the latter. The observed early spatio-temporal pattern may thus reflect neural coding of the relationship between intero- and exteroceptive stimulus processing signifying their actual balance since otherwise there would be no need for regions predominantly associated with exteroceptive stimulus processing to be implicated so early. While it seems to be less compatible with the assumption of primarily independent interoceptive processing that becomes secondarily modulated by exteroceptive stimuli.

Anatomical connectivity and the convergence between intero- and exteroceptive stimulus processing

The medial orbitofrontal cortex (MOFC) and the ventromedial prefrontal cortex (VMPFC) have been demonstrated to be implicated in interoceptive processing. Using biofeedback arousal and relaxation tasks in fMRI, Nagai et al. (2004) demonstrated that resting state neural activity in the VMPFC and MOFC co-varied with the basal level of sympathetic skin conductance whereas regions like the SACC/DACC, the insula and the hypothalamus were related to the rate of change in skin conductance. The level of neural activity in VMPFC and MOFC, which are part of the so-called anterior cortical midline structures (aCMS), may thus represent the basal sympathetic or autonomic tone independent of some actual stimuli. Since the aCMS have been shown to be modulated also by exteroceptive stimuli, neural activity within these regions may mirror a dynamic balance between attention to extero- and interoceptive stimuli (see also Nagai et al. 2004). This assumption is well compatible with the connectivity pattern of these regions. The MOFC and VMPFC as the entrance door to the aCMS receive connections from all regions associated with primary and/or secondary exteroceptive sensory modalities (olfactory, gustatory, somatosensory, auditory and visual; see Rolls et al. 1999; Rolls 2000; Kringelbach and Rolls 2004; Barbas 2000; Damasio 2003a). The aCMS are also densely connected to regions (insula, brain stem regions like hypothalamus, PAG, colliculi, etc.) processing interoceptive sensory signals; these include the proprioceptive and vestibular senses, the visceral sense, and the sense of the interoceptive milieu which can be taken together with that of pain and temperature (Barbas 2004; Damasio 2003a; Rolls et al. 1999; Rolls 2000; Kringelbach and Rolls 2004; Carmichael and Price 1996; Price 1999). The aCMS, especially the MOFC, VMPFC and SACC/DACC, are also connected to regions associated with distinct functional domains including motor (premotor and motor cortex, basal ganglia), cognitive (lateral prefrontal cortex), and emotional (amygdala, brain stem) domains (Barbas 2000; Ongur and Price 2000; Carmichael and Price 1996; Rolls et al. 1999; Rolls 2000; Kringelbach and Rolls 2004). Due to such extensive intero- and exteroceptive connections involving different functional domains, the MOFC and VMPFC (and, in

conjunction, the amygdala) can be characterized as polymodal convergence zone (Rolls et al. 1999; Rolls 2000; LeDoux 2002; Schore 2003).

This connectivity pattern predisposes the aCMS for neural processing irrespective of the sensory modality of the respective stimulus, i.e. supramodal processing. The assumption of supramodal processing in aCMS is supported by results from imaging studies. Emotions in either exteroceptive modality (visual, auditory, gustatory, olfactory) induce neural activity in various regions of the aCMS (see above as well as Phan et al. 2002 and Northoff and Bermpohl 2004). Moreover, processing of interoceptive stimuli induces also activation in aCMS regions like MOFC, VMPFC, and ACC (Critchley et al. 2004; Nagai et al. 2004; Craig 2002, 2003, 2004; Wicker et al. 2003). Finally, stimuli from different origins, i.e., of different sensory modalities or of different functional domains (motor, emotional, cognitive, and sensory) induced analogous activation in aCMS (Northoff and Bermpohl 2004; and Northoff et al. 2006). Taken together, connectivity pattern and imaging data suggest that neural processing in aCMS is supramodal and domain-independent: What apparently matters for inducing neural activity in the aCMS is not so much the modality or domain, i.e., the origin of the stimulus, be it either intero- or exteroceptive or cognitive, motor, sensory, or emotional, but how it is related to the respective intero- or exteroceptive stimulus (see below for further discussion).

Neural activity in anterior CMS may reflect bottom–up modulation by interoceptive processing in subcortical regions, which corresponds to their close connectivity with the aCMS (see above as well as Nagai et al. 2004). Analogous neural activity in anterior aCMS may also be induced by exteroceptive stimuli via bottom–up modulation that may be traced back to the close connections of the aCMS to sensory cortical regions. In addition to bottom–up modulation of the aCMS by regions involved in intero- and exteroceptive processing, the aCMS may also modulate, i.e., top–down modulate the very same regions. For example, the aCMS may top–down modulate interoceptive processing in subcortical regions via the anterior insula (Critchley et al. 2004; Nagai et al. 2004; Craig 2002, 2003). Or, as supposed by Davidson (2000, 2004), the medial prefrontal cortex may top–down modulate or inhibit neural activity in the amygdala which receives strong intero- and exteroceptive inputs. Since anterior aCMS regions like the MOFC and the VMPFC are regarded as polymodal convergence zones, intero- and exteroceptive processing may interfere via top–down and bottom-modulation. This could result in mutual adjustment and reciprocal modulation between intero- and exteroceptive processing which in subjective experience may be reflected in figure–background relationships. The bodily state may be the continuous background against which we subjectively experience our environment. However the relation may also be converse with the body and its interoceptive changes being the figure and the environment remaining in the background as in neuropsychiatric disorders like somatic depression and somatoform disorder where subjects experience strong bodily feelings (see below for further details about bodily feelings) rather than showing feelings directed towards environmental events.

In addition to the aCMS, subcortical midline regions like the periaquaeductal grey (PAG), the colliculi, the dorsomedial thalamus, and the ventral striatum may also be considered in processing interoceptive stimuli in relation to exteroceptive ones. Panksepp (1998; and also Damasio 1999), for instance, assumes that these regions

are crucial in constituting emotional feelings. Since the very same regions are also characterized by strong motor connections both afferent and efferent, he and others like Ellis (2005; unlike Damasio who assumes a sensory-based view of feelings) assume emotional feeling to be motor-based which is well compatible with Panksepp's characterization of emotional feeling as reaching-out to the environment thus reflecting what I called the relational concept of emotional feeling. Unfortunately, subcortical regions have often been neglected in imaging studies of emotions which, at least in part, may be due to the fact that neural activity in these regions is rather difficult to reliably visualize in current imaging techniques like fMRI. However, animal experiments demonstrate the crucial role of these subcortical midline regions in constituting emotional feelings (Panksepp 1998, 2005); future studies in humans are thus needed to investigate subcortical neural activity during emotional feeling in order to bridge the current gap between animals and humans. Furthermore, the relationship between emotional feeling and motor function also needs to be investigated in detail by, for instance, investigating emotional feeling in dependence on variation of motor function and its neural underpinnings (and vice versa).

Interoceptive-based translational versus intero-exteroceptive relational coding of neural activity in emotional feeling

What is the implicit presupposition that drives most of the above cited authors to interpret their data in favour of the James–Lange theory? They seem to presuppose a clear-cut distinction between intero- and exteroceptive stimulus processing with both systems being separate, distinct and only interacting at specific node points. According to such view, exteroceptive stimuli are translated into interoceptive stimulus processing whose perception, in turn, is supposed to induce feeling. Exteroceptive stimuli thus have at best an only indirect and mediated impact on emotional feeling in that they must first be translated into interoceptive stimulus processing before they can modulate feelings. I therefore call this model the interoceptive-based translational concept of feeling. Since exteroceptive stimuli have only an indirect and mediated, the interoceptive-based translational concept attributes no constitutive role of exteroceptive stimuli and the environment thus presupposing an "embodied" concept of emotional feeling.

However, anatomical connectivity suggests otherwise. Throughout the brain at all levels both subcortical and cortical and especially in the subcortical–cortical midline system there is convergence between intero- and exteroceptive inputs. This is especially true for regions like the colliculi, the PAG, the tectum and the aCMS where both intero- and exteroceptive afferences converge onto common neurons (see Panksepp 1998, 2005; Rolls et al. 1999). This suggests that interoceptive stimuli are not only modulated by exteroceptive stimuli at specific node points but rather that the relation, e.g., the degree of convergence and divergence, between intero- and exteroceptive stimuli is coded in neural activity in the subcortical–cortical midline system. Exteroceptive stimuli are thus not so much translated into interoceptive stimulus processing but rather directly and unmediated related to them and it is this relation that seems to be coded in neural activity. I therefore call this model the intero-exteroceptive-based relational concept of feelings (see also Fig. 1). Since

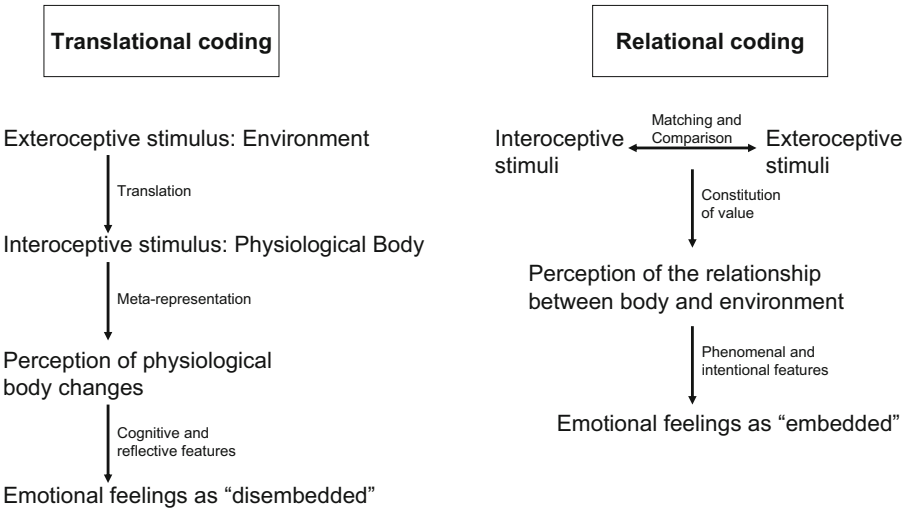

Fig. 1 Translational vs relational models of neural coding in emotional feelings

exteroceptive stimuli have a direct and unmediated role in the relational model, they must be considered constitutive for feeling which in turn must be considered embedded rather than remaining "disembedded". However, this assumption must be considered preliminary since further experiments both imaging and computational are necessary to lend further support to the assumption of intero-exteroceptive relational coding rather than interoceptive-based translational coding in emotional feeling.

Is there any empirical evidence in favour of the intero-exteroceptive relational model of neural coding? Critchley (2005, 162), one of the main investigators of interoceptive processing in imaging, states, that the "right insula maps bodily arousal states" and "it does so contextually" which therefore "represents an integration of external emotional information with peripheral states of arousal" (Critchley 2005, 759). What seems to be coded in the brain is not so much the interoceptive stimulus itself but its relation to the respective exteroceptive stimulus. If neural activity codes the actual relationship and balance between intero- and exteroceptive stimuli, one would expect strong contextual dependence of emotional feelings. The constitution of the emotional feeling, the type of feeling, should then depend on the respective context which implies that different contexts may lead to different types of emotional feelings even in identical situations. In other terms, the environmental context does not only modulate emotional feelings but actively participates in constituting emotional feelings. This is well in accordance with the Schacter and Singer experiments where different contexts resulted in different types of emotional feelings; if the role of the context is merely modulatory, subjects would not have shown completely different and opposing emotional feelings in the two situations but rather variants of the same feeling. These experiments thus lend further support to the assumption of a constitutive role of the environmental context in emotional feelings (rather than remaining merely modulatory).

How are intero- and exteroceptive stimuli related and balanced with each other in relational coding? Rather than coding the intero- or exteroceptive stimulus itself, the degree of correspondence between intero- and exteroceptive stimuli is coded signalling their convergence or divergence. If, for instance a lion approaches, the heart rate may increase, which may signal strong correspondence and convergence between intero- and exteroceptive stimuli and consecutively leads to the constitution of a corresponding emotional feeling, the feeling of fright and anxiety. If, in contrast, the approach of the lion is not accompanied by heart rate increases, as for instance if one is not clear whether the lion is real or not, there may be a mismatch between intero- and exteroceptive stimuli which may result in a different emotional feeling, the feeling of doubt and hesitation. This means that the degree of convergence and divergence between intero- and exteroceptive stimuli may determine the kind of emotional feeling which is well in accordance with the relational concept rather than the embodied one that claims for an interoceptive- and thus bodily-based approach.

Taken together, I assume that our brain's design is such that there is no way for interoceptive stimuli other than to be processed in relation to exteroceptive stimuli and vice versa. Interoceptive stimulus processing remaining isolated, unrelated and independent from exteroceptive stimulus processing is consequently assumed to remain (principally) impossible. This implies what I call intero-exteroceptive relational coding while it excludes interoceptive-based translational coding. What does this imply in experimental regard? The experimental efforts to isolate interoceptive stimulus processing and to search for its specific neural correlates may be futile since exteroceptive stimulus processing may always already be implicated in interoceptive stimulus processing. One may better focus on experimentally investigating different intero-exteroceptive stimulus configurations and thus different constellations between body and environment as nicely demonstrated in the Schacter and Singer experiments. I assume, for instance, that strong activity in the right insula may signal a configuration where interoceptive input predominates and the body is subjectively experienced as the figure while exteroceptive inputs are of minor importance so that experientially the actual environment remains in the background. This specific intero-exteroceptive stimulus configuration may phenomenologically be described by the concept of bodily feeling (see below for further discussion of bodily feelings) which may thus be considered an extreme case on one end of the continuum of different possible body-environment constellations that may reflect different kinds of emotional feelings.

Neurophilosophical implications

Relational concept of emotional feeling and phenomenal consciousness

How should emotional feelings be conceptualized on the basis of the intero-exteroceptive relational model of neural coding? What we subjectively experience as emotional feeling is thus not so much mere perception of an interoceptive stimulus like the heartbeat perception but rather the relation between intero- and exteroceptive stimulus processing. Emotional feelings can no longer be determined in an interoceptive-based way as perceptions of physiological body changes. Instead,

emotional feelings may better be described in an intero-exteroceptive relational way thus focusing more on the relation between body and environment than on either the body or the environment itself [4]. What is constitutive of emotional feelings is thus the relation between body and environment so that feelings reflect the respective person's relationship to the world. This is paradigmatically reflected in what Ratcliffe (2005, 2008) calls existential feelings. Based on Heidegger, he describes existential feelings as feelings that characterize our relation to the world, i.e., as ways of 'finding ourselves in the world'. This is also pointed out by Solomon (2004, 77–8, 84) in a more recent writing when he claims for "an existential notion of emotions" which he considers to be "subjective engagements within the world"[5]. For instance, different existential feelings characterize different relations to the world like feelings of homeliness, separation, belonging, power, control, etc. Most important, emotional feelings like anger, grief, etc. presuppose existential feelings so that both emotional and existential feelings can be characterized as relational. If so, the body itself may only be considered the medium through which feelings can be constituted. Feelings are the relation between person/body and environment rather than some perception of either bodily or environmental changes; in other terms, feelings are this relation implying that this relationship is felt.

Due to the very basic and foundational character of the person/body–environment relation, the relational concept considers emotional (and existential) feelings basic and primary for emotions, i.e., feelings are then the "core nucleus" of emotions. This is very much in line with the neuroscientific approach by Jaak Panksepp (1998, 2005) who assumes what he calls "primary affective consciousness". He regards "primary affective consciousness" as basic and crucial for all forms of subjective experience and thus for consciousness in general. Analogously, the relational view considers our relation to the world primary, basic and crucial to our subjective experience or, as Ratcliffe would probably say, the relation is existential. Since the relational concept characterizes the person/body–environment as basic, primary, and constitutive of feelings, the here advanced relational concept of emotional feelings seems to complement the empirical approach by Panksepp in conceptual regard. Feelings and thus affective consciousness can only be primary and basic, as Panksepp claims, because they are our relation to the world. Another complementary point is Panksepp's (and other authors like M.Sheets-Johnstone, N.Humphrey and R. Ellis) insistence on the close linkage between motor function and emotional feeling, i.e., the primary motor basis of affective consciousness. In contrast to Damasio, who opts for a rather sensory-based view of emotional feeling, Panksepp (and others like Ellis 2005) argues for a primary "motor view" of affective consciousness and emotional feeling because all presumably involved subcortical regions like the PAG, the colliculi, etc. show strong connections to the motor system receiving motor

[4] This is well compatible with the relational approach to meaning and personal significance as suggested by Ben-Ze'ev (1993, 2000) that undercuts the traditional assumption that higher-order cognitive functions are necessary to give meaning and personal significance to otherwise meaningless and personally insignificant sense data.

[5] One may off course argue that we can have subjective experience without emotion in for instance so-called "cold" cognitions. "Cold" cognitions may however be considered just as an extreme case on a continuum in the relationship between emotion and cognition where feelings may still be involved in the background though being maximally suppressed.

afferences from and sending out motor efferences to other cortical and subcortical regions. Accordingly, Panksepp (and others like Ellis 2005) claims that there is intrinsic linkage between motor action and emotional feeling resulting in what may be described as "I act, therefore I feel". The assumption of motor underpinnings as being crucial to emotional feeling is well compatible with the relational concept. The relational concept presupposes bilaterally dependent and constitutive linkage between person/body and environment. Mere linkage by sensory function would result in unilateral and rather instrumental linkage where the person/body cannot directly impact the environment. It is only by motor function that the person/body becomes intrinsically anchored in and non-instrumentally, i.e., constitutionally linked to the environment. In other terms, motor function must be considered the empirical means by means of which what I conceptually described as relational becomes possible. Panskepp's insistence on motor underpinnings of emotional feelings may thus be considered complementary to the here advanced relational concept of emotional feeling.

Once emotional feelings are considered to be the core nucleus of both emotions and consciousness, the often made distinction between "having an emotion" and "feeling an emotion" becomes no longer applicable. Following Bennett and Hacker (2003, 210–4), there is no principal distinction between "having an emotion" and "feeling an emotion" since, as Kripke (1972) already pointed out, the having of pain is to be identified with the feeling of pain. Either we have pain and subjectively experience or feel pain or we do not feel any pain and then we have no pain. "Having an emotion" is consequently to be identified with "feeling an emotion" and their distinction remaining untenable and implausible. According to Bennett and Hacker (2003, 214), the main difference should better be drawn between "feeling an emotion", as being identical with "having an emotion", and "realizing what emotion one feels". "Feeling an emotion" might then indicate subjective experience and thus what currently is called phenomenal consciousness (see below for further explication) whereas "realizing what emotion on feels" might be considered to implicate higher-order cognitive functions and thus be associated with what has been called reflective consciousness.

By considering feeling as constitutive of emotion and phenomenal consciousness, the relational concept of emotional feeling argues against the explanation of feelings in terms of higher-order cognitive and reflective functions mirroring what is called reflective consciousness. Roughly, reflective consciousness describes the person's awareness that it has subjective experience and thus phenomenal consciousness – reflective consciousness may thus focus on higher-order cognitive functions. Phenomenal consciousness, in contrast, does not describe cognitive and behavioural aspects associated with subjective experience. Instead, it focuses on the subjective experiential aspect itself that is described as the "phenomenal aspect" (Chalmers 1995; Block 1996). A number of alternative terms and phrases pick out approximately the same core property of phenomenal consciousness. These include "qualia", "phenomenology", "subjective experience", and "what it is like" which, despite subtle differences, we here consider to describe the same phenomenon for pragmatic purposes. I characterize emotional feeling by "qualia" and "what it is like" thus presupposing phenomenal consciousness. This is well in accordance with Goldie's approach who emphasizes the phenomenal, e.g. unreflective, qualitative,

and "what it is like" character of emotional feeling (Goldie 2000, 68–9). Goldie (2000, 1–2, 41) argues that the phenomenal character of feelings is due to the involvement of a point of view, a perspective, by means of which they become "fundamentally personal". The relational concept claims that such personal point of view is established by constituting the relationship between person/body and environment and thus by constituting feelings be they existential or emotional. How such personal point can be established by relating person/body to the environment remains to be discussed in detail which however is beyond the scope of this paper (see Northoff 2004; Northoff and Bermpohl 2004; Northoff et al. 2006).

Relational concept of emotional feeling and intentionality

This constitutive interdependence between body and environment may account for what philosophers describe as the intentionality of emotions, i.e., that they are about something and that they are directed at or about objects, events, or states of affairs in the environment. According to Goldie (2000, 16–17), emotional feelings are not mere beliefs or desires but are directed towards objects in the world – Goldie (2000, 17–9) speaks therefore of "world-directed intentionality" that characterizes what he calls "feeling towards". "Feelings towards" are an "unreflective emotional engagement with the world beyond the body" (see Goldie 2002, 241) which thus mirror well the relation between person/body and environment in a paradigmatic way – in other terms, "feeling towards" mirror the here advanced relational concept of emotional feeling in a paradigmatic way. Goldie distinguishes "feeling towards" from "bodily feelings". "Bodily feelings" do not concern objects, events, or state of affairs in the environment but rather the phenomenal (or as he says unreflective) consciousness of bodily changes, i.e., the "phenomenology or qualitative nature of our personal experience of these changes" inside our body (muscular, hormonal, autonomic; Goldie 2000, 51–2). In contrast to "feeling towards", "bodily feelings" show no direct intentionality towards objects in the world, i.e. "world-directed intentionality" since they are rather directed towards one's body (Goldie 2000, 55–8). Though bodily feelings by themselves refer only to the body, they nevertheless seem to include feelings that are directed towards objects in the world. Consequently Goldie assumes that "bodily feelings" and "feelings towards" are "united in consciousness in being directed towards an object" in the world: "For example, sexual desire is felt with the whole being – body and soul – for the one we desire. And likewise, our whole being aches in grief for the one we have lost." (Goldie 2000, 55). Due to their associative unity with "feeling towards" in consciousness, "bodily feelings" can quasi participate in and "borrow" the "world-directed intentionality" of "feelings towards" which Goldie describes by the concept of "borrowed intentionality".

My neurophilosophical hypothesis is that what Goldie calls "borrowed intentionality" of "bodily feelings" on a conceptual level may correspond empirically to what I above described as intero-exteroceptive relational coding. "Bodily feeling" may be considered an extreme case at one end of the continuum of possible intero-exteroceptive stimulus configurations where interoceptive stimuli predominate over exteroceptive stimuli. However, predominance does not imply elimination so that even the predominating interoceptive stimuli are still coded in relation to

exteroceptive ones which conceptually may well correspond to Goldie's concept of "borrowed intentionality". The participation of "bodily feelings" in the "world-directed intentionality" of "feeling towards" may empirically be possible only on the basis of the neural coding of interoceptive stimuli from one's body in relation to exteroceptive ones from the environment. This relationship between "borrowed intentionality" and intero-exteroceptive relational coding may become even more apparent when one imagines the converse empirical case in a thought experiment. In the case of interoceptive-based translational coding, "bodily feeling" would remain isolated and disconnected from "feelings towards" so that the two types of feelings would no longer share world-directedness and intentionality. This, in turn, would make both the associative unity between "bodily feelings" and "feeling towards" in consciousness and the participation of the former in the "world-directed intentionality" of the latter impossible. This thought experiments demonstrates that intero-exteroceptive relational coding may be considered a necessary empirical condition of the "borrowed intentionality" of "bodily feelings", i.e., that "bodily feeling is thoroughly infused with the intentionality of the emotion; and, in turn, the feeling towards is infused with a bodily characterization" (Goldie 2000, 57). Due to intero-exteroceptive relational coding, even "bodily feelings" mirror some relation to the environment so that they, similar to "feelings towards", must be considered relational and intentional rather than as merely embodied as presupposed in the James–Lange theories and its modern advocates[6].

Characterization of both "feeling towards" and bodily feelings by intentionality raises the question for their phenomenological distinction in subjective experience. I assume that world-directed intentionality of both types of feeling presupposes what I call the relational concept. The relational concept characterizes emotional feelings by the body–environment relationship which may be constituted in different ways with either the body or the environment predominating or both being balanced equally. Empirically, either intero- or exteroceptive stimulus processing may imprint stronger on the relational coding of neural activity. In the case of strong physical bodily activity, for instance, interoceptive stimulus inputs may be much stronger than and predominate over exteroceptive ones. The intero-exteroceptive relational coding may thus allow for variable balances between intero- and exteroceptive inputs. The balance between intero- and exteroceptive inputs may then provide the empirical basis for the organisation of subjective experience along the phenomenological distinction between figure and background (see also Ratcliffe 2005, 49). What empirically appears as predominant interoceptive input when compared to exteroceptive input may subjectively be experienced as "bodily feeling" with the body as figure and the environment remaining in the background of subjective experience. This is, for instance, the case after strong physical activity where your body aches leading to strong bodily feelings. If, conversely, exteroceptive inputs

[6] Taken together, Goldie (2002, 252) characterizes emotional feelings by both their phenomenal and intentional nature which he considers to be intrinsically and "inextricably linked" with each other. The conditions for such linkage between phenomenality and intentionality in emotional feelings remain however unclear. Empirically, I assume intero-exteroceptive relational coding which, conceptually, may implicate constitution of a personal point of view (see above), to be crucially involved in intrinsically linking phenomenal and intentional features in emotional feelings. This however is a rather speculative hypothesis that needs both empirical and conceptual elaboration.

predominate over interoceptive ones, the environment may shift into the centre, i.e., as figure, of subjective experience with the body remaining in the background. Even if you experience bodily pain, this remains experientially and thus phenomenologically in the background once a lion approaches and you are in severe danger. It is the virtue of the here assumed intero-exteroceptive relational coding that it allows to code for different intero-exteroceptive stimulus configurations or balances which phenomenologically may provide the basis for different possible body–environment constellations ranging on a continuum between both extremes where either the body (e.g., as in the example with physical activity) or the environment (e.g., as in the example with the lion) predominates as figure with the respective other remaining in the background.

I characterized both bodily feelings and "feeling towards" by intentionality, intero-exteroceptive balance, and figure–background relationship. This implies that both types of feelings may be considered as two extremes of on continuum, the relation between person/body and environment, rather than two distinct conceptual types of feelings. This raises the question whether Goldies' distinction between bodily feelings and feeling towards as two different types of feeling is really justified. Ratcliffe (2005, 47), for instance, agrees with Goldie in that feelings "are inextricable from experience of the world and have a directedness towards things" whereas he does not share Goldie's distinction between "feeling towards" and bodily feelings by means of intentionality. He argues that the location of bodily feelings in the body does not determine their directedness and thus "what it is a feeling of" (Ratcliffe 2005, 48). Touching a snowball, for instance, feels cold in the hand and it is this bodily feeling of coldness that predominates subjective experience. One should however not forget that the bodily feeling of coldness is directed towards the snowball; in other terms, the bodily feeling of coldness reflects the relation between hand/body and snowball/environment with the former predominating over the latter. What is subjectively experienced in the body thus reflects something in the environment which Ratcliffe (2005, 48) lends to assume that "feeling of the body and feeling towards objects in the world are two sides of the same coin". If so, the conceptual distinction between bodily feeling and "feeling towards" as suggested by Goldie can no longer be maintained. This can be supported even further by considering the conceptual implications of the relational concept of emotional feelings with regard to the concept of intentionality. The relational concept assumes that the person/body–environment relation provides the very basis of both bodily feelings and feelings towards. If so, the respectively associated types of intentionality, "borrowed intentionality" and "world-directed intentionality", may be traced back to a common underlying and more basic concept of intentionality that can account for what I here called the person/body–environment relation. Such common basic concept of intentionality may be characterized as pre-reflective and pre-theoretical which Merleau-Ponty (1962), relying on Husserl, characterized as "operative intentionality" and distinguished it from the one of cognition what he calls "act intentionality": "This is why Husserl distinguishes between intentionality of act, which is that of our judgments and of those occasions when we voluntarily take up a position – the only intentionality discussed in the Critique of Pure reason – and operative intentionality (fungierende Intentionalität), or that which produces the natural and antepredicative unity of the world and of our life, …." (Merleau-Ponty 1958, xx). Though beyond

the scope of this paper, future investigation is needed, off course, to characterize "operative intentionality" in further detail (see Zahavi 2005) and to conceptually link it to "borrowed intentionality" and "world-directed intentionality" of bodily feelings and feeling towards (see also Ellis 2005 who speaks of "preconscious emotional intentionality"). Most importantly, my neurophilosophical hypothesis is that such common basic intentionality, i.e., "operative intentionality", corresponds on the conceptual level to what empirically I here described as intero-exteroceptive relational coding. If this can be demonstrated one may be able to develop a truly neurophilosophical and unifying theory of emotional feelings where bodily feelings and feeling towards are no longer distinguished conceptually as characterized by different types of intentionality (in the sense of Goldie) but only phenomenologically as distinct figure–background configurations in subjective experience (in the sense of Ratcliffe).

Conclusion

The often favoured James–Lange theory and many current neuroscientific approaches that consider feeling as mere perception of bodily changes and thus as "embodied" may be extended by considering the crucial role of the environment in directly constituting emotional feelings. I therefore suggested in this paper to complement the embodied concept of emotional feelings by a relational concept that assumes emotional feelings to be constituted by the person/body–environment relationship. The relational concept assumes that the environment has not only instrumental and thus indirect impact on emotional feelings via the body but also a direct, e.g., non-instrumental and thus constitutional role in constituting emotional feelings. The present paper focuses on whether such relational concept of emotional feelings is compatible with current empirical data on the neuroscience of emotion processing. If the relational concept of emotional feeling is empirically plausible, even interoceptive awareness should implicate brain regions that process exteroceptive stimuli which both, e.g., intero- and exteroceptive brain regions, should be closely linked to each other in terms of anatomical connectivity. Human brain imaging data show strong involvement of the ventromedial prefrontal cortex and other anterior cortical midline structures in emotional feelings. These regions can be characterized by strong convergence between intero- and exteroceptive inputs which suggests what I call an intero-exteroceptive relational mode of neural coding rather than interoceptive-based translational neural coding. The here assumed intero-exteroceptive relational mode of neural coding may well correspond on the empirical level to what conceptually I call the relational concept of emotional feeling. Whereas the merely embodied concepts of emotional feelings may rather correspond to an interoceptive-based translational neural coding and thus a bodily-based concept of emotional feelings as in the James–Lange theory and its current neuroscientific versions. In addition to empirically presupposing different forms of neural coding, the relational concept has also conceptual implications that concern the characterization of emotional feeling by phenomenal consciousness and a basic form of intentionality. I therefore conclude that, if further elaborated, the here advanced

relational concept of emotional feeling may provide the opportunity to develop a coherent neurophilosophical concept of emotional feeling.

Acknowledgment I am thankful to two anonymous reviewers for helpful comments as well as Peter Goldie and Aaron Ben-Ze'ev for stimulating discussions about the philosophy of emotions.

References

Anderson, A. K., Christoff, K., Stappen, I., Panitz, D., Ghahremani, D. G., Glover, G., et al. (2003). Dissociated neural representations of intensity and valence in human olfaction. *Nature Neuroscience*, *6*(2), 196–202.

Barbas, H. (2000). Complementary roles of prefrontal cortical regions in cognition, memory, and emotion in primates. *Advances in Neurology*, *84*, 87–110.

Barbas, H. (2004). Dead tissue, living ideas: Facts and theory from neuroanatomy. *Cortex*, *40*(1), 205–206.

Bechara, A. (2004). The role of emotion in decision-making: evidence from neurological patients with orbitofrontal damage. *Brain and Cognition*, *55*(1), 30–40.

Bechara, A., & Naqvi, N. (2004). Listening to your heart: interoceptive awareness as a gateway to feeling. *Nature Neuroscience*, *7*(2), 102–103.

Bennett, M. R., & Hacker, P. (2003). *Philosophical foundations of neuroscience*. Oxford: Blackwell.

Ben-Ze'ev, A. (1993). *The perceptual system – a philosophical and psychological perspective*. New York: Peter Lang Publishing.

Ben-Ze'ev, A. (2000). *The subtlety of emotions*. Cambridge, MA, USA: MIT Press.

Berridge, K. C. (2003). Pleasures of the brain. *Brain and Cognition*, *52*(1), 106–128.

Block, N. (1996). How can we find the neural correlate of consciousness? *Trends in Neurosciences*, *19* (11), 456–459.

Carmicheal, S.T., & Price, C. J. (1996). Connectional networks within the orbital and medial prefrontal cortex of macaque monkeys. *Journal of Comparative Neurology*, *371*, 179–207.

Chalmers, D. J. (1995). The puzzle of conscious experience. *Science AM*, *273*(6), 80–86.

Clark, A. (1997). *Being there: Putting brain, body, and world together again*. Cambridge MA, USA: MIT Press.

Clark, A. (2003). *Natural-born cyborgs: Minds, technologies, and the future of human intelligence*. Oxford: Oxford University Press.

Colombetti, G. (2005). Appraising valence. *Journal of Consciousness Studies*, *12*(8–10), 103–126.

Colombetti, G. (2007). Enactive appraisal. *Phenomenology and the Cognitive Sciences*, *6*(4), 527–546.

Colombetti, G. (2008). Emotion, sense-making and enaction. In J. Stewart, O. Gapenne, & E. Di Paolo (Eds.), *Enaction: Towards a new paradigm for cognitive science*. Cambridge MA, USA: MIT Press.

Colombetti, G., & Thompson, E. (2005). Enacting emotional interpretations with feeling. *Behavioral and Brain Sciences*, *28*(2), 200–201.

Colombetti, G., & Thompson, E. (2007). The feeling body: Towards an enactive approach to emotion. In W. F. Overton, U. Müller, & J. Newman (Eds.), *Body in mind, mind in body: Developmental perspectives on embodiment and consciousness*. Lawrence: Erlbaum.

Craig, A. D. (2002). How do you feel? Interoception: The sense of the physiological condition of the body. *Naturalist Review*, *3*, 656–666.

Craig, A. D. (2003). Interoception: the sense of the physiological condition of the body. *Current Opinion in Neurobiology*, *13*, 500–505.

Craig, A. D. (2004). Human feelings: why are some more aware than others? *Trends in cognitive sciences*, *8*(6), 239–241.

Craig, A. D. (2005). Forebrain emotional asymmetry: a neuroanatomical basis. *Trends in cognitive sciences*, *9*(12), 566–571.

Critchley, H. D. (2005). Neural Mechanisms of autonomic, affective, and cognitive intergration. *Journal of Comparative Neurology*, *493*, 154–166.

Critchley, H. D., Wiems, S. W., Rotshtein, P., Oehman, A., & Dolan, R. J. (2004). Neural systems supporting interoceptive awareness. *Nature Neuroscience*, *7*(2), 189–195.

Damasio, A. R. (1999). *The feeling of what happens: body and emotion in the making of consciousness*. New York: Harcourt Brace.

Damasio, A. (2003a). Feelings of emotion and the self. *Annals of the New York Academy of Sciences*, *1001*, 253–261.

Damasio, A. (2003b). Mental self: The person within. *Nature*, *423*(6937), 227 15.

Damasio, A. R., Grabowski, T. J., Bechara, A., Damasio, H., Ponto, L. L., Parvizi, J., et al. (2000). Subcortical and cortical brain activity during the feeling of self-generated emotions. *Nature Neuroscience*, *3*(10), 1049–1056.

Davidson, R. J. (2000). Emotion, plasticity, context, and regulation: Perspectives from affective neuroscience. *Psychological Bulletin*, *126*, 890–909.

Davidson, R. J. (2004). What does the prefrontal cortex "do" in affect: Perspectives on frontal EEG asymmetry research. *Biological Psychology*, *67*(1–2), 219–234.

De Sousa, R. (2003). *Emotion*. Stanford Encyclopedia of Philosophy.

Edelman, G. M., & Tononi, G. (2000). *A universe of consciousness: How matter becomes imagination*. New York: Basic Books.

Ekman, P. (1999). *Handbook of cognition and emotion*. Sussex, UK: Wiley.

Ellis, R. D. (2005). *Curious emotions. Roots of consciousness and personality in motivated action*. New York: John Benjamin.

Fliessbach, K., Weber, B., Trautner, P., Dohmen, T., Sunde, U., Elger, C. E., et al. (2007). Social comparison affects reward-related brain activity in the human ventral striatum. *Science*, *318*(5854), 1305 Nov 23.

Frijda, N. H. (1999). Emotions and hedonic experience. In D. Kahneman, E. Diener, & N. Schwarz (Eds.), *Well-being: The foundations of hedonic psychology* (pp. 190–210). New York: Russell Sage Foundation.

Gallagher, S. (2005). *How the body shapes the mind*. Oxford: Oxford University Press.

Gallagher, S., & Marcel, A. J. (1999). The self in contextualized action. *Journal of Consciousness Studies*, *6*, 4–30.

Goldie, P. (2000). *The emotions: A philosophical exploration*. Oxford: Oxford University Press.

Goldie, P. (2002). Emotions, feelings and intentionality. *Phenomenology and the Cognitive Sciences*, *1*(3), 235–254.

Griffiths, P. E. (2004). Is emotion a natural kind? In R. C. Solomon (Ed.), *Thinkin about feeling. contemporary philosophers on emotions* (pp. 233–249). New York: Oxford University Press.

Grimm, S., Schmidt, C. F., Bermpohl, F., Heinzel, A., Dahlem, Y., Wyss, M., et al. (2006). Segregated neural representation of distinct emotion dimensions in the prefrontal cortex-an fMRI study. *Neuroimage*, *30*(1), 325–340.

Heinzel, A., Bermpohl, F., Niese, R., Pfennig, A., Pascual-Leone, A., Schlaug, G., et al. (2005). How do we modulate our emotions? Parametric fMRI reveals cortical midline structures as regions specifically involved in the processing of emotional valences. *Brain Res Cogn Brain Res*, *25*(1), 348–358.

Hurley, S. (1998). *Consciousness in action*. Cambridge, MA, USA: Harvard University Press.

Hurliman, E., Nagode, J. C., & Pardo, J. V. (2005). Double dissociation of exteroceptive and interoceptive feedback systems in the orbitofrontal and ventromedial prefrontal cortex of humans. *Journal of Neuroscience*, *25*(18), 4641–4648.

James, W. (1884). What is an emotion? *Mind*, *9*, 185–205.

Kihlstrom, J. F. (1999). The psychological unconscious. In L. A. Pervin & O. P. John (Eds.), *Handbook of personality: Theory and research* (pp. 424–442, 2nd ed.). New York: Guilford Press.

Kihlstrom, J. F., Eich, E., Sandbrand, J., & Tobias, B. (2000). Emotion and memory: Implications for self-report. In J. E. A. Turkkan & A. Stone (Eds.), *The science of self-report: Implications for research and practice*. Mahwah, NJ, USA: Lawrence Erlbaum Associates.

Kringelbach, M. L. (2005). The human orbitofrontal cortex: linking reward to hedonic experience. *Nature Reviews. Neuroscience*, *6*(9), 691–702.

Kringelbach, M. L., Jenkinson, N., Green, A. L., Owen, S. L., Hansen, P. C., Cornelissen, P. L., et al. (2007). Deep brain stimulation for chronic pain investigated with magnetoencephalography. *Neuroreport*, *18*(3), 223–228 Feb 12.

Kringelbach, M. L., O'Doherty, J., Rolls, E. T., & Andrews, C. (2003). Activation of the human orbitofrontal cortex to a liquid food stimulus is correlated with its subjective pleasantness. *Cerebral Cortex*, *13*(10), 1064–1071.

Kringelbach, M. L., & Rolls, E. T. (2004). The functional neuroanatomy of the human orbitofrontal cortex: evidence from neuroimaging and neuropsychology. *Progress in Neurobiology*, *72*(5), 341–372.

Kripke, S. (1972). Naming and necessity. In D. Davidson & G. Harman (Eds.), *Semantics of natural language* (pp. 253–355, 2nd ed.). Dordrecht: Reidel Publishing.

Lambie, J. A., & Marcel, A. J. (2002). Consciousness and the varieties of emotion experience: A theoretical framework. *Psychological review*, *109*(2), 219–259.
Lane, R. D., Reiman, E. M., Axelrod, B., Yun, L. S., Holmes, A., & Schwartz, G. E. (1998). Neural correlates of levels of emotional awareness. Evidence of an interaction between emotion and attention in the anterior cingulate cortex. *Journal of Cognitive Neuroscience*, *10*(4), 525–535.
Lang, P. J., et al. (1993). Looking at pictures: Affective, facial, visceral, and behavioral reactions. *Psychophysiology*, *30*, 261–273.
LeDoux, J. E. (1996). *The emotional brain: the mysterious underpinnings of emotional life*. New York: Simon and Schuster.
LeDoux, J. E. (2002). *Synaptic self: how our brains become who we are*. New York: Viking Penguin.
Merleau-Ponty, M. (1962). *Phenomenology of perception*. London: Routledge.
Merleau-Ponty, M. (1958). *Phenomenology of perception*. London, New York: Routledge.
Nagai, Y., Critchley, H. D., et al. (2004). Activity in ventromedial prefrontal cortex covaries with sympathetic skin conductance level: a physiological account of a "default mode" of brain function. *Neuroimage*, *22*(1), 243–251.
Niedenthal, P. M. (2007). Embodying emotion. *Science*, *316*(5827), 1002–1005 May 18, Review.
Niedenthal, P. M., Barsalou, L. W., Winkielman, P., Krauth-Gruber, S., & Ric, F. (2005). Embodiment in attitudes, social perception, and emotion. *Personality and Social Psychology Review*, *9*(3), 184–211 Review.
Noë, A. (2004). *Action in perception*. Cambridge, MA, USA: MIT Press.
Northoff, G. (2004). Why do we need a philosophy of the brain. *Trends in Cognitive Sciences*, *8*(11), 484–485 Nov.
Northoff, G., & Bermpohl, F. (2004). Cortical midline structures and the self. *Trends in Cognitive Sciences*, *8*(3), 102–107.
Northoff, G., Heinzel, A., de Greck, M., Bermpohl, F., Dobrowolny, H., & Panksepp, J. (2006). Self-referential processing in our brain – a meta-analysis of imaging studies on the self. *Neuroimage*, *31* (1), 440–457 15.
Northoff, G., & Musholt, K. (2006). How can Searle avoid property dualism? Epistemic-Ontological Inference and Autoepistemic Limitation. *Philosophical Psychology*, *19*(5), 1–17.
Ohman, A. (2000). Fear and anxiety: Evolutionary, cognitive, and clinical perspectives. In M. Lewis & J. M. Haviland-Jones (Eds.), *Handbook of emotions* (pp. 573–593). New York: The Guilford Press.
Ohman, A., & Soares, J. J. (1998). Emotional conditioning to masked stimuli: expectancies for aversive outcomes following nonrecognized fear-relevant stimuli. *Journal of Experimental Psychology General*, *127*(1), 69–82.
Ongur, D., & Price, J. L. (2000). The organization of networks within the orbital and medial prefrontal cortex of rats, monkeys and humans. *Cerebral Cortex*, *10*(3), 206–219.
Panksepp, J. (1998). *Affective neuroscience: The foundations of human and animal emotions*. Oxford: Oxford University Press.
Panksepp, J. (2005). Affective consciousness: Core emotional feelings in animals and humans. *Consciousness and Cognition*, *14*(1), 30–80.
Phan, K. L., Wager, T., Taylor, S. F., & Liberzon, I. (2002). Functional neuroanatomy of emotion: a meta-analysis of emotion activation studies in PET and fMRI. *Neuroimage*, *16*(2), 331–348.
Phillips, M. L., Williams, L. M., Heining, M., Herba, C. M., Russell, T., Andrew, C., et al. (2004). Differential neural responses to overt and covert presentations of facial expressions of fear and disgust. *Neuroimage*, *21*(4), 1484–1496.
Pollatos, O., Herbert, B. M., Matthias, E., & Schandry, R. (2007a). Heart rate response after emotional picture presentation is modulated by interoceptive awareness. *International Journal of Psychophysiology*, *63*(1), 117–124.
Pollatos, O., Kirsch, W., & Schandry, R. (2005). On the relationship between interoceptive awareness, emotional experience and brain processes. *Brain Research Cognitive Brain Research*, *25*(3), 948–962.
Pollatos, O., Traut-Mattausch, E., Schroeder, H., & Schandry, R. (2007b). Interoceptive awareness mediates the relationship between anxiety and the intensity of unpleasanr feelings. *Journal of Anxiety Disorders*, *21*(7), 931–943.
Price, J. L. (1999). Prefrontal cortical networks related to visceral function and mood. *Annals of the New York Academy of Sciences*, *877*, 383–396.
Prinz, J. (2004). Embodied emotions. In R. C. Solomon (Ed.), *Thinking about feeling. Contemporary Philosophers on Emotions* (pp. 44–61). Oxford: Oxford University Press.
Ratcliffe, M. J. (2005). The feeling of being. *Journal of Consciousness Studies*, *12*(8–10), 43–60.

Ratcliffe, M. J. (2008). *Feelings of being: Phenomenology, psychiatry and the sense of reality*. Oxford: Oxford University Press.

Rolls, E. T. (2000). The orbitofrontal cortex and reward. *Cerebral Cortex*, *10*(3), 284–294.

Rolls, E. T., Tovee, M. J., et al. (1999). The neurophysiology of backward visual masking: Information analysis. *Journal of Cognitive Neuroscience*, *11*(3), 300–311.

Schachter, S., & Singer, J. E. (1962). Cognitive, social, and physiological determinants of emotional state. *Psychological Review*, *69*, 379–399.

Schore, A. N. (2003). *Affect Regulation and the Repair of the Self*. New York: W.W. Norton.

Sheets-Johnstone, M. (1999). Emotion and movement. *Journal of Consciousness Studies*, *6*(11–12), 259–277.

Small, D. M., Gregory, M. D., Mak, Y. E., Gitelman, D., Mesulam, M. M., & Parrish, T. (2003). Dissociation of neural representation of intensity and affective valuation in human gustation. *Neuron*, *39*(4), 701–711 14.

Solomon, R. C., & Harlan, L. C. (Eds) (2004). Thinking about feeling. Contemporary Philosophers on Emotions. Oxford University Press.

Thompson, E., & Varela, F. J. (2001). Radical embodiment: Neural dynamics and consciousness. *Trends in Cognitive Sciences*, *5*, 418–425.

Tsuchiya, N., & Adolphs, R. (2007). Emotion and Consciousness. *Trends in Cognitive Sciences*, *11*(4), 158–167.

van Gelder, T. J., & Port, R. F. (1995). *Mind in motion: Exploration in the dynamics of cognition*. Cambridge, MA, USA: MIT Press.

Wicker, B., Keysers, C., Plailly, J., Royet, J. P., Gallese, V., & Rizzolatti, G. (2003). Both of us disgusted in My insula: the common neural basis of seeing and feeling disgust. *Neuron*, *40*(3), 655–664.

Williams, L. M., Liddell, B. J., Rathjen, J., Brown, K. J., Gray, J., Phillips, M., et al. (2004). Mapping the time course of nonconscious and conscious perception of fear: an integration of central and peripheral measures. *Human Brain Mapping*, *21*(2), 64–74.

Winkielman, P., Berridge, K. C., & Wilbarger, J. L. (2005). Unconscious affective reactions to masked happy versus angry faces influence consumption behavior and judgments of value. *Personality & Social Psychology Bulletin*, *31*(1), 121–135.

Zahavi, D. (2005). *Subjectivity and Selfhood. Investigating the first-person perspective*. Cambridge/MA: MIT Press.

Zajonc, R. B. (1998). Emotions. In D. Gilbert, S. T. Fiske, & G. Lindzey (Eds.), *The handbook of Social Psychology, vol.1* (pp. 591–632). Boston: McGraw-Hills.

Zajonc, R. (2000). Feeling and thinking: Closing the debate over the independence of affect. In J. Forgas (Ed.), *Feeling and thinking: The role of affect in social cognition*. Cambridge, UK: Cambridge University Press.