Social and affective neuroscience of embodiment

Chapter 3
Social and Affective Neuroscience of Embodiment

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Abstract Embodiment has been discussed in the context of social, affective, and cognitive psychology, and also in the investigations of neuroscience in order to understand the relationship between biological mechanisms, body and cognitive, and social and affective processes. New theoretical models have been presented by researchers considering not only the sensory–motor interaction and the environment but also biological mechanisms regulating homeostasis and neural processes (Tsakiris M, Q J Exp Psychol 70(4):597–609, 2017). Historically, the body and the mind were comprehended as separate entities. The body was considered to function as a machine, responsible for providing sensory information to the mind and executing its commands. The mind, however, would process information in an isolated way, similar to a computer (Pecher D, Zwaan RA, Grounding cognition: the role of perception and action in memory, language, and thinking. Cambridge University Press, 2005). This mind and body perspective (Marmeleira J, Duarte Santos G, Percept Motor Skills 126, 2019; Marshall PJ, Child Dev Perspect 10(4):245–250, 2016), for many years, was the basis for studies in social and cognitive areas, in neuroscience, and clinical psychology.

Keywords Embodiment · Empathy · Racial bias · Social embodiment · Emotion embodiment

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Introduction

Embodiment has been discussed in the context of social, affective, and cognitive psychology, and also in the investigations of neuroscience in order to understand the relationship between biological mechanisms, body and cognitive, and social and affective processes. New theoretical models have been presented by researchers considering not only the sensory–motor interaction and the environment but also biological mechanisms regulating homeostasis and neural processes (Tsakiris, 2017).

Historically, the body and the mind were comprehended as separate entities. The body was considered to function as a machine, responsible for providing sensory information to the mind and executing its commands. The mind, however, would process information in an isolated way, similar to a computer (Pecher & Zwaan, 2005). This mind and body perspective (Marmeleira & Duarte Santos, 2019; Marshall, 2016), for many years, was the basis for studies in social and cognitive areas, in neuroscience, and clinical psychology.

However, the dichotomous discussion of mind and body has been replaced by an approach that considers the individual's integrality. Embodiment, in turn, arises from the connection between body, emotions, brain, and environment (Marshall, 2016). Thus, the body is no longer seen as a simple sensory–motor interface, neither is the mind seen as a set of logical functions and isolated cognitive abilities. Together, the body and mind become an integral biological system modulated by experiences provided by homeostatic self-regulation interconnected with interactions with other individuals and with the environment (Marmeleira & Duarte Santos, 2019). In this perspective, embodiment is understood as a representation of the self and its interaction with the world. In this chapter, we are discussing embodiment in both social and affective processes.

Neuroscience of Embodiment

Embodiment is experienced through representations in the brain based on simulations of predictions and patterns constructed by our experiences both at the perceptual and motor level (Barrett, 2017; Longo & Tsakiris, 2013). Our perceptual experience occurs through sensory inputs, such as auditory, visual, or vestibular sensations, and also through somatic experiences, such as touch, pain, vibration, and the position of the body itself. To exemplify, let us consider the action of grasping a pen with the fingers. The tactile sensation when touching the pen is temporally and spatially congruent with seeing the fingers grasping the pen. Incoming visual information about the location of the body (i.e., fingers grasping the pen) is processed by the visual cortex and is related to a somatic representation of the perception of the visual space around the body parts (Holmes & Spence, 2004; Kilteni et al., 2015). The execution of the motor action (here: grasping a pen) includes efferent motor signals and the associated touch sensation includes afferent feedback. The synchronous integration of the visuo-tactile and proprioceptive signals promotes the experience of the moving body parts being perceived as one's own (Longo & Tsakiris, 2013; Tsakiris, 2010). These integration processes allow to differentiate between one's own perceptual experiences and those of others but also serve as the basis for experiences being grounded in one's body (hence, embodiment).

The brain areas of the posterior parietal cortex (PPC) and ventral premotor cortex (MPCv) play a fundamental role in the perception of the body and the surrounding space (Holmes & Spence, 2004). Visual–somatosensory coordination includes encoding the position of the body in space and comparing the felt with the seen position. Multisensory neurons respond to tactile and proprioceptive stimulation (e.g., touch sensation when grasping a pen and knowledge of the hand's location in space), but also to visual stimulation (seeing the hand moving and the fingers grasping the pen) (Graziano, 1999; Zopf et al., 2010). The representation of an action can be used in simulations to predict sensations and to track mismatches between sensory predictions and real perception of the sensory environment (Barrett, 2017). The continuous coupling of visuo-tactile and proprioceptive signals can explain the strong neural connections between the visual, motor, and somatosensory cortex.

These processes can be facilitated by specific neurons that fire both during action observation and action execution. Early monkey studies showed that some neurons (in the pre-motor brain area F5) fire during action observation as well as action execution (Gallese, 2007; Rizzolatti et al., 1996) which serves as a potential explanation for simulation processes and understanding others' actions. These neurons are now called mirror neurons. In the study conducted by Rizzolatti et al. (1996), it was discovered that some neurons fired when the monkey saw a grasping action and it were the same neurons that fired when the monkey was performing a grasping action. Another experiment included a second monkey and a human experimenter and a similar response of this group of neurons was found (Rizzolatti et al., 1996). These results demonstrate the activation of the mirror neuron system when observing movement-related action. Mirror neurons were found to be somatotopically arranged in the premotor cortex and reciprocally connected in the posterior parietal cortex; these areas are considered analog to the areas containing mirror neurons in monkeys (Rizzolatti et al., 1996).

The experiments in monkeys revealed that in addition to the activation of the F5 area for observation of the action and execution of the action, this brain area is also active during partially hidden observation, when it is possible to predict the result of the action, even in the absence of complete visual information of the execution of the action and interaction with the target object. Umiltà et al. (2001) conducted a study with monkeys with two experimental conditions: "total" vision condition, when the monkey was shown a fully visible action directed at an object (hand–object interaction), and the "partial" vision condition, when the same action was shown, but the final part of the action was hidden. The results showed that there was activation of mirror neurons in the F5 area in both experimental conditions (Umiltà et al., 2001), which provides support to suggest that the understanding of the action can be based on predictions of the internal motor representation of the action, through the anticipation of the final objective of the action performed by others, and, therefore, this mechanism can be understood as a precursor of more sophisticated skills of understanding the intention of others (Gallese, 2007).

Gallese (2007) calls the mechanism of mirror neurons capable of helping us understand others "incorporated simulation." The incorporated simulation theory by Gallese (2007) proposes that the mirror neuron system may be involved in processes of social cognition, such as understanding others' actions and intentions, attributing mental states to others, and language. Other studies suggest that the mirror neuron system is involved in social cognition processes, such as facial expression recognition and ultimately empathy (Mier et al., 2010; Schulte-Rüther et al., 2007); the mirror neuron system is thought to include the fusiform gyrus, superior temporal sulcus, posterior parietal cortex, ventral premotor cortex, and tonsil (Schmidt et al., 2021).

Overall, such evidence suggests that there is an embodied nature to actions and cognitive processes. This embodiment makes it possible to run simulations to guide action and to use such internal models to give meaning and coherence to sensations. (Barrett, 2017). Thus, brain simulations function as filters for sensory stimulus inputs, driving action, and constructs perception of both cognition and emotions (see Barret review, 2017). Conversely, the manipulation of multisensory stimuli can modulate representations of the body and create perceptual illusions of body parts and embodiment illusions of the self and self-other (see next section). Having touched upon the neuroscience of embodiment, this chapter continues by delving into social and affective processes that can be explained by embodiment.

Embodiment and Social Embodiment

Embodiment is centered on our subjective experiences grounded in our physical body (Gillihan & Farah, 2005). It is through this bodily self-awareness that we understand that we have a body, that we feel it as our own, that it occupies a place in space, and that there is a space around it. The formation of this body self-awareness depends on the integration of bodily signs of different sensory modalities, which signal the location of body parts and of the entire body in space, as well as providing information that we are within this body. Therefore, this body assumes the perspective of the "self" in experimentation and interaction with the world (Blanke et al., 2015; Mul et al., 2019).

Embodiment from the internal body representation perspective can be expressed through the sensations of body ownership and of motor agency. The sensation of agency precedes a motor action, and it involves the efferent component because centrally generated motor commands precede a voluntary movement (Tsakiris et al., 2006). It is the intention and execution of actions that allow the sensation of movement control of the body in a given task (Gallagher, 2000; Tsakiris et al., 2006). Body ownership is related to the sensation of the presence of the body itself. According to Gallagher (2000), it is the feeling that "my body" belongs to me, and it is always present in one's mental life. This feeling of embodiment is present during motor actions in performing a task, as well as during passive bodily experiences such as being touched (Tsakiris et al., 2006). The body scheme's neural construction is formed throughout life: a dynamic update based on sensory cues experienced by the body and its interaction with the environment (Cardinali et al., 2009). Hence, we learn cognitive and motor skills and the perception of our own body based on these sensory experiences. Embodiment is modulated by bodily experiences, but also by affective experiences and internal body representation (Braun et al., 2018; Marmeleira & Duarte Santos, 2019).

Therefore, the sense of body ownership should be considered as a result of external sensory stimuli that integrate different sensory signals (somatosensory, vestibular, visual, somatosensory) to the formation of body perception (Botvinick & Cohen, 1998; Kilteni et al., 2015; Tsakiris, 2010), and internal, interoceptive stimuli, which form the internal body representation. This multisensory information interacts with motor systems in motor action, making it possible for the body scheme to locate and perceive a body part's position in space (Margolis & Longo, 2014; Medina & Coslett, 2010), contributing to the implementation of actions involved in the interaction with the environment (Assaiante et al., 2014).

The plasticity of the multisensory integration, through simultaneous sensory stimuli of spatial and temporal congruence, has been vastly studied, showing that bodily representations and peripersonal space can be modulated after seconds of sensory manipulation, incorporation of instruments, mirror images, and use of inanimate objects such as a rubber hand. Synchronous visuo-tactile or visuomotor interactions make it possible to change one's perception of peripersonal and body space, which can modify the body scheme and induce the sensation of body ownership, including someone else's body part, as in the rubber hand illusion (Botvinick & Cohen, 1998; Holmes & Spence, 2004; Kilteni et al., 2015). In this illusion, the participant's hand is occluded from their vision and replaced by a prosthesis with similar characteristics, positioned close to the body aligned with the shoulder. In order for the illusion to occur both the real and the fake, hands must be touched synchronously in time and precisely in the same location. This visuo-tactile–proprioceptive interaction generates a conflict of what is seen in the prosthesis and what is felt in the hand, and it promotes incorporation of the rubber hand by the body scheme and the sensation of body ownership (Botvinick & Cohen, 1998). Thus, the illusions that manipulate the sense of body ownership are potentially experimental tools for investigating body representation and peripersonal space (Costantini & Haggard, 2007).

In this context, it is possible to suggest that self-awareness is highly malleable and influenced by external sensory information as evidenced by several studies. However, in addition to external sensory information, we have internal representations formed by interoceptors that allow us to have consciousness of our body (Tsakiris, 2017). Craig (2009) presented in a review that interoceptive representations contained in the insular cortex provide a basis for the subjective feelings of body and consciousness. The insula is the interoceptive center in the brain, and it plays a fundamental role in the representation of self-awareness involving the integration of external stimuli arising from the environment and the feeling of agency and control of one's own body. The insula is also linked to the affective processing of the self and the other and of processes of social cognition, such as empathy, representation of oneself, and sense of identity (Craig, 2009; Tsakiris, 2017). Thus, interoception plays a fundamental role in the self-awareness and in the stability of the internal representation that, despite the influences of exteroceptive signs and social interaction with others, maintains the representation of the body's self-awareness as being "mine" (Tsakiris, 2017).

From this perspective, social neuroscience began studying embodiment in order to have a better understanding of social perception, attitudes, and emotion of the self and the others (Niedenthal & Barsalou, 2005). Studies have shown that embodiment can be influenced by social experiences and by the processes of perceived social information, which makes us susceptible to experiencing overlap of body representation of the other (Tsakiris, 2017). Sforza et al. (2010) demonstrated that by synchronic touching, the face of people who were seeing simultaneous touches on a partner's face, induced by the "enfacement" illusion, the partner's facial characteristics were incorporated in the representation of the participant's own face; the same did not happen during asynchronic touch. Similar results were found in the study carried out by Tajadura-Jiménez and Tsakiris (2014); in addition, the authors showed the role of individual interoceptive sensitivity in the modulation of exteroceptor signals by stimulation multisensory synchronic recognition. These findings suggest that the sense of body ownership is malleable through multisensory integration, and it is possible to induce the sense of ownership of the part of the body of the other as being my own body, yet the perception of the recognition of the body itself, as distinct from others, is weighted by individual interoceptive sensitivity.

From studies on the embodiment of the self and the other, it is possible to demonstrate how perceptual illusions can modulate multisensory integration, but also the social perception of the other. In the study conducted by Paladino et al. (2010), the sensation of being touched synchronously to the observed touch of another person provoked more positive affective reactions than in the asynchronous condition. In addition, participants felt closer to the other person and perception of face resemblance was increased. Other studies were conducted in order to understand whether the modulation of social perception in the embodiment of the other can influence racial bias. Peck et al. (2013), through virtual reality, investigated whether the embodiment of light-skinned people in virtual bodies of dark skin, light skin, purple skin, and without virtual body modulated the implicit racial bias. The results revealed that the implicit racial bias decreased when the dark-skinned virtual body was incorporated. Farmer et al. (2014) used the rubber hand illusion with black-and-white hands in Caucasian participants. The synchronous stimulation in the dark-skinned rubber hand was demonstrated to have a more positive implicit attitude toward black people and induced a sensation of body ownership. However, the authors observed that the most favorable results of the illusion of the rubber hand were influenced in the participants with low racial attitudes implied in relation to dark-skinned. Similarly, Lira et al. (2017) revealed that the increase in racial bias implied in relation to dark-skinned affected the temporal dynamics of multisensory integration during the rubber hand illusion and promoted delay in assigning the sense of body ownership of the hand of another racial group in Caucasian participants. These results together show that social embodiment and recognition of the self and the other are influenced by the way we are connected to the other, which involves cultural, emotional, and affective aspects.

Finally, perceptive illusions have been shown to be an important tool to manipulate the embodiment of the body itself and the body of the other. Interestingly, the embodiment of the other has helped to understand social processes such as empathy, racial bias, change of the negative valence for the judgment of the other, social perception, among other aspects. The studies have shown us the malleability and the rapid adaptability to the judgment of the implicit social attitude when we experience the body of the other despite the existing cultural differences. Perhaps the advancement of studies of social embodiment allows us to better understand categorization, prejudice, and discrimination from the embodiment of the other and its neural and physiological correlates.

Embodiment of Emotion

Embodied cognition accounts postulate that there are interrelations between the body (e.g., body posture, gestures) and cognition, and it is assumed that emotions are also embodied. Darwin (1872) observed that physical bodily actions are closely related to an emotional experience and that an experienced emotion seems to result in a particular behavioral pattern. The assumption of embodiment is that we acquire memory and thus knowledge on concrete objects or abstract concepts (e.g., emotions) through experience and store all information of the specific experience (i.e., context, affect, behavior, etc.) together in a representation (Barsalou, 2008). Sensory experiences from all modalities (motor, sensory, and affective) are stored in these representations. When knowledge is required of a concrete object or abstract concept, the memory stored in its representation can get activated and a simulation of the initial state when the knowledge was acquired takes place in sensory–motor brain areas and can initiate responses across the body, although this can be a partial re-enactment of lesser intensity (Barsalou, 2008; Niedenthal, 2007). Using functional magnetic resonance imaging, Wicker et al. (2003) showed that the same brain region (i.e., insula) is activated in participants when they are seeing a facial expression of disgust as when they are experiencing disgust themselves, demonstrating that the same neural network is involved in the representation as in the experience of this emotion. It is very likely that a triggered representation of an emotion presents itself beyond the neural activation and changes occur across the body.

Representations are indeed not solely localized in the brain but encompass the whole body. Nummenmaa et al. (2014) conducted multiple experiments on the representation of emotions across the body. In one experiment, participants were asked to localize specific emotions in the body (by coloring in body maps) where the emotion would be felt. In another experiment, emotions were elicited in participants, and they were asked to report the accompanying bodily sensations. In yet another experiment, participants were asked to link observed facial emotion to parts of the body where the emotion would be felt by the person displaying the emotion facially. The results showed that bodily sensations are linked to discrete emotions reflecting the representation of emotion concepts across the body. For example, the emotion of sadness was portrayed as a reduction in bodily sensations in the limbs in line with the lowered muscle tone and drive in activity experienced during sadness. In a further study, Nummenmaa et al. (2018) showed there are neural activation patterns associated with emotional states and demonstrated again that emotions are embodied.

The various aspects stored in a representation of an emotion, i.e., body postures, facial expressions, physiological responses (e.g., pulse), can each trigger the other parts of the representation. As such, verbally reporting about a joyful experience and thereby accessing the conceptual knowledge on joy is likely to activate the representation of joy, leading to the experience of positive affect (that was felt when the situation initially occurred), an associated facial expression of smiling and other physical components. This occurrence has been demonstrated experimentally. Providing participants with one-sentence descriptions of emotional situations and prompting them to imagine the scenario leads to respective subjective feelings and facial muscle activation associated with the emotion imagined (Brown & Schwartz, 1980). Likewise, research has shown that the mere production of a facial expression associated with a specific emotion can activate the representation of this emotion and lead to subjective experience of said emotion. Hess et al. (1992) asked participants to either feel (to generate the feeling but to keep it inside and not show it) the emotions anger, sadness, happiness, and peacefulness, or to merely express these emotions, or to express and feel the emotions. Self-report ratings of felt emotions were obtained and showed that even the experimental condition of mere production of facial emotional expression led to emotion experience, despite the instruction to not feel and only express the emotion. A recent study further demonstrated that emotions are represented across the body. Participants observed facial expressions of fear and anger while electromyography was recorded from muscles in the face and arm each associated with expressions of fear and anger and the results showed congruent muscle activity in face and arm for the emotions investigated (Moody et al., 2017). Such results demonstrate that individual aspects of conceptual knowledge can activate other parts of the emotion representation including changes across the body.

The literature presented in this section thus far has included an explicit emotional stimulus which activated emotion representations. However, activation of emotion representations also take effect across the body when people are unaware of the activated emotion representation, that is, without explicit emotional stimulus. In a study, participants believed brain lateralization was measured using electroencephalography while they listened to music and were told they had to relax/contract facial muscles as a conflicting task (Duclos et al., 1989). However, the facial muscle activation manipulations actually resulted in facial expressions associated with individual emotional expressions and no brain activity was measured. Self-ratings on emotional experience were obtained but covered up as a necessity to control for interference with the obtained electroencephalography recordings. Results showed that facial expression manipulations associated with anger, disgust, fear, and sadness resulted in higher emotional experience reports for each of these emotions. In a second experiment, the body posture of participants was manipulated to represent fear, anger, and sadness and resulted in the respective emotional experiences. Since emotion representations can be triggered without us perceiving an emotional stimulus, it might be the case that elicited emotion representations have further effects, in that bodily states might also affect our behavior and cognitions related to an emotion experience, and this without our awareness.

Embodied aspects of emotions indeed affect cognitions that are related to a current bodily state even in the case that the relationship between the bodily action and the emotion is unknown to a person. Probably the most famous study on the effects of bodily action on cognition was conducted by Strack et al. (1988) who manipulated participants' mouth position and examined the effects on evaluations of cartoons regarding their funniness. When participants were holding a pen with their teeth, sticking out of their mouth, and so unconsciously simulating a smile, participants rated cartoons as funnier than participants holding a pen with their lips in a way that smiling was prevented. The experimentally induced smile was not an expression of truly felt positive affect but elicited the respective representation and could so influence the evaluations of the cartoons. In both experimental conditions included in the study by Strack et al. (1988), muscular feedback from the face influenced the evaluations of the cartoons. One explanation is that the experimentally induced smile was perceived by participants as resulting from the cartoons and interpreted as being amused, which is a more cognitive explanation. An alternative explanation, rooted in the body, is that the experimentally induced smile created muscular feedback which elicited the respective emotion representation, and thereby altered evaluations, respectively. This study constitutes one example of how the body can influence cognitions without being aware of this influence. However, it should be noted that a multicentre replication study did not consistently reproduce the same results (Wagenmakers et al., 2016). Nonetheless, a preceding study also demonstrated that manipulations of facial expression toward frowning and smiling without participants' awareness affected participants' emotional experience as well as funniness evaluations of cartoons (Laird, 1974). Such findings further align with aforementioned literature in this chapter on bodily state manipulations related to emotions and respective emotional experiences. It is clear that physical changes occur within the body during emotional experience, but it has also been demonstrated that these changes serve a purpose, in that they prepare for subsequent action, e.g., increased blood flow to skeletal muscles during fear to prepare for flight (e.g., Balters & Steinert, 2017; de Gelder et al., 2004). Consequently, it is no long stretch to assume that bodily states would also affect cognitions, which is the fundamental proposition of grounded cognition or embodiment theories (Barsalou, 2008) and many research findings support this assumption (Winkielman et al., 2015).

A further example of how embodiment of emotions can affect cognitions provides a study on memory. Participants enacted body postures associated with specific emotions (but were unaware of this emotion-related manipulation), which facilitated recalling of personal experiences containing these emotions (Schnall & Laird, 2003). In this case, the facilitation of the performance resulted from the congruency between the triggered emotion representation and the emotion in the task. Hence, incongruence between bodily state and emotion stimulus should lead to hampered performance. That bodily states incongruent with an observed stimulus in a task can affect cognitions was demonstrated in a study where facial muscle activations were manipulated and its effect on facial emotion recognition investigated. When participants were holding a pen in their mouth in a way that antagonist muscles to the observed facial emotional expressions were activated, this induced facial muscle feedback that was incongruent with the muscle activation underlying the observed facial expression and lowered recognition rates compared to a control condition without mouth movement manipulation (Wingenbach et al., 2018). These results can be explained with embodiment of emotion. Given that the observation of a specific facial emotional expression should elicit its representation (including the respective facial muscle activity), motor information incongruent with the visual information, i.e., observed emotion, should cause interference with the elicited representation, and thus hamper recognition. Similarly, an electroencephalography study demonstrated that interfering with the simulation of observed facial emotion through facial muscle activation manipulation impairs processing of the observed facial emotion as evidenced by greater semantic retrieval demand, i.e., larger N400 amplitude (Davis et al., 2017). In a similar fashion, botulinum toxin-a injections in the corrugator muscle of the face (associated with frowning) impaired language comprehension of the emotional content of sad and angry nature (both emotional expressions include corrugator activation) as measured by reading time compared to pre-injection (Havas et al., 2010). These results exemplify the effect bodily states can have on cognitions and highlight the all-encompassing nature of emotion representations across the body.

The relationship between bodily states and cognitions within the framework of embodiment of emotion is bidirectional. That is, cognitive processes related to emotion can have an effect on our bodily states just as bodily states can affect cognitions. For example, participants' posture was measured in vertical height during generation of terms associated with pride and disappointment and a significant decrease in height was found during the disappointment condition compared to the pride condition (Oosterwijk et al., 2007). The experience of pride is generally accompanied with a straightened body posture, whereas disappointment usually results in a slumping position and the conceptual understanding of these terms reflected in participants' posture. Further evidence for the effect of cognition on bodily states based on embodiment of emotion comes from a study where participants had to pull or push a lever while seeing positive and negative stimuli and were found to push faster for negative valenced stimuli than they pulled and vice versa for positive valance stimuli (Chen & Bargh, 1999). The results can be explained by an evaluation of a stimulus as positive or negative that is embodied in the bodily behavior by facilitating approach for positive stimuli and avoidance for negative stimuli. Similar results were obtained from a study where participants were faster at pulling a slider when the content of a read sentence was positive compared to negative in content and pushed faster for negative compared to positive content (Filik et al., 2015). The literature demonstrates that conceptual knowledge on emotion-related stimuli reflects in bodily actions and facilitates corresponding actions.

Interestingly, embodiment of emotions goes beyond the own body and can even reflect in our language and the physical space surrounding us. For example, when describing emotional states, an individual that is currently in a sad mood might describe themselves as “feeling down” and an individual in good spirits might “feel elevated.” The arousal level and valence associated with both of these affective states (low/negative and high/positive, respectively) reflect in the language used to communicate about these affective states. A study asking participants to place negative, neutral, and positive valenced terms within a three-dimensional space found their valence to reflect the placement (Marmolejo-Ramos et al., 2018). Words associated with positive valence were placed high up and close to the participants, words of negative valence were placed low and farther away from participants, and neutral words in between. The evaluation of a term as positive vs negative thus affected the vicinity of proximity. It seems that embodiment of emotion does not only entail our own bodies but also the physical space surrounding our bodies.

Neuroscientific methods can also be used to demonstrate the effect embodiment of emotion has on our cognitions, behavior, and body itself. Price et al. (2012) conducted a study displaying positive and neutral images to participants while electroencephalography was recorded, and the position of participants was manipulated to reclining or leaning. Results showed that the late positive potentials were larger when participants were leaning toward positive images, but no effect of body posture was found during the viewing of neutral images. This study demonstrates that even in the absence of a cognitive task, embodiment of emotion takes effect as specific body postures modulated brain activity. Such findings suggest that embodiment of emotion might be the result of primal reactions like approach and avoidance of emotional stimuli taking effect also in higher order processing of emotional stimuli. To conclude this section, embodiment of emotion can be investigated on a behavioral, peripheral–physiological, and neural level, individually or in combination as has been shown in the various parts of this chapter.

Conclusion

Embodiment is a subject that has broadened the scientific discussion about the biological system, self-regulation, and neural processes. As shown in this chapter, perceptive illusions have been demonstrated as an important tool to manipulate the corporation of the body itself and the overlap with the body of the other. Interestingly, the embodiment of the other has helped to understand social processes such as empathy, racial bias, change of the negative valence for the judgment of the other, social perception, among other aspects. The studies have shown us the malleability and the rapid adaptability to the judgment of the implicit social attitude when we experience the body of the other despite the existing cultural differences. The advancement of research of social embodiment has allowed us to better understand categorization, prejudice, and discrimination from the embodiment of the other and its neural and physiological correlates. Moreover, neuroscientific methods help us demonstrate the similarity in neural patterns during emotional experience and during the simulation of an emotional experience, and can thus provide evidence for the embodiment of emotion. This neuroscientific evidence is in addition to the vast evidence from behavioral studies on embodiment of emotion, such as embodied emotion expressed through body posture, facial expression, language, and cognitive processes (e.g., stimulus evaluations).

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