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Embodiment of emotion and its situated nature

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Introduction

Embodiment theories have now become a major conceptual framework for understanding the mind. The main idea behind these theories is that higher-level processing is at least partly based in one's perceptual, motor, and somatosensory systems — leading such frameworks to often be called *grounded cognition theories* (Barsalou, 2008; Wilson, 2002). The origin of modern embodiment theories can be traced back to classic research on mental imagery (which showed the involvement of perceptual systems in conceptual operations; Kosslyn, 1994), cognitive linguistics (which highlighted the metaphorical grounding of many concepts; Gibbs, 2003; Lakoff, 1993), and work on motor affordances (which demonstrated tight links between perception and action; Tucker & Ellis, 1998). However, one could argue that the recent exponential growth in embodiment research comes from its extension to social and emotional life (see Figure 1 in Mahon, 2015). As such, embodiment theories have been applied to understanding the processing of facial expressions, emotional words and concepts, emotion regulation, social relations, and even moral concepts (Barrett, Wilson-Mendenhall, & Barsalou, 2015; Meier, Schnall, Schwarz, & Bargh, 2012; Niedenthal, Barsalou, Winkielman, Krauth-Gruber, & Ric, 2005; Schubert & Semin, 2009). In this chapter, we describe recent evidence for this account — particularly in the domain of emotion processing across social contexts. We also discuss potential limits of the framework and challenges for future research.

To do this, we start our chapter by briefly contrasting embodiment theories with other more "traditional" frameworks that emphasize an amodal and propositional nature of mental representations. We then review evidence for embodiment's role in emotional processing — focusing on responses to facial expressions and emotional language. Next, we move on to describing embodiment in an interpersonal domain with action *mirroring* — or the replication of others' actions, behaviors, gestures, and expressions. Throughout the chapter, we argue that in order to reach a comprehensive account of embodiment, one must consider its situated, flexible, and dynamic nature

— especially within the social environment. We conclude that while embodiment theories likely cannot satisfactorily account for all aspects of cognition and emotion, they have led to fundamental empirical discoveries and theoretical developments. As such, embodiment theories offer substantive contributions to illuminating how the mind works.

"Traditional" frameworks: Amodal processing

The human conceptual system performs a vast array of cognitive operations — from simple stimulus recognition to complex decision-making. Major models of the conceptual system within cognitive psychology have traditionally been focused on associative networks (e.g., Anderson, 1983; Collins & Loftus, 1975). For instance, imagine that you perceive an individual in your social network (such as a friend or family member). On this amodal view, inputs are initially encoded in the brain's modal systems, such as the visual and auditory regions (which are likely linked to affective systems). This information is then extracted into an abstract, language-like symbol (a *proposition*) and stored as a *node*. Within an associative network, in this example, the node might be something like the word "BROTHER". This symbol or node is stored with connections to other representative features like "SMART", "FUN", and "STRONG." Critically, these features were initially encoded in the brain's modal systems, but they now represent abstract conceptual nodes. Consequently, when thinking about one's brother at a later time, information is extracted in a language-like form (i.e., a concept label with associated features), which is then used for inference and responding.

Thus, nodes generally represent units of information in associative network models. These nodes are further interconnected by *associative links* (although this term can be slightly misleading, since links can have different structures, such as having certain properties, inheriting certain features, etc.). When a node is activated, linked nodes are also activated as a function of the associative strength between them, via *spreading activation* (i.e., the greater the interconnectedness among the nodes, the greater the probability that it will be activated by its neighbors). As a result, ideas that are already stored in memory impact online processing in accordance with their activation level — and overall, the full set of nodes in the associate network constitutes a person's conceptual system. In theory, this conceptual system then serves as the basis for processes such as inference, categorization, and other higher-order cognitive operations.

Importantly though, note that amodal and associative network theories require endorsing two key assumptions. First, on this view, advanced mental operations are basically symbol manipulations, which are defined by their functional roles. As such, they are not essentially constrained by the specific physical states and structure of the body and brain. That is, amodal theories subscribe to the principles of *functionalism*, which views the mind as a software that operates on the brain's hardware, but could principally be ported to any other hardware that can realize the same functional roles (Block, 1995). Second, amodal views assume that advanced cognition consists of operations on abstract symbols — "thoughts" that operate as amodal, propositional states, which are fully detached from the original analogue form encoded in the perceptual system (e.g., vision or audition; Fodor, 1975; Newell & Simon, 1972; Pylyshyn, 1984). Surely, these symbols can be still be associatively connected to different perceptual and motor modalities, but these embodied components do not causally contribute to any "pure" cognitive activities such as categorization, comprehension, or inference (Mahon, 2015). As we explain next, research in psychology, cognitive science, and neuroscience casts doubt on both assumptions (Barsalou, 2008).

Embodiment theories

On the most general level, embodied cognition theories propose that information processing is shaped by the brain, body, and its interactions with the external physical world (Barsalou, 1999, 2008; Clark, 1999; Wilson, 2002). This claim by itself may be relatively uncontroversial, but specific branches of embodiment theories go much farther, in different directions (see Wilson, 2002 for a broad overview of different meanings for embodiment). Thus, some embodied theories focus on a much stronger claim that the body (or even the world, according to "extended cognition" theses) is literally a part of the physical realization of cognition. On this view, cognition is seen as emerging from the interactions of the brain with the body and the world (Clark, 1997). Emotion can viewed similarly — a thesis that is elaborated and extended by Colombetti (2014, this book).

In contrast, our perspective is more modest and informed by Barsalou's perceptual symbol system view (Barsalou, 1999). On this view, the generation of a thought involves partial reproduction or *simulation* of experiential and motor states that occur when the perceiver has actually encountered the object. For example, imagine you are trying to describe one of your favorite colleagues to a friend — you might recall and/or actively generate traces of direct perceptual experiences with that colleague (e.g., mimicking his or her movements and expressions, reconstructing the sound of his or her voice, etc.). In other words, embodied conceptual processing involves partial reactivations of the sensory-motor systems that are used during real-world interactions with the stimulus in-question. Note here that the "simulation" assumption is not shared by some of the more radical, anti-representational views on embodiment within philosophy (but going into this debate is not essential for the current chapter).

Crucially for the current chapter, an embodiment perspective applies particularly well to thinking about emotion (Niedenthal, 2007; Niedenthal & Barsalou, 2009; Niedenthal, Barsalou, Winkielman, Krauth-Gruber, & Ric, 2005; Winkielman, Niedenthal, & Oberman, 2008). William James (1890) observed that "every representation of a movement awakens in some degree the actual movement which is its object" (p. 526). Similarly, when our thoughts focus on some joyful personal moment, we also partially reproduce the joyful feeling. Embodiment theories hold that such reenactments are far from incidental by-products of recalling past states — instead, they can be crucial to social reasoning, processing emotional concepts, interpreting language, and relating to others' emotional states. These reenactments also do not have to be conscious, full-blown physical episodes, but could involve only a sufficient level of re-instantiation for the original experience, such that it is useful for social and conceptual processing. As we discuss later, embodied reactions do not only result from associative connections between percepts, concepts, and somatic states, but they can also be selectively produced when it is necessary to represent the conceptual content during information processing.

Emotional embodiment

William James was one of the main predecessors of modern embodiment theories, and his canonical example of coming upon a bear in the woods is an apt starting point for this discussion. James (1896) roughly said the following — you see such a bear, and as a result, your autonomic nervous system is automatically activated (e.g., elevated heart rate and blood pressure, increased sweating, etc.). Upon noticing this altered bodily state, you recognize that you are afraid — simply put, we do not tremble because we are afraid; we are afraid because we tremble. More generally across emotional states, James proposed that an external exciting stimulus leads to a physiological reaction, with the interpretation of said reaction leading to a given emotion.

Obviously, modern emotion theories deem the emotional cascade of events as a much more complex, iterative process — with somatosensory and motor resources recruited at multiple times in the emotion perception, understanding, experience, and production process (Barrett & Bliss-Moreau, 2009; Cunningham, Dunfield, & Stillman, 2013; Scherer, 2009; Wood, Rychlowska, Korb, & Niedenthal, 2016). Further, most modern theories do not take actual changes in bodily states to be necessary to experience an emotion, instead focusing on brain representation of somatosensory and motor processes. For instance, the *somatic marker hypothesis* argues that the brain transforms physiological events into representations of the bodily state to constitute an emotional feeling — and together with past outcomes, these emotional feelings can guide decision-making strategy (Damasio, 1999). Nevertheless, the basic Jamesian point remains, in that mental representations of the bodily state are integral parts of emotional processing and experience. This core insight has been supported by several lines of research, including the role of embodiment in processing of facial expressions, somatic involvement in valence processing (e.g., approach-avoidance effects), affective processing as a modality, and comprehension of emotional language.

Processing of facial expressions

Perhaps the most investigated contribution of emotional embodiment is with the processing of facial expressions (for a recent review, see Wood, Rychlowska, Korb, & Niedenthal, 2016). Note that on many traditional models, expression recognition is basically a matter of detecting features and the configurations that are probabilistically associated with an expression (Haxby, Hoffman, & Gobbini, 2000). For example, detecting a smile relies on the decoding of features such as curves at the corners of the mouth, lines in the corners of the eyes, and relative changes in mouth and eye positions (among others). In other words, recognition of a smile is very much like the recognition of any other stimuli, and thus can be potentially implemented in completely disembodied systems (Dailey, Cottrell, & Adolphs, 2000). However, on the embodied perspective, recognition of a smile involves motor reproduction of the smile and a partial simulation of the presumed state of happiness (Goldman & Sripada, 2005). This can bootstrap recognition and, via facial feedback, provide verification of a match between one's own state and the mood of the person we are imitating (Niedenthal, Mermillod, Maringer, & Hess, 2010).

There is quite a bit of evidence for correlational links between the perception of facial expressions and activation of spontaneous facial motor movements (e.g., Dimberg, 1990), along with greater activity in somatosensory areas of brain (e.g., Carr, Iacoboni, Dubeau, Mazziotta, & Lenzi, 2003). One classic interpretive objection, however, is that such findings do not reflect "simulations" (i.e., attempts to build a reenactment of the social stimulus) — but instead, they are just simple associative reactions. These imitative reactions, while reliably produced, are essentially by-products of the frequent association between smile perception and smile action (when we see smiles, we usually smile back).

Fortunately though, there is some evidence suggesting a causal role of embodied resources in emotion recognition. As an example, temporarily preventing participants from engaging expression-relevant facial muscles impairs their ability to detect briefly presented or relatively ambiguous facial expressions that involve that muscle (Niedenthal, Brauer, Halberstadt, & Innes-Ker, 2001; Oberman, Winkielman, & Ramachandran, 2007; Ponari, Conson, D'Amico, Grossi, & Trojano, 2012). Lesion studies have also revealed emotion recognition impairments to occur after damage to somatosensory and motor feedback mechanisms (Adolphs, Damasio, Tranel, Cooper, & Damasio, 2000; Pistoia et al., 2010). Further, temporary inactivation of the brain's face representation areas with repetitive transcranial magnetic stimulation (rTMS) tends to impair emotion recognition (Pitcher, Garrido, Walsh, & Duchaine, 2008).

Of course, this does not mean that embodiment is *always* involved in the processing of facial expressions, nor is it always causally necessary. For instance, patients with facial paralysis (also called *Moebius syndrome*, primarily from the underdevelopment of cranial nerves VI and VII) can recognize facial expressions using non-embodied routes (Bogart & Matsumoto, 2010). In another example, a recent study found that inhibiting the right primary motor (M1) and somatosensory (S1) cortices with TMS reduced spontaneous facial mimicry and delayed the perception of changes in facial expressions (Korb et al., 2015). However, note that these effects only occurred only for female participants and TMS had no influence on males — perhaps reflecting greater reliance by females on the embodied simulation strategy, in order to enhance emotion understanding. These findings highlight our message of contextual flexibility of embodied simulation and its dependence on the resource availability and situational goals.

Somatic involvement in valence processing: Approach-avoidance effects

Another well-investigated connection between embodiment and emotion is the link between valence perception and specific action tendencies. One classic illustration comes from Darwin (1872), when he visited a snake exhibit in a London zoo. He writes the following: "I put my face close to the thick glass-plate in front of a puff-adder in the Zoological Gardens, with the firm determination of not starting back if the snake struck at me; but, as soon as the blow was struck, my resolution went for nothing, and I jumped a yard or two backwards with astonishing rapidity" (p. 40).

Since then, psychological research has found plenty of evidence for emotion-action links using a variety of stimuli. This has led many modern emotion theories to posit that affective and motivational processes are organized along an *approach-avoidance* dimension, which are linked to specific action-tendencies (Harmon-Jones, Harmon-Jones, & Price, 2013). Thus, individuals are generally faster to pull a lever toward the body for positive stimuli and/or push a lever away from the body for negative stimuli (Chen & Bargh, 1999; Krieglmeyer, Deutsch, De Houwer, & De Raedt, 2010). These experiments were motivated by the observation that we use the motor action of pushing to stimuli that we do not like (either as a practical action or as a communicative gesture), but we pull objects that we do like towards us (or indicate our liking of objects to others via some type of pulling gesture). Considering the notion that specific motor actions are tied to abstract valence representations, it follows that reactions to the task would be facilitated when the valence of the physical action is congruent with that of the concept being evaluated. Indeed, several studies have shown that positive stimuli (e.g., words, picture, and faces) trigger faster approach reactions, whereas negative stimuli trigger faster avoidance reactions.

Note, however, that the automaticity of approach-avoidance effects is still debated. The initial claims were that affective stimuli spontaneously and rapidly trigger adaptive actions, without much involvement of conceptual processes (Chen & Bargh, 1999). In contrast, many of these effects require focusing participants on the evaluative nature of the task. For example, happy faces trigger approach movements but only when they are evaluated on emotion, not gender (Rotteveel & Phaf, 2004; Krieglmeyer, Deutsch, De Houwer, & De Raedt, 2010). Further, notice that the specific nature of the link between valence and action appears to be at least partially shaped by conceptual processes. For instance, originally, these approach-avoidance tendencies have been reported to follow body-centered direction (i.e., movements toward vs. away the subject's own body; Chen & Bargh, 1999) and specific muscle activation (i.e., bicep flexion vs. tricep extension; Cacioppo, Priester, & Berntson, 1993). However, later experiments found such effects with participants' movements that brought the object closer or farther to the "self," even when the self is a mere symbolic representation on the screen by participants' names (i.e., Markman & Brendl, 2005; but also see Van Dantzig, Zeelenberg, & Pecher, 2009). In short, along with other research presented in our chapter, this argues that while some embodied connections are relatively simple (and perhaps associative), others interact with sophisticated conceptual processes.

In this context, one intriguing line of research shows that rapid approach-avoidance actions are shaped by the ease of information processing. This is interesting because it suggests that rapid embodied responses can result from the mere dynamics of mental operations. Specifically, extensive research has shown that *fluency* (or fast and easy processing) augments positive affective responses (Winkielman & Cacioppo, 2001), evaluative judgments like attractiveness and trust (Schwarz, 1998; Winkielman, Schwarz, Fazendeiro, & Reber, 2003; Winkielman, Olszanowski, & Gola, 2015), and real-world decisions like brand assessments and stock purchases (Alter & Oppenheimer, 2006; Lee & Labroo, 2004). These effects can occur with manipulations that target the ease of semantic understanding and categorization, such as making a stimulus more difficult to assign into categories (e.g., Owen, Halberstadt, Carr, & Winkielman, 2016). They can also arise even with manipulations that are purely perceptual (e.g., increased stimulus repetition, priming, clarity, contrast, and/or duration). According to the *hedonic fluency model*, fluency impacts ratings and behavior because easy processing elicits mild positive affect, which is then (mis)attributed to the target stimulus (Winkielman, Schwarz, Fazendeiro, & Reber, 2003).

Given these fluency findings, Carr, Rotteveel, & Winkielman (2016) tested whether increasing the perceptual fluency of neutral pseudowords (i.e., pronounceable strings of letters with no actual meaning) would facilitate rapid approach movements. Participants were instructed to use their "gut" to evaluate different pseudowords on whether they were "good or bad" (i.e., affective judgment; Experiments 1 and 3) or "living or non-living" (i.e., non-affective judgment; Experiments 2 and 4). Participants made these decisions using a vertical button-stand, which mapped responses onto approach (i.e., bicep contraction with arm flexion to hit the top button) and avoidance (i.e., tricep contraction with arm extension to hit the bottom button). The findings showed that fluent (easy to read) pseudowords led to faster approach movements, consistent with the idea that fluency can infuse initially neutral stimuli with a positive valence. Interestingly, this fluency-action effect occurred only in the affective judgment context (i.e., experiments that involved "good or bad" judgments; not "living or non-living" judgments). This is intriguing when considering the EMG findings, which measured physiological muscle responses for smiling (*zygomaticus major*) and frowning (*corrugator supercilii*). Carr, Rotteveel, & Winkielman (2016) observed increased smiling EMG and reduced frowning EMG to fluent pseudowords across both contexts (i.e., affective "good or bad" and non-affective "living or non-living"). These findings are important for two main reasons. First, they suggest that perceptual fluency can imbue neutral stimuli with enough positivity to make them elicit embodied action responses that are similar to intrinsically valenced stimuli (e.g., emotional words or facial expressions). Second, these findings also illustrate the flexible nature of these effects, where fluent stimuli increased smiling and reduced frowning across both contexts — but only led to approach actions in affective contexts. Therefore, fluency instantiates a low-level hedonic response across multiple domains, but this affective response is only selectively translated to action-tendency based on the relevance to the task at-hand (i.e., ones that require emotionally based judgments). While these findings should certainly be extended, they raise the interesting possibility that embodied approach-avoidance responses go beyond highly valenced, intrinsically affective stimuli.

It is worth noting here that the context-dependency of approach-avoidance effects has also been observed in other experiments. In terms of task context, one recent review argues that approach-avoidance effects on action are only robustly observed when such action is embedded in affective classification tasks (even to strongly valenced stimuli; see Phaf, Mohr, Rotteveel, & Wicherts, 2014, for a meta-analysis). For instance, positively valenced faces facilitate approach action when participants classify such emotional faces into affective categories, such as "positive" or "negative," but not into non-affective categories, such as "male" or "female" (Rotteveel et al., 2015; Rotteveel & Phaf, 2004). Moreover, the internal emotional context also matters. For example, in an investigation of approach- and avoidance-related physical responses to face images, Van Peer et al. (2007) found faster responses to press a button using arm flexion (i.e., approach movement) when viewing happy faces (compared to angry faces), while the opposite was true when the button press required arm extension. Critically, this motor effect of viewing angry faces was heightened by the administration of cortisol versus placebo in highly anxious participants, providing additional evidence that the effect is linked to emotional context. Thus, physical movements are not contextindependent — they are enhanced or impeded by specific task and affective environments.

Recently, Harmon-Jones (Harmon-Jones, Gable, & Price, 2011; Harmon-Jones & Peterson, 2009) and Price (Price, Peterson, & Harmon-Jones, 2011) have applied this approach-avoidance framework to explore other emotional embodiment effects. Here, emotions associated with approach include anger and joy, in contrast to avoidant emotions, such as fear, anxiety, and disgust. Neurophysiological measures like asymmetries in frontal cortical electroencephalographic (EEG) activation can dissociate these motivational tendencies — with left-sided activation indicating approach, and right-sided activation indicating avoidance.

Aside from hand movements, body postures involved in approach and avoidance are also linked to affect. Harmon-Jones & Peterson (2009) showed that in the upright posture, hearing a negative, anger-inducing peer evaluation increased participants' left cortical EEG activity (associated with approach). However, no such response was observed in the reclining position. Furthermore, Price, Dieckman, & Harmon-Jones (2012) found that forward-leaning body postures lead to diminished startle magnitude and larger LPP responses to those pictures — but only when the pictures were appetitive, creating a context of potential reward. In contrast, this effect was completely absent when neutral pictures (with no appetitive value) were displayed.

In short, these approach-avoidance effects demonstrate somatic involvement in processing of emotional stimuli. That is, they demonstrate that people's bodies are adaptively engaged when processing emotional stimuli and that manipulating body engagement changes the response to incoming emotional information. At the same time, they highlight that the specific task and motivational contexts flexibly and dynamically shape the nature of these effects. As discussed below, similar conclusions follow from other lines of research on emotion concepts.

Affect as a type of modality

One of the classic lines of evidence for the grounded cognition approach comes from studies which ask participants to verify properties for concepts (i.e., judge whether an object or a concept does or does not have certain attributes). Importantly, when two subsequent concepts imply different modalities, this produces switching costs (Pecher, Zeelenberg, & Barsalou, 2003). Thus, verifying a property that involves the auditory modality (e.g., BLENDER-loud) was slower after verifying a property that involves a gustatory modality (e.g., CRANBERRIES-tart) than after verifying a different property in the same auditory modality (e.g., LEAVES-rustling). Experiments using the switching paradigm also suggest that affect can be considered as a modality unto itself (Vermeulen, Niedenthal, & Luminet, 2007). In those experiments, participants had to verify auditory (e.g., KEYS-jingling) and visual (e.g., TREASURE-bright) features of nouns that were either neutral or had strong affective value (either positive or negative). Each target pair was preceded by a priming pair (e.g., TRIUMPH-exhilarating followed by COUPLE-happy). The structure of these pairs was experimentally manipulated so that subjects had to consecutively verify properties either of the same or different modalities (i.e., visual, gustatory, auditory, affective) with either similar or different valences (i.e., positive or negative). For example, a same-modality same-valence pair might be [TANK–khaki: WOUND–open]; a different-modality same-valence pair might be [TANK–khaki: SOB–moaning]; and a different-modality different-valence pair could be [TANK-khaki: VICTORY-sung]. Another example includes [BABY–babbling], where the same-modality same-valence pair would be [LAUGHTER–heard] and different-modality same-valence pair would be [ROSE–red].

The findings showed that verifying features of concepts from different modalities produced costs of longer reaction times and higher error rates than concepts from the same modality. Critically, this included switching between affective and other modalities. There were also costs of crossing processing modality, while keeping valence constant. These results are difficult to account for with amodal models of concept representation, which view affect as just another node in the semantic network.

Situated simulation in the embodiment of emotional language

Much of the research in the embodiment literature focuses on what specific features people simulate (and when). This focus reflects the growing appreciation that people do not simulate all properties but only those that are required by the current situation (hence, *situated* simulation). One of the earliest demonstrations comes from cognitive work (Wu & Barsalou, 2009) showing that different perceptual features are simulated when participants are asked to list properties of different objects, like watermelon vs. half watermelon (e.g., green and striped vs. red with seeds). Presumably, the concept of "half watermelon" invites a different simulation (i.e., one dealing with internal properties, like red with seeds) than just "watermelon" (i.e., one dealing with external properties, like green with stripes).

More recent experiments explored situated simulation processes in understanding abstract mental states. Note that these mental states can be affective (e.g., anger or happiness) or cognitive (e.g., thinking or remembering). Here, the idea is that the understanding of abstract concepts referring to mental states can vary, depending on what perceptual perspective is activated. Many mental states have a clear *internal* or *experiential* component — people "feel" a certain way when they are in these states (e.g., anger feels hot, memory retrieval feels effortful, etc.). These internal experiences may be simulated when people understand conceptual references to mental states. On the other hand, mental states can also be described from an *external* or *action* perspective — where simulation of visible outside features may be more relevant for understanding (e.g., anger makes the face red, memory retrieval involves head-scratching, etc.). In one study using a switching costs paradigm, participants saw semantically unrelated sentences describing emotional and non-emotional mental states, while manipulating their "internal" or "external" focus (Oosterwijk et al., 2012). To give a specific example, the concept of disgust could be presented in an internal sentence like "she was sick with disgust" or an external sentence like "her nose wrinkled with disgust." Results showed that switching costs (slower RTs) also occurred when participants shift between emotional sentences with an internal and external focus. Moreover, a follow-up study showed that reading sentences about emotional states which imply an internal versus external perspective activates different brain areas related to different aspects of the emotion process (Oosterwijk et al., 2015). Specifically, emotion sentences written from the external perspective activate a brain region related to action representation (i.e., the inferior frontal gyrus), whereas sentences about the same emotion written from the internal perspective activate a brain region associated with the generation of experiential states (i.e., the ventromedial prefrontal cortex). These findings further emphasize that different forms of simulation contribute to understanding mental states from different points of view. This conclusion is important, as it shows that even abstract emotion concepts are grounded in modalities, but this grounding is flexible (and the specific properties that are revealed depends on the requirement(s) of a specific "perspective").

Causal role of embodied processes in emotional language. Critically, there is also causal evidence for the role of embodiment in how people process emotional words and concepts (using their own facial muscles). In one study, authors first used subcutaneous injections of Botox to temporarily paralyze the facial muscle used in frowning, after which they had participants read emotional sentences (Havas et al., 2010). The results showed that participants were slower to understand emotional sentences that involved the use of the paralyzed muscle. Davis, Winkielman, & Coulson (2015) also demonstrated that facial blocking impedes comprehension of emotional words (e.g., via the N400 EEG ERP component that indexes processing of semantic meaning).

Another important example comes from Niedenthal, Winkielman, Mondillon, & Vermeulen (2009), who had participants view emotional words (e.g., concrete nouns, such as SUN or SLUG, or abstract words, such as FOUL and JOYFUL). Some participants were simply asked whether the words were capitalized or not (a shallow perceptual task), while others were asked whether the words were associated with an emotion (a deeper conceptual task). Crucially, during this task, the activation of participants' facial muscles was measured with EMG. Consistent with the idea of strategic and context-dependent modal processing, the results showed that facial muscles were subtly activated in emotion-specific patterns when participants were evaluating the meaning of the words — but not when they made judgments of letter case. These results clearly argue against a "simple emotional reaction account," where measured emotions are just reflexive reactions to reading the word. Furthermore, Niedenthal, Winkielman, Mondillon, & Vermeulen, (2009) conducted another experiment explicitly designed to manipulate the strategic need for emotion simulation. Participants generated features of emotional concepts (e.g., FRUSTRATION) by thinking of and listing associated properties, while facial EMG was recorded. Crucially though, depending on condition, participants were informed that the features were being produced either for an audience that was interested in emotional "hot" features of the concepts (like a good friend with whom they have a close relationship and can share anything) or for an audience interested in more factual "cold" features of the emotion concepts (like a supervisor with whom they have a formal relationship). Interestingly, participants were able to produce normatively appropriate emotion features in both the "hot" and "cold" conditions. However, the physiological results showed that there was greater activation of the expected sets of facial muscles when participants were asked for features of emotion words in the "hot" condition, compared to the "cold" audience condition. This demonstrates that embodied simulations are recruited in concept understanding, but only if they are relevant for solving the task (Wu & Barsalou, 2009). Again, this is important because it argues against the idea that embodiment reactions are passive by-products of conceptual processing (i.e., sensory-motor reflexes that are just there "for the ride"). Note that these studies also somewhat qualify "strong" embodiment claims, which suggest that embodied reactions are *necessary* to understand such concepts. Given that participants in the "cold" condition were still able to successfully generate emotion features, this suggests that embodied responses may serve as one input that informs understanding (but there are likely alternative routes to understanding that do not require embodiment).

Finally, it is worth discussing recent evidence suggesting that the representation of emotional concepts is affected by externally induced changes in physiological arousal (Kever et al., 2015). Concretely, participants saw emotion words in the classic attentional blink (AB) paradigm, requiring detection of a target word in a stream of distractors (Raymond, Shapiro, & Arnell, 1992). Participants completed the AB task once after a short physical exercise session (increased arousal) and once after a relaxation session (decreased arousal). During the AB task, two target words (T1 and T2) were presented in close succession in a rapid serial visual presentation (RSVP) of distractor items. The AB effect refers to the reduced ability to report the second of two targets (T2) if it appears 200 to 500 milliseconds after the first to-be-detected target (T1). In the present study, T1 was always a neutral word, whereas T2 was either a high arousal word (e.g., *terror*, *orgasm*) or low arousal word (i.e., *distress*, *flower*). The results revealed that increased physiological arousal led to improved reports of high arousal T2 words, while reduced physiological arousal led to improved reports of low arousal T2 words. Neutral T2 words remained unaffected by the arousal conditions. These findings emphasize that experiencing a level of physiological arousal that matches the emotional arousal value of a concept promotes the awareness of the concept (e.g., being highly aroused while processing a highly arousing word such as "orgasm" or "terror"). In other words, congruence between an individual's level of bodily arousal and the emotional arousal of a to-be processed stimulus influences the way attention is allocated (and consequently, its access to awareness). One could even go further in this interpretation by suggesting that the arousal dimension of emotional concepts is (at least partially) grounded in our bodily systems of arousal.

Emotional language and memory for faces. If the perception of facial expressions and perception of emotion words both involve embodiment, one may expect interactive links between these processes. Specifically, motor-conceptual interactions might serve to support (as well as distort) memories of other people's facial expressions. This was investigated by Halberstadt, Winkielman, Niedenthal, and Dalle (2009), where participants were first asked to look at faces of several ambiguous facial expressions for different individuals and think about why each of these individuals might possibly feel "happy" or "angry" (concept label was randomly paired with the face). Later, participants were asked to recall what exact expression was presented for each individual. The data showed that participants' memory for the expressions was biased in the direction of the earlier language concept (e.g., remembering a face as happier when it was earlier associated with a happy label). Critically, this memory distortion was related to the degree to which the conceptual label assigned to the expression (i.e., happy vs. angry) elicited a corresponding facial EMG response during the initial perception of the face. Presumably, this concept-driven motor representation got tied with the actual perceptual representation of the face and later served as a retrieval cue.

Emotional language and metaphor. One of the most fascinating questions about the embodiment of emotion is its relation to higher-order conceptual processes. This classic question, discussed since William James, is receiving new urgency in light of data showing the strong influence of conceptualization and categorization on basic processes of emotional recognition and experience (Barrett et al., 2015). Clearly, conceptual processes are informed by and grounded in bodily states. At the same time, conceptual processes shape how exactly the body is being used. One source and result of that linkage are linguistic and conceptual *metaphors*, which are presumably grounded in embodied processes but also invite us to think about emotions in embodied terms (Lakoff, 1993). We will briefly review some of the key studies on embodied metaphor and emotion. Importantly, note that some studies make a direct claim about the role of somatosensory processes and embodied simulation, whereas others explore the body-emotion link in more linguistic realm without committing to any role for somatosensory involvement (for a discussion of relations between linguistic and simulationist views, see Casasanto & Gijssels, 2015; Landau, Meier, & Keefer, 2010).

Consider a restaurant where you feel most at home — it may have a "warm" waiter who talks to you in a familiar way. In contrast, the places you least like to go (e.g., government offices) may be described as feeling "cold." Similarly, an old friend can be described as being "close" to us, or perhaps we have gone different directions and have actually gotten quite "distant" from one another. Several lines of research suggest that thinking about emotion is metaphorically tied to physical distance and temperature. One set of studies suggests that manipulations of physical distance can increase feelings of emotional distance (Williams & Bargh, 2008a; but also see Pashler, Coburn, & Harris, 2012). In these studies, subjects completed a priming manipulation where they were asked to plot two points in two-dimensional space — with some subjects plotting points that were very close together, and others plotting points that were quite far apart. Subsequently, subjects who plotted the far (as opposed to close) points perceived themselves as having weaker emotional attachment to their hometowns and family members, and were less affected by a story relating a distressing experience (presumably because they felt more distant from the situations presented). In this context, it is interesting that one way in which psychological distance (Trope & Lieberman,

2010) can decrease emotional responses is by reducing reliance on embodied responses (Maglio & Trope, 2012).

Another set of experiments used a similar logic and primed participants with physical sensations that bear on the embodied metaphor for warmth (Williams & Bargh, 2008b). These studies showed that participants find an interaction partner as a "warmer" person when they were holding a warm cup of coffee in an unrelated task (rather than a cold one). Zhong & Leonardelli (2008) also asked some subjects to recall an experience of social rejection, while others had to recall an experience of social inclusion. Afterwards, both groups were asked to estimate room temperatures, and interestingly, participants that recalled exclusion guessed significantly lower temperatures than those who recalled inclusion. Their second experiment involved the "cyberball" manipulation, where subjects played an online game. This game was supposedly multi-player, but in reality, all participants were playing with a computer program that either included or excluded them in a game of virtual catch. After this game, participants were given a marketing survey, where they had to rate the desirability of various food and drink items, some warm and some cold (e.g., cold cola vs. hot coffee, cold apples vs. hot soup, etc.). Excluded participants (i.e., those that were tossed the virtual "cyberball" just 2 times out of 30) rated hot items as more desirable than included participants (i.e., tossed the "cyberball" an equal number of times as all other players). Finally, a recent provocative result suggests that psychological coldness (i.e., social rejection) may even literally reduce skin temperatures (IJzerman et al. 2012).

Other research suggests that bottom-up embodied cues influence which conceptual metaphor guides emotion understanding. Note that multiple metaphors are usually available for understanding an emotional state. One classic example for this is "love," which could be understood as a journey, a flower, a game, or a unity (Lakoff, 1993). These framings are consequential for emotional reactions, as shown by a study where participants were more distressed by relationship conflicts when they had a "unity" rather than "journey" frame in mind (Lee & Schwarz, 2014). But when and why are specific metaphors preferred? And how do they guide our understanding of emotional material? These questions were addressed in an exploratory study by Tseng, Hu, Han, & Bergen (2007), where the researchers noticed that similar emotional words (e.g., happiness and joy) are differently associated with metaphorical frames. Thus, the expression "searching for happiness" is more common than "searching for joy," whereas the expression "full of joy" occurs more often than "full of happiness." In turn, subtly activating different metaphors through embodied cues should influence which emotional term ("joy" or "happiness") is applied to ambiguous emotional material. To test this, the experimenters approached participants as they were either searching for something (like a book in a library) or drinking something from a container. Participants were then shown a photo of a person with a very positive facial expression and asked whether it is better described as "happiness" or "joy." As expected, participants who were drinking (and presumably activated the "container" metaphor) were more likely to describe the picture as showing "joy," whereas people who were searching were more likely to describe the expression as showing "happiness."

The just-discussed work also fits well with studies on embodied metaphors of morality. These studies show that the physical act of washing seems to remove the negative feeling associated with a moral transgression. In an experiment by Zhong & Liljenquist (2006), participants were asked to write about a past moral transgression and then either cleaned their hands with wipes or did not. Next, they filled out an emotional state questionnaire and were later approached (without forewarning) about participating in another study for a desperate graduate student. In previous studies, the reliving of moral transgressions had been shown to increase propensity to engage in good deeds — this held in the current study, but only for participants who had not cleaned themselves. Participants who had already cleaned their hands were less likely to help the graduate student, and they also reported lower scores on measures of moral emotions (e.g., disgust, regret, guilt, shame, embarrassment, and anger) but not for amoral emotions (e.g., confidence, calm, excitement, and distress). In the same vein, Lee & Schwarz (2010) showed that the need for cleansing induced my immoral action was specific to the body part used for the dirty deed. Participants asked to type a lie showed a greater preference for hand wipes, whereas participants who spoke a lie preferred mouthwash. It is important to note that the connection between physical cleanliness and morality is not completely straightforward or consistent, with some studies reporting that cleanliness reduces the severity of moral judgments (Schnall, Benton, & Harvey, 2008), other studies reporting that cleanliness enhances moral harshness (Zhong, Strejcek, & Sivanathan, 2010), and yet other studies failing to obtain such effects altogether (Johnson, Cheung, & Donnellan, 2014). Clearly, whether and how specifically a bodily feeling translates into an abstract moral decision must depend on a variety of interpretational factors (e.g., Who is "clean" here? Me or someone else? Is the feeling induced by the target of judgment? Is this a moral problem for which a feeling is relevant?).

Summary. The social environment is complex, flexible, and dynamic. As a result, we have to efficiently construct context-appropriate affective responses. The lines of research summarized above (as well as others not mentioned here) provide increasing evidence that situated and embodied aspects of emotion processing contribute to generating such adaptive responses.

Mirroring as embodied cognition

As mentioned, one prominent idea guiding embodiment research is that perceivers often replicate others' states using their own motor and somatosensory resources. Neurally, researchers often assign this function to the putative *mirror neuron system (MNS)*, which reenacts the observed action in the perceiver's motor system (Rizzolatti & Craighero, 2004). However, there is no accepted psychological explanation to-date for the function of mirroring and behavioral mimicry. Is it mostly an epiphenomenon, as a simple by-product of frequent perception-action links (Heyes, 2011)? Does it reflect a common cognitive representational format for perception and action (Preston & De Waal, 2002)? Or is it a processing strategy in service of better understanding (Goldman & Sripada, 2005) or social-emotional regulation (Hess & Fischer, 2013)?

One debate that bears on this issue concerns the relative role of representational and non-representational processes in mirroring responses (see Carr & Winkielman, 2014). Note that while definitions of "mental representations" do vary across different papers and fields, they are generally viewed as products of propositional encoding from incoming sensory information. This sensory information is translated into abstract mental symbols which can be cognitively manipulated, after which they are back-translated into motor responses (Gallese, 2003). Several mirroring accounts appeal to higher-order representational processes (e.g., Goldman and Sripada, 2005), and arguably some of the strongest pro-representational evidence comes from studies showing that mirroring responses dynamically adapt to environmental cues. As examples, motor imitation (e.g., finger-lifting, hand-opening and closing, etc.) is modulated by prosocial attitudes (Leighton, Bird, Orsini, & Heyes, 2010), affiliative drive (Lakin & Chartrand, 2003), and eye contact (Wang, Ramsey, & Hamilton, 2011). This also extends to spontaneous facial mimicry of emotional expressions (i.e., smile-to-a-smile, frown-to-a-frown, etc.), which can shift dramatically based on social factors, like negative attitudes (Likowski, Mühlberger, Seibt, Pauli, & Weyers, 2008), competition (Weyers, Mühlberger, Kund, Hess, & Pauli, 2009), and social power (Carr, Winkielman, & Oveis, 2014).

In contrast, others argue that mirroring can occur with *minimal* contribution from conceptual representations (that is, mirroring does not necessitate the use of abstract symbolic representations to generate action from perception). For example, one major non-representational framework proposes that "mirror neurons" are just reactions generated from perception-action links that are built throughout development, which pair contingent and contiguous stimulus and response (Heyes, 2011). Here, the MNS does not code the goal-directed nature of observed actions, nor does it necessarily even strictly "mirror" those perceived behaviors (Cook, Bird, Catmur, Press, & Heyes, 2014). Other non-representational accounts for mirroring echo this same general sentiment, but they also posit that action understanding is purely motoric in nature and based within the specific neural function of the MNS (Sinigaglia, 2009). Much work in psychology and neuroscience on spontaneous imitation in humans seems to support this non-representational perspective. These experiments have shown that mirroring is modifiable by low-level perceptual and motor factors, like simple training (Catmur, Walsh, & Heyes, 2007), visual feedback (Cook, Johnston, & Heyes, 2013), and testing environment (Cook, Dickinson, & Heyes, 2012). In social situations, people also seem to imitate even against strong competitive incentives *not* to do so (Belot, Crawford, & Heyes, 2013) and when they are clearly convinced that a model lacks any intentionality (e.g., androids that have no conscious will or agency for action; Hofree, Ruvolo, Bartlett, & Winkielman, 2014; Hofree, Urgen, Winkielman, & Saygin, 2015). Finally, mirroring of some basic actions (e.g., intransitive finger movements) seem impervious to some higher-level manipulations of social context, such as status and power of the model (Farmer, Carr, Svartdal, Winkielman, & Hamilton, 2016).

An advantage of the embodiment framework is that it could possibly integrate this rather confusing mirroring literature. One way is by deepening the understanding of the functionality of spontaneous mimicry (Kavanagh & Winkielman, 2016). As an example, gestural and postural mimicry have been frequently linked to affiliation and rapport between the mimicked party (the model) and the person doing the imitating (the mimic). Individuals who like each other tend to mimic one another, and being mimicked by another person tends to increase one's feelings of affiliation towards that person (Chartrand & Bargh, 1999). These tendencies have led to mimicry being labeled a form of "social glue" because it seems to foster cohesion between social groups

(Lakin, Jefferis, Cheng, & Chartrand, 2003). Embodiment theories help to explain why this is the case — mimicry contributes to creation of the same somatically grounded emotional state, thus facilitating understanding (Kavanagh & Winkielman, 2016).

Critically, just like with other forms of embodied information, the effects of dyadic mimicry are moderated by contextual information. One of most basic forms of socially relevant information is group membership. Indeed, recent studies show that gestural mimicry by an ingroup member makes one feel socially and physically warmer, yet mimicry by an outgroup member makes one feel colder (Leander et al., 2012). These data are consistent with previous work on facial mimicry, which found that negative attitudes towards the model are associated with counter-mimicry (Likowski, Mühlberger, Seibt, Pauli, & Weyers, 2008) and subliminally priming the concept of competition reduces or even reverses facial mimicry (Weyers, Mühlberger, Kund, Hess, & Pauli, 2009).

Keep in mind that mimicry's function is not limited to directly interacting parties. Observers can also make social judgments about people based on whom they mimic. In some situations, third-party observers will infer from the presence of mimicry that the members of the dyad are socially related and positively affiliated (Bernieri, 1988). Another example from Kavanagh, Suhler, Churchland, & Winkielman (2011) showed even more complex inferences. They found that if a target person mimics a model who is rude to the person, third-party observers of this interaction will judge the mimic as incompetent — even when observers fail notice the presence of mimicry. In fact, in that situation, the mimic was rated as *less* competent then the non-mimic. This suggests that if a person chooses to mimic a rude model, the person is non-selective or injudicious in using embodied responses (i.e., socially incompetent).

In short, inferences supported by embodied cues can be quite complex and context-dependent. Importantly, this does not challenge the value of embodiment theories, but instead suggests that such social reactions and inferences are based on a flexible and situated recruitment of embodied resources that are relevant to the current context.

Conclusion

In the current chapter, we discussed theory and evidence for the embodiment of emotional and affective information across social contexts. On this perspective, embodied conceptual processing involves the partial reuse and reinstatement of experiential and motor states that occur when the perceiver has actually encountered the object. In other words, reactivations of the sensory-motor systems can be used to inform understanding of emotional stimuli during real-world interactions.

We have illustrated that embodied resources are often routinely activated in information processing, including higher-order conceptual tasks. They can also play a causal role in emotion understanding, and perceivers can flexibly deploy them in order to facilitate mental processing. Note, however, that such embodied responses do not always appear to be necessary to perceive, understand, or generate affective information. Thus, while we embrace the strengths of the embodiment perspective, we nevertheless emphasize that a satisfactory account must also consider the interaction of embodied processes with context-sensitive, conceptual processes. As such, future work on the embodiment of emotion should further explore the interplay between amodal frameworks and modal embodiment theories, in order to better gauge when and how these responses adapt to a constantly changing social environment.

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