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Dynamicity in Emotion Concepts

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Embodied Simulation as Grounds for Emotion Concepts

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Abstract:

Knowledge about emotion is essential for functioning in the social world. But how, mechanistically, is such knowledge represented in the mind? Recent theories of embodied (grounded) cognition suggest that thinking about emotional information involves perceptual, somato-visceral, and motoric reexperiences (embodied simulation) of the relevant emotion in the self. Consistent with this view, recent studies show that processing emotion concepts involves embodiment, as reflected in psychological and physiological measures. Critically, changes in the embodiment of emotion, even when induced by simple manipulations, such as facial expression or arm movement, can causally influence the processing of emotional information, including perception, understanding, and judgment. We review relevant studies and discuss potential mechanisms underlying embodiment and simulation. We especially highlight the role of emotion embodiment in understanding the abstract language used to refer to emotion. We also stress the importance of social context and flexible use of embodiment in emotional processing.

Keywords:

Embodiment, emotion, concepts, facial expression, language, cognition, psychology.

1. Introduction

Emotion concepts, from simple ones such as "happy" to complex ones such as "resentment", are fundamental for understanding the social world. They help us to categorize, interpret, and predict the attitudes, behaviors, and intentions of other individuals. Emotion concepts are also critical for understanding one's own feeling states. And finally, they are central for learning and the ability to function in culture, where much is explained by appeals to potential emotional consequences. For example, consider the phenomenon of instructed fear learning. When a parent tells a child that a particular object (e.g., snake or a drug) will be harmful, the child can avoid that object or event without ever having to experience the fear or harmful effects with which it is (said to be) associated.

Unsurprisingly, research shows that people know a lot about emotions. They master dozens of emotion terms, can explain when and why emotions occur and describe their features in rich detail (e.g., Keltner and Haidt, 2003; Scherer, Wallbott, Matsumoto, and Kudoh, 1988; Tangney, 1992). People's knowledge of emotion also appears to be systematically organized and shows important similarities across individuals and across some cultures (e.g., Feldman, 1995; Russell, 1991; Russell, Lewicka, and Nitt, 1989). Emotion knowledge, at least as expressed in the English language, seems to be structured in hierarchically organized, fuzzy categories (Fehr and Russell, 1984; Keltner and Haidt, 2003; Shaver, Schwartz, Kirson, and O'Connor, 1987).

However, how exactly is such knowledge mentally represented and processed? The present contribution focuses on psychological research on the mechanisms of mental representations and processing of emotion concepts. We propose that mechanisms governing the use of emotion knowledge are better accounted for by recent models that are based on embodied simulation than by traditional models that emphasize operations on propositional structures.

2. Propositional models of emotion representation

Until recently, psychologists have assumed that emotion knowledge is represented in semantic networks (Bower, 1981; Ingram, 1984; Lang, 1984; Teasdale, 1983). Under this view, knowledge, emotional or not, is represented in networks composed of "units" of representation, sometimes called "nodes", "concepts" or "tracers." When a unit is activated, this activation spreads to connected units and the amount of activation transferred is proportional both to the degree of activation of the original unit and the strength of connections between these units (Collins and Quillian, 1969). This is now a standard connectionist assumption. Once the degree of activation of a particular unit passes a critical threshold, then knowledge represented by that unit rises to the level of awareness. In semantic models, emotional states (e.g., anger) are represented by a central unit of information, around which related experiences are organized. Units that represent beliefs, antecedents, and physiological patterns associated, for instance, with anger are linked to the anger unit in memory. When anger is experienced, the anger unit is activated, and it then diffuses activation to associated units (angry experiences, words, etc). The ideas that those units stand for are then more likely to enter consciousness and guide subsequent behavior. Conversely, activation can spread from anger-associated information in the emotion network to the anger node, thereby generating the emotion itself.

A key feature of semantic network models is that information is stored and transformed in propositional form. That is, the analog, sensory, modal information is always transformed into some sort of "mental language" description. Of course, a semantic node can be activated via connection from sensory organs, but in order to enter further processing, the sensory input needs to be "digitized, " (e.g., into a list of features). In the semantic network account, therefore, emotion concepts are associations of propositions that stand for different parts of an emotion, including its likely antecedents and bodily features. A related view is that emotion knowledge is represented as feature lists and that such lists are represented in word-like entries. For example, a feature list representation of the state of anger might be: ANGER [frustration, fists clenched, face red, yelling, cursing] (see Barsalou, Niedenthal, Barbey, and Ruppert, 2003; Niedenthal, 2007, 2008).

The view that higher order mental content is represented in a propositional, language-like way (e.g., Fodor, 1975) dominates accounts of emotion concepts in the psychology literature. Appraisal theories, semantic network theories, and many prototype theories are all built on this assumption (see Niedenthal, 2008, for discussion). Such a view presumes that the concepts that exist in our minds do not represent the perceptual experience of the objects, events, or states to which they refer or in which they have their genesis. Rather, they are transductions of such experiences into language-like representations (see Pylyshyn, 1981; Smith and Medin, 1981, for discussions of this view). Under this view, there are modal (analogue) states in perception, action, and introspection. However, these states can only influence processing of higher level concepts if they are first transduced into language-like symbols (Barsalou, 1999). We may, for example, be able to conjure up or remember traces of a somatic experience of a particular incident (say anger after capturing the cheating spouse in the lustful act). However, these traces do not directly contribute to a higher level conceptual understanding of the situation. Instead, the content of the concept of anger are the amodal symbols that have redescribed these different features of the emotional state. In the case of anger at the cheating spouse, such amodal conceptual content are beliefs about one's current state ("I am boiling inside", "I want to hit someone"), which can interact with other beliefs about the features of the situation, such as beliefs about the negativity of the act ("this is so unfair"), blameworthiness of the act (she is at fault), controllability of the event (he could have easily avoided it), etc.

3. Embodied representation of emotion knowledge

In recent years, theories of embodied cognition, or "embodied simulation" accounts have advanced the view that knowledge is fact directly grounded in modality-specific systems (Barsalou, 1999; Clore and Schnall, 2008; Damasio, 1999; Decety and Jackson, 2004; Gallese, 2003; Glenberg, 1997; Niedenthal, Barsalou, Winkielman, Krauth- Gruber, and Ric, 2005; Semin and Cacioppo, 2008; E. R. Smith and Semin, 2007; Winkielman, Niedenthal, and Oberman, 2008). This approach proposes that the modality-specific states that represent perception, action, and introspection that occur when one operates in the world of objects and events are relied on to represent the objects and events when they are no longer present. For example, calling to mind the memory of a particular opera may rely on partial reproduction of the brain states in visual and auditory areas that were involved in the experience of attending the opera. The act of remembering an action may require partial activation of the motor states that produced it in the first place.

It may seem intuitively obvious that recollection of a particular situation often involves some amount of simulation (e.g., visualization of where one left the keys in the office). This should be particularly true for emotion, where reprocessing an emotional episode has been long known to involve reactivating parts of the neural states that occurred when one originally experienced that emotion (Niedenthal, 2007; see also Cacioppo and Petty, 1981, and Lang, 1979, for earlier related arguments). In one view of how specifically this can happen, during initial perception of an emotional stimulus, the induced modality-specific states (e.g., somatic responses) are partially captured by the brain's association areas (Damasio, 1989). Later, when information about that emotional stimulus is used in memory or categorization, conjunctive neurons partially reactivate the pattern of neural states across the relevant modalities (if such reactivation is necessitated by the task). Similarly, by this account, knowledge of an emotion concept is not reducible to a feature list or description. Rather, the knowledge is represented by partial reproductions of the emotional states that the concept denotes. Although an embodied simulation does not have to be a conscious emotional episode, it will reinstantiate enough of the original experience or experiences to be useful in conceptual processing. Importantly, such simulations do not result from associative connections of emotion concepts to somatic states. They are the conceptual content and they are reinstantiated when it is necessary to represent this conceptual content in information processing.

4. Evidence for embodied models from the non-emotional domain

A number of studies on general knowledge representation have tested, and found support for, the prediction by embodied accounts that modality-specific systems are used in conceptual tasks (Gallese and Metzinger, 2003; Glenberg and Kaschak, 2002; Pecher, Zellenberg, and Barsalou, 2003; Stanfield and Zwann, 2001; for a review of the embodiment of linguistic meaning, see also Gibbs, 2003).

Some research has made use of the property verification task, in which participants indicate whether the typical instance of a given category usually possesses a particular feature. Solomon and Barsalou (2004) used this task. They showed that different types of perceptual features had predictable effects on the speed of property verification. As an example, they showed that larger properties were verified more rapidly, presumably because they were easier to "find" on a representation. In another study, Kan, Barsalou, Solomon, Minor, and Thompson-Schill (2003) measured activation of modality-specific brain areas such as audition and vision while participants verified a property typically processed in these and the other modalities. Their findings show that modality-specific areas of the brain were activated when properties that were processed in the area were being verified. In other words, when asked about the auditory features of concepts, the auditory cortex was selectively activated.

Another task that has been used to test the predictions of embodied accounts is the property generation task, also known as a feature listing task, wherein participants freely produce features of typical members of categories (Rosch and Mervis, 1975). Wu and Barsalou (2009) showed that the perceptual experience characteristic of a particular object (i.e., the visual characteristics of the object) influenced the features that participants produced when performing this task. For example, when participants had to list the features of the concept, HALF WATERMELON, they were more likely to produce the features "seeds" and "red" compared to when they had to list the features of the concept, WATERMELON. Presumably the interior visual features of the watermelon were "revealed" in simulating the former concept and not the latter. These findings extended also to quite novel concepts such as GLASS CAR (as opposed to CAR) showing that the patterns of performance could not be due to stored associations between amodal propositions. The authors of a more recent study (Simmons, Hamann, Harenski, Hu, and Barsalou, 2008) further found that participants who performed a property generation task activated modality-specific brain areas (visual, auditory, tactile, etc.) corresponding to the processed concepts.

One important feature of embodied accounts is their assumption that the nature of the task influences whether simulation will be used, and if so, what kind of simulation will be performed. More specifically, note that embodied simulation is not required to perform all tasks. For example, sometimes property verification tasks can be performed using "shallow" strategies like the detection of associations between words (Kosslyn, 1976). In such cases, embodied simulation is not necessary (e.g., Solomon and Barsalou, 2004). The use of a particular embodied simulation also depends on the specific situated conceptualization or the context in which the concept is being processed

(Barsalou, 2003). For example, if the task does not require generation of internal properties, then they are not simulated (Wu and Barsalou, 2004).

In summary, the results from research on non-emotional object concepts using both property verification and property generation tasks suggest that when individuals use concepts, they simulate perceptual states involved in interacting with those concepts. More important, those simulations are task dependent and thus cannot reflect pure associative reactions to concept names. Overall, those results are not consistent with the predictions of an amodal, purely propositional model of concept representation.

5. Emotion concepts

A growing number of findings in emotion and social psychology literature can now be taken as consistent with the embodied simulation account of emotion knowledge (Barsalou et al., 2003; Niedenthal, 2008). Some of these findings come from studies on the connection between the conceptual and motor systems. Chen and Bargh (1999) had participants indicate the valence of presented words (e.g., love, hate) either by pulling a lever toward them or by pushing it away. Whether a push or a pull indicated positive or negative valence was changed from trial to trial, however. The gesture of pushing something away from oneself is generally associated with items or people that one dislikes (avoidance behavior) while the act of pulling something near to oneself is more consistent with those things that we like (approach behavior). If somatic experiences (in this case pushing and pulling) are intimately involved with cognition (in this case the judgment of valence and decision about the direction in which to push the lever) then identification should be easier when it is achieved by a physical act that has a valence similar to that of the word being identified (congruence). Consistent with this reasoning, participants identified the valence of positive words more quickly when positive valence was indicated by pulling the lever toward them and correctly identified negatively valenced words more quickly when this was achieved by pushing the lever away, indicating that categorization of the words' valence is facilitated by a congruent bodily state. Similar findings have been reported by Neumann and Strack (2000); Forster and Strack (1997, 1998); Cacioppo, Priester, and Berntson (1993); and Alexopoulos and Ric (2007). In summary, the findings suggest that the meaning of emotional words is at least tied to the motor states involved in the approach versus avoidance responses to the words' referents (Niedenthal, 2007).

Other findings consistent with the embodiment approach come from studies on the recognition of emotional facial expressions. Wicker et al. (2003) instructed participants to inhale odors that orally induced feelings of disgust. The same participants later watched videos displaying other individuals

expressing disgust. Neuroimaging results showed that the same areas of the anterior insula and also, to a lesser extent, the anterior cingulate cortex were activated when individuals felt disgust and also when they perceived the experience and expression in another individual. This suggests that understanding someone else's actions or experience and performing an action or having an experience oneself may be processed by highly overlapping neural circuits (for related evidence with other facial expressions, see Carr, Iacoboni, Dubeau, Mazziotta, and Lenzi, 2003; Dimberg, 1990; Halberstadt, Winkielman, Niedenthal, and Dalle, 2009; McIntosh, Reichmann-Decker, Winkielman, and Wilbarger, 2006). More generally, this is consistent with a broader set of findings pointing towards the existence of a "mirror neuron system" – neural circuitry that maps observed actions to performance of those same actions (e.g., Gallese, Fadiga, Fogassi, and Rizzolatti, 1996; Rizzolatti, Fogassi, and Gallese, 1997).

Research on the recognition of facial expressions also provides some evidence for the causal role of embodied simulation in emotion processing. For example, preventing participants from engaging expression-relevant facial muscles can impair accuracy of detection of facial expressions that involve that muscle (Niedenthal, Brauer, Halberstadt, and Innes-Ker, 2001; Oberman, Winkielman, and Ramachandran, 2007). In summary, both correlational and causal evidence suggests that embodied simulation is involved in the perception of facial expressions of emotion (see Niedenthal, 2007, for a fuller discussion).

Another type of evidence for embodiment in emotion processing comes from research on conceptual "switching costs." Such work relies on a basic finding in the area of perception, namely that changing the focus of attention from one sense modality, say vision, to another, say audition, incurs temporal processing costs (e.g., Spence, Nicholls, and Driver, 2001). Recent work on conceptual processing reveals similar costs. In a classic demonstration of this effect, Pecher and colleagues (Pecher, Zeelenberg, and Barsalou, 2003, 2004) showed that participants verified features of a concept in one modality more slowly if they had just verified a feature from another (versus the same) modality (e.g., "BOMB-loud" followed by "LEMON-tart"). This again provides some evidence of perceptual processes in conceptual representation (see Kan et al., 2003, for neuroimaging evidence). Inspired by this basic conceptual switching cost effect, Vermeulen and colleagues (e.g., Vermeulen, Niedenthal, and Luminet, 2007) instructed participants to verify affective features that involved processing in vision, audition and the affective system, of positive and negative concepts and also features of more neutral concepts. Their findings showed that verifying features of positive and negative concepts from different modalities produced costs of longer reaction times and higher error rates. Furthermore, switching costs were observed also when switching from the affective system to sensory modalities, and vice versa. These findings seem to imply that the recognition of features that are primarily experienced in a given modality (i.e., visual, auditory, tactile, etc) is facilitated by the performance of an earlier task in the same modality. This is in line with the generally accepted principle of perceptual resource activation. Thus, the simplest explanation of the switching phenomenon is that different perceptual resources are "activated" by the processing of features that are, say, auditory in nature versus those that are visual or tactile. This resource pre-activation speeds subsequent recognition of features in the same modality, but not in different modalities (regardless of the propositional overlap in the actual conceptual content). Embodied accounts posit that the cognitive resources in question are the areas that store modality-specific trace memories (see Havas, Glenberg, and Rinck, 2007, for related findings in the area of language comprehension).

6. Recent research on embodied emotion concepts

Recent studies provided perhaps the most critical tests of embodied accounts of the processing of emotion-related concrete and abstract concepts (Niedenthal, Winkielman, Mondillon, and Vermuelen, 2009). The studies used the classic property verification task (Experiments 1, 2, and 3) and the property generation task (Experiment 4). Emotional embodiment was defined as changes in facial expression, which was measured with facial electromyography (EMG).

6.1. Four experiments

The first experiment tested the idea that simulation of emotional states occurs only when individuals need to use the emotional content of words, and not necessarily when other properties of the words are processed. Experimental participants were exposed to concrete nouns, half of which were had some emotional meaning, and half of which had no emotional meaning (e.g., pocket, chair). Then, in one experimental condition, participants indicated by a button press whether the words were printed in capital or small letters. In another experimental condition, participants indicated whether or not the words were related to an emotion. Emotion words were divided evenly among those related to joy (e.g., smile, cuddle), disgust (e.g., excrement, vomit), and anger (e.g., murder, fight). Relations of all words to specific emotions and the difficulty of imagining their referent were established in pre-testing. In order to test the hypothesis that judgment about emotion words involve reproductions of specific somatic states, the EMG measurement focused on specific facial muscles that are typically involved in producing expressions of the three specific emotions indicated by the words (joy – smiling muscles, disgust – nose-crinkling muscles,

anger – brow-furrowing muscles). The results were consistent with the notion that processing of the meaning of emotion words involves modal, embodied simulation, which is selectively employed on the basis of task needs. Specifically, facial muscles were activated when participants were evaluating the emotional content of an emotion word, but not when the word was neutral. Further, there were no EMG effects when participants were simply determining whether a word was capitalized, showing that the EMG responses were not simply due to a reflexive reaction to the words. Finally, participants' facial expressions while determining a word's content tended to be similar to the facial expression associated with the actual emotion. For example, joy-related words evoked activation of "smiling" muscles, as in actual joy (albeit to a much lesser degree). This means that processing of an emotion word involves a reproduction (partial and weaker) of a somatic state that characterizes emotional reactions elicited by a real emotion-inducing stimulus.

The second experiment in this series was very similar in design to the first except that the emotion words were chosen to be more abstract. They were adjectives that were either synonymous with or very closely related to the emotions of anger (e.g., enraged), disgust (e.g., repelled), and joy (e.g., delighted). The idea here was to see whether simulation was involved in the processing of high-level concepts. Again, the results showed that specific facial muscles were activated when participants determined whether a given emotion word was associated with an emotion, but not when participants determined whether a given word was capitalized. These results lend support to the idea that embodied processing is indeed used even in the processing of abstract concepts.

A third experiment in this research series showed that direct blocking of embodied simulation can interfere with processing of emotion words. Here participants took part in an experiment very similar to the first experiment except that some participants were instructed to hold a pen in their mouth. This manipulation has been found in previous studies to block expressions of happiness and disgust (Oberman et al., 2007). Thus, if the reproduction of somatic states (in this case facial expressions) associated with a particular concept is part and parcel of the emotional processing of that concept, occupying facial muscles with the task of holding a pen should impair emotional processing. The results of these trials were again consistent with the embodied hypothesis – participants were less accurate classifying words related to the specific emotions of happiness and disgust when the face movements specific to these emotions were blocked by the pen.

The last experiment tested whether embodied simulation is used flexibly in the production of emotion-associated words. Here participants were required to perform a feature generation task. Each was given a booklet and was instructed to list in it the features of concepts that were presented to them one at a time. Eight of these concepts were related to joy (e.g., joyful, happy), 8 were related imply that the recognition of features that are primarily experienced in a given modality (i.e., visual, auditory, tactile, etc) is facilitated by the performance of an earlier task in the same modality. This is in line with the generally accepted principle of perceptual resource activation. Thus, the simplest explanation of the switching phenomenon is that different perceptual resources are "activated" by the processing of features that are, say, auditory in nature versus those that are visual or tactile. This resource pre-activation speeds subsequent recognition of features in the same modality, but not in different modalities (regardless of the propositional overlap in the actual conceptual content). Embodied accounts posit that the cognitive resources in question are the areas that store modality-specific trace memories (see Havas, Glenberg, and Rinck, 2007, for related findings in the area of language comprehension).

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6.2. Emotional imagery versus simulation of emotion knowledge

It is worth highlighting how the findings by Niedenthal et al. (2009) differ from earlier observations that emotional imagery triggers bodily signs of the corresponding emotion. For instance, Grossberg and Wilson (1968) instructed experimental participants to imagine situations that typically evoke emotions such as fear. The findings revealed systematic changes in heart rate and skin conductance during imagery about fearful situations, but not during imagery about neutral situations (see Lang, Kozak, Miller, Levin, and McLean, 1980; Vrana, Cuthbert, and Lang, 1989; Vrana and Rollock, 2002). In a subsequent study, Schwartz and his colleagues looked at positive and negative imagery. They found that when individuals engaged in positive imagery, there was greater activity over zygomaticus major – the smiling muscle. When individuals engaged in negative imagery, there was greater activity over corrugator supercilii – the frowning muscle (Brown and Schwarz, 1980; Schwartz, Fair, Salt, Mandel, and Klerman, 1976). Taken together such results support the conclusion that emotional imagery is accompanied by corresponding physiological changes and they are indeed consistent with an embodied simulation account. However, unlike the studies by Niedenthal et al. (2009) they say little about (i) how individuals represent abstract conceptual content, such as words, (ii) how embodiment is conditional depending on task needs, and (iii) how embodiment is causally involved in understanding emotional content. This last point is elaborated on next.

6.3. Essential role of embodied simulation

We mentioned earlier that in the view of amodal representational models, referents of words can be associatively connected to the bodily system. However, they do not need to be simulated in sensory, motor, or affective systems. This is because concepts are mentally represented using a system of abstract propositions implemented as a semantic network or as feature lists. Thus, it is particularly telling that in the above studies by Niedenthal et al. (2009), even fast conceptual judgments about concrete words, and especially abstract words, were accompanied by embodied simulations of the emotion. Our interpretation is that the accompaniment is not epiphenomenal, but indicates that accessing the conceptual content of emotion concepts involves reenactments of the emotional states themselves. This interpretation is strengthened by the absence of simulation by participants in this same series of studies who were assigned to the "letter task" condition that exposed participants to the same emotion words but did not require access to their conceptual content but rather asked them to identify whether the words were capitalized. Note also that in this condition, participants did have to perform a task, but this task could be performed on the basis of the perceptual features of the words (i.e., whether they were written in capital or small letters) and not their emotional content. If embodiment was a matter of simple association, it should have appeared even in the letter task condition.

Experiment 3 and 4 in Niedenthal et al. (2009) provide convergent evidence for the conclusion that the embodiment of emotion serves as conceptual grounding and does not simply reflect automatic emotional responses to seeing emotion words or thinking about emotion concepts per se. Specifically, Experiment 3 showed that embodiment is causally important in conceptual processing. And Experiment 4 showed, further, that the manipulation of situational factors can alter the nature of the process of representing a concept. An embodied simulation occurs only under expected conditions: when the generation of the embodied information provides information that is useful for the task at hand.

7. Emotional responding versus emotion simulation

The central argument in the current paper is that sometimes people respond bodily to emotion words "as if" they were experiencing emotions. However, what is the difference between a real emotion and an emotion simulation for the purpose of understanding the concept? In theory, there are a number of factors that distinguish simulation and an emotional response to an object. One factor is efficiency. What is it like, emotionally, to notice real vomit on the bus seat next to you? The olfactory processing is followed by a focus of visual attention to the semi-liquid green or yellowish object. Sometime during this sensory processing, one feels the shudder of disgust and then makes expressive displays of that emotion. An energetic action of turning away might also occur. Although a simulation, which, as we propose, grounds the ability to say that vomit is associated with an emotion, should involve the activation of corresponding neural states, it would not involve the full-blown experience, as just described, unless there was time and motivation to relive the whole experience. A simulation can, according to the various possible accounts, be processed in central somatosensory loops, which take place in a more rapid and incomplete way than the coordinated peripheral and central processes of full-blown emotion (Damasio, 1994). A mirror system account – the idea that there is neural circuitry that automatically maps observed and performed actions – also distinguishes between an actual emotional experience and a simulation. In empathic responding to pain or to emotion, mirror systems show overlapping, but not identical, activity during actual own experience versus perceived experience (e.g., Decety, Michalska, and Akitsuki, 2008; Jackson, Rainville, and Decety, 2006). The results of such studies do not point to the conclusion that people are in (freshly evoked) pain because they see another person feeling pain but rather suggest that individuals can understand and make inferences about this experience through simulation of partial aspects of the emotion.

8. Conclusion

Emotion concepts are essential for functioning in the social world. They help us not only understand ourselves, but also interpret the attitudes, behaviors, and intentions of other individuals in their social environment. They are also fundamental to the development of an individual's behavioral repertoire – actions towards desired and undesired things, whether personally experienced, or just symbolically learned. Impairment in the processes underlying embodiment may even shed light on certain developmental disorders with a large social component, such as autism. For example McIntosh et al. (2006) have shown that autistic individuals do not automatically reproduce facial expressions that they see in others, as do typically functioning participants. As numerous other studies have shown that this reproduction aids recognition, there is reason to suppose that a deficit in reproduction may hinder understanding of non-verbal cues in autists (see Winkielman, McIntosh, and Oberman, 2009 for a fuller review of theory and evidence in this area). People affected by autism have been shown to have impairments in empathy and understanding of "other minds" (mentalizing). Presumably, these skills are partially supported by the ability to construct an embodied simulation of the other.

In this contribution we focus on the question of psychological mechanisms underlying the representation and processing of emotion concepts. Surprisingly, the literature on this central issue is quite small. Further, most accounts rely on the assumption that emotions are mentally represented by a set of amodal language-like symbols – lists or networks of features, propositions, etc. As an alternative, we present an embodied simulation account, which assumes that emotion concepts rely on modal, analogical representations that actively utilize the brains somatosensory and motor resources. We believe that the account presented here offers a more promising way of understanding the functioning of emotional knowledge, and generates several exciting new hypotheses, many of which have already been confirmed behaviorally. In short, it is time to put our theories of emotion concepts on a new ground.

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