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# Moving the mind: embodied emotion concepts and their consequences

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# Chapter 1

## Introduction and Overview

*'He felt his heart pounding fiercely in his chest. How strange that in his dread of death, it pumped all the harder, valiantly keeping him alive. But it would have to stop, and soon. Its beats were numbered. How many would there be time for, as he walked through the castle for the last time, out into the grounds and into the forest?'* (J.K. Rowling, 2007, pp. 554).

Even though the word 'fear' is not used in the former sentences describing Harry Potter's state, details about Harry's bodily reactions and thoughts make it quite clear that he is afraid. To be able to understand Harry's state we need emotion knowledge. We cannot comprehend these sentences without knowing what a fear state is, in which situations people experience fear, or what someone feels when afraid. Now let's consider something else. Imagine J.K. Rowling using her knowledge about fear while writing about Harry facing a final battle with Voldemort. Do you think her heartbeat increased while she wrote these sentences? Did her body mimic the fear reactions she was writing about? And what about the readers' bodily reactions: do our bodies react when we read about the fearful experiences of Harry Potter? And, does this increase our understanding of Harry's experiences? These and similar questions form the focus of the present dissertation. They are important because they touch on the nature of our understanding of emotions in general, but also on the nature of the representation of emotion knowledge and how this may affect our bodily state.

In the example above, Harry Potter's state is transferred through words. When printed, these words are just symbols; they have no meaning until someone reads them and understands what they are about. Knowledge is crucial in this process. Embodiment theories assume that the body plays an important role in how our knowledge is represented and consequently in the emergence of meaning (Barsalou, 1999; Barsalou, 2008; Gallese & Lakoff, 2005; Glenberg, 2010; Niedenthal, 2007). These theories are highly applicable to the realm of emotion knowledge, not in the least because of the great variety of bodily changes that accompany emotional

states. As indicated by the ontology of the word 'emotion', stemming from the Latin word 'emovere' (i.e., 'to move'), emotional states literally move the body. Fear is, for example, associated with sympathetic nervous system activity (i.e., arousal), activity of certain facial muscles and an urge to move away. If these bodily reactions are such an important component of *being* afraid, then they may be intrinsically related to our knowledge of fear, because they represent what fear *is*.

With embodiment perspectives as a theoretical framework, the present dissertation will explore how the body is affected when we think, read or write about emotions. The following introduction will provide the reader with the relevant theoretical and experimental background concerning the main focus of the present dissertation. First, we will present different approaches to the representation of (emotion) knowledge. Subsequently, we will introduce the most relevant embodiment perspectives. Even though these perspectives concern the representation of knowledge in general, we think it is important to address these views, because they are fundamental to embodiment views that focus specifically on emotion knowledge. In addition, we will provide an overview of the experimental evidence supporting these embodiment accounts. Third, we will thoroughly discuss embodiment views on the representation of emotion knowledge, and provide the reader with an overview of the experimental status quo. Finally, we will address how the idea of embodiment has motivated the experiments that constitute this dissertation.

## Emotion concepts

The conceptual system holds knowledge of the world. Within the conceptual system, concepts are seen as the most basic unit of knowledge representing particular categories, such as a bicycle or a cat. Conceptual knowledge plays a central role in all cognitive processes, including perception, recognition, retrieving memories, understanding language, and thinking (Barsalou, Simmons, Barbey, &

Wilson, 2003). Thus, when we see a cat, read the word cat, think about a cat or remember a certain cat, we use the concept '*cat*'.

Emotion concepts represent knowledge about emotions. They hold information about how emotions are elicited (e.g., situations), about behaviors that are associated with emotions (e.g., actions) and about the subjective experiences and bodily states that can occur when people are in an emotional state (Niedenthal, 2008). As all concepts, emotion concepts are important for a multitude of processes. We use emotion concepts when we are confronted with emotional stimuli in the real world, for instance when we are in an emotional situation, recognize emotions in other people, or label our own emotional state. In addition, emotion concepts are important in so-called 'offline' processes (Wilson, 2002; see also Niedenthal, Barsalou, Winkielman, Grauth-Gruber, & Ric, 2005). In offline processing there is no 'real' emotional stimulus present, for example when we retrieve emotional memories, imagine emotional situations, or process emotion language. These offline processes will be the focus of the present dissertation.

There are several models concerning emotion concepts. Some of these models analyze the content of emotion concepts, or theorize how different emotion concepts can be distinguished from each other (Fehr & Russell, 1984; Wiezbierca, 1992; see for an overview Niedenthal, 2008). For the present dissertation, however, models that describe *how* emotion concepts represent emotional states are most relevant. There are several models that formulate assumptions about the representation of emotion knowledge (see for an overview Phillippot & Schaefer, 2001). Interestingly, these models propose that emotion knowledge is represented by a propositional system that is not directly linked to affective, experiential or bodily states (Phillippot & Schaefer, 2001; Teasdale, 1999). These models resemble classic amodal approaches to conceptual representation. Amodal approaches (e.g., Fodor, 1975; Pylyshyn, 1984) assume that concepts are represented by abstract, language-like symbols. These symbols represent knowledge without preserving experiential information, such as

experiences from the different sensory modalities (e.g., vision, smell, touch, etc.), bodily states (e.g., action, physiology) or introspective experiences. Amodal approaches assume that modality-specific states are 'transduced' (i.e., redescribed) into arbitrary, abstract symbols that represent knowledge (Barsalou, et al., 2003b). Thus, even though most models concerning conceptual (emotion) representation incorporate abstract symbols for bodily experiences, these symbols re-describe bodily states in such a way that the final representation holds no reference to the actual state itself.

Amodal approaches imply that the meaning of abstract symbols can only be defined by other abstract symbols within the conceptual network. This is problematic, however. Consider the Chinese dictionary thought experiment (Harnard, 1990; see also Searle, 1980), which asks the following question: Can you learn Chinese from a Chinese dictionary? In a Chinese dictionary Chinese symbols are defined by other Chinese symbols. Thus, when you want to know the meaning of a Chinese symbol, the only information available is written in other unknown Chinese symbols. Because there is no connection between the symbols in the dictionary and the real world (i.e., the symbols are not 'grounded'), you will never be able to understand the meaning of any of these symbols. In other words, it seems impossible to understand an abstract symbol, when the symbol is disconnected from what it refers to. This is known as the symbol grounding problem. Applying this to emotions, the question is: if the symbols representing emotional states are arbitrary (i.e., in no way related to actual emotional experiences), how can they represent what it *means* to experience an emotion?

**Embodied cognition**

Theories of embodied cognition (Barsalou, 1999; Gallese & Lakoff, 2005; see for an overview Barsalou, 2008; Glenberg, 2010) provide an alternative view on conceptual representation by suggesting that concepts are grounded in experience (i.e., 'embodied'). One of the most elaborate theories is Perceptual Symbol Systems

theory (PSS; Barsalou, 1999). PSS assumes that during interaction with objects, perceptual (e.g., vision, audition, smell, touch, taste), motor, bodily, and introspective states are 'captured' and stored. These captured states form 'perceptual symbols' that represent the object. During conceptual processing these states are subsequently re-enacted, or *simulated*, in modality specific systems. This notion of simulation implies that any state that occurs during interaction with a certain object can be reactivated in the relevant brain and bodily systems when we think or read about that object. Because Barsalou (1999) proposes that introspective states, such as emotional and affective states (e.g., feeling sad, angry or aroused) are stored and simulated to represent abstract concepts, including emotion concepts, PSS is especially applicable to the focus of the present dissertation.

Importantly, PSS does not simply propose associations between bodily and perceptual states and conceptual processing; instead PSS assumes that simulations across many different modalities form the foundation of concepts. In this, PSS can be contrasted with the previously reviewed amodal approaches to conceptual representation, because PSS does not incorporate any form of re-description (i.e., into abstract symbols). Rather, PSS proposes that re-enactments in the modality-specific areas associated with *actual* states underlie conceptual knowledge. It is important to note, that these simulations consist of *partial* re-enactments; they never fully match the experiences that were captured (Barsalou, Niedenthal, Barbey, & Ruppert, 2003). In addition, the mechanism proposed here is automatic, and not mediated by active imagery. Even though simulation underlies mental imagery, mental imagery is not necessary for simulation to occur (Pecher, van Dantzig, Schifferstein, 2009). Moreover, simulations do not necessarily result in subjective experiences. Full-blown, conscious simulations are rare; most simulations underlying conceptual processing operate unconsciously (Barsalou, 2008; Barsalou et al., 2003a).

Simulation can underlie processing of real world objects (e.g., recognizing an instance of a concept), and offline processing (e.g., thinking or reading about an instance of a concept). Take a bicycle, for example. While in interaction with a bicycle, many different experiences can occur: visual experiences of what the bicycle looks like, haptic experiences of what the bicycle feels like, motor experiences concerning cycling movements, and maybe even a subjective experience of joy when you ride your bicycle through a muddy meadow. Across many different interactions, these states are stored to represent a bicycle, and may consequently be partially simulated in modality specific systems when you see a bicycle or read about a bicycle. Thus, seeing someone else riding a bicycle may result in the neural re-enactment of the motor movements of cycling. Or, reading an article about cycling in the mud may lead to a simulation of a muddy bicycle in visual systems or a feeling of effort or joy in systems associated with feeling states. In other words, processing bicycles may involve simulations across different modalities, including vision, touch, action and introspection.

Multiple studies have provided support for the idea that perceptual simulations in modality-specific systems underlie conceptual processing (Barsalou, 2008). An important contribution has been made by experiments that demonstrate modality switching costs (Marques, 2006; Pecher, Zeelenberg, & Barsalou, 2003; Van Dantzig, Pecher, Zeelenberg, & Barsalou, 2008; Vermeulen, Niedenthal, & Luminet, 2007). For example, Pecher, Zeelenberg and Barsalou (2003) asked people to verify certain modality specific properties of concepts. If these conceptual judgments would be associated with simulation, then switching costs should occur when people switch from one modality to the other. As expected, participants were indeed slower in verifying that *an apple is green* (i.e., visual modality) after they previously verified that *an airplane is loud* (i.e., auditory modality) compared to when they previously verified that *a zebra is striped* (i.e., visual modality). This effect is explained by flexible simulations in the modalities relevant for verifying the

different properties. Recent brain imaging studies add to these behavioral findings in showing that modality-specific areas in the brain are active when people verify modality-specific properties (Goldberg, Perfetti, & Schneider, 2006; Kan, Barsalou, Solomon, Minor, & Thompson-Schill, 2003). Together; these findings highlight the role of simulation in conceptual understanding.

In addition to research that focuses on simulation across different sensory modalities during conceptual processing, another influential body of research specifically targets the role of action simulation in language comprehension. For example, Hauk, Johnsrude and Pulvermuller (2004) showed that processing the word 'kick' activated areas in the brain specifically associated with a kicking movement (see also Hauk, Shtyrov, & Pulvermuller, 2008). Furthermore, Glenberg and Kaschak (2002) examined the hypothesis that action simulation plays a role in sentence comprehension (see also Zwaan & Madden, 2005; Zwaan & Taylor, 2006). They found that movements interfered with sensibility judgments of sentences describing action. For instance, when judging a sentence implying a movement away from the body (e.g., 'close the drawer') participants were faster in responding with an away movement than with a movement towards the body. The Indexical Hypothesis (IH; Glenberg & Roberston, 2000) offers a theoretical framework to explain these findings. According to IH, language is made meaningful by action simulation. Interactions between language comprehension and actual bodily activity occur because the same action systems are active when comprehending a sentence and performing an actual action. Importantly, Glenberg, Webster, Mouilso, Havas and Lindeman (2009) have recently extended the simulation account of language understanding forwarded by IH by proposing that simulation in emotion systems is a causal factor in understanding emotion language.

In addition to the Indexical Hypothesis (Glenberg & Roberston, 2000) and Perceptual Symbols System theory (Barsalou, 1999), Lakoff and Johnsson (1980) have proposed an embodied view on conceptual knowledge that focuses on metaphoric

representation. This view specifically concerns the representation of abstract concepts, including those referring to emotion. According to their theory, abstract concepts are mapped onto concrete dimensions (such as brightness, vertical position and distance). These concrete dimensions, with their underlying bodily experiences, form the foundation of concepts such as positive, negative, good and bad. Experimental research has indeed demonstrated a connection between concrete dimensions and affective concepts (see for an overview Crawford, 2009). For instance, studies have shown a link between good/bad judgments and color (Meier, Robinson & Clore, 2004) and affect and vertical position (Meier & Robinson, 2004).

This approach to ground emotion concepts in concrete dimensions seems insufficient, however. For example, in the sentence 'fear slowly crept up on him', the metaphoric representation of space and movement is used to *communicate* something about fear (Crawford, 2009). It does not, however, represent the state of fear itself. In other words, metaphoric dimensions such as space, movement and color may be important in linguistic communication and reasoning about emotions (Crawford, 2009), but they do not ground the essential meaning of an emotion concept (see also Barsalou, 1999). Emotions are 'embodied' by nature; they are accompanied by internal states, actions, expressions and subjective feelings. Because these states can directly ground what it means to experience an emotion, it seems that a better avenue may be to incorporate bodily and experiential states into a theoretical account of how emotion concepts are represented (Glenberg, et al., 2009). Nevertheless, some concrete dimensions, such as temperature, are associated with specific bodily sensations. Recently, research has demonstrated that representations of heat (e.g., depiction of flames) facilitate the categorization of anger words (Wilkowski, Meier, Robinson, Carter & Feltman, 2009) and that priming with anger words increases judgments of heat. This research, however, focused on 'cognitive' representations of heat, and as such leaves open the question whether neural, bodily and experiential simulations of heat sensations mediate these effects.

**Embodied emotion concepts**

To illustrate how bodily and experiential states are crucial in grounding the meaning of emotion concepts, consider the Dutch word 'gezellig'. The word 'gezellig' is extremely hard to translate. It refers not only to a certain style of decoration or a social context, but also to a feeling. For example, you can refer to an engaging party or to an intimate one-on-one dinner as being 'gezellig'. Although this feeling is not considered to be a specific emotional state, it certainly has emotional components. On multiple occasions I have tried to explain the word 'gezellig' to American friends. I referred to bodily states ('gezelligheid makes you relax'), compared 'gezelligheid' to emotions ('gezelligheid will make you feel happy') or used a metaphor ('gezelligheid will make you feel warm and fuzzy'). These three descriptions could serve as 'Rosetta stones' for my American friends, because they are grounded in bodily states that my friends have experienced themselves. When comparing 'gezelligheid' with happiness, people ground the meaning of happiness by simulating a happy state, and can thereby deduce the meaning of 'gezelligheid'. But now, imagine that I have to explain gezelligheid to an extraterrestrial. This seems impossible. Not only because of the obvious language barrier, but also because the extraterrestrial does not share any experience that can ground a possible explanation. Happiness, a relaxed state, a warm and fuzzy feeling, none of these things would mean anything when there is no connection with underlying states. Hence, again, we have a grounding problem. Meaning will not arise in the absence of a connection between a concept and the real world, or in the case of emotion concepts, between concepts and actual emotional states.

Bodily states are undeniable an important component of emotion, even though the specifics of the link between emotion and the body are intensely debated (see Barrett, 2006). When confronted with an emotional stimulus, people respond, for example, with facial or bodily expressions (Ekman, 2007; De Gelder, 2006), approach or avoidance behavior (Chen & Bargh, 1999; Rotteveel & Phaf, 2004) or

physiological reactions (Levenson, 2003; Mauss, Levenson, McCarter, Wilhelm & Gross, 2005). Because these bodily states are fundamental to emotional reactions, they may be essential in grounding emotion concepts. Niedenthal and colleagues (2005a) forward an important approach to emotion processing by proposing that knowledge about emotion is grounded in simulating (or embodying) the states that normally occur in interaction with emotional stimuli. Thus, in contrast to the assumption of amodal theories that knowledge is represented by re-describing underlying states into abstract symbols, Niedenthal and colleagues view 'embodiments as the core conceptual content of emotion knowledge'. The basic underlying mechanism is as follows; all states that occur when someone experiences an emotion can potentially be captured and stored to represent knowledge about that emotion. Consequently, emotional states and emotion concepts share neural and bodily systems; systems in the brain and body that are active while experiencing emotional states, such as motor areas, areas associated with internal states, facial muscles or the sympathetic nervous system, also underlie emotion knowledge. When emotion knowledge is activated, for instance during memory retrieval, while reading words or sentences, or when understanding emotional stimuli, meaning is created by simulating emotional states in the relevant systems.

It is important to note that both brain states, bodily states and states that are subjectively *felt* can ground emotion concepts. According to Barsalou (1999), for example, introspective experiences are central to the conceptual representation of emotions. The distinction we make between bodily states and subjective feeling states is important, because feeling states are conscious by definition, whereas bodily states (e.g., facial expressions, motor actions or physiological reactions) are not necessarily consciously experienced (Winkielman & Berridge, 2004; Lambie & Marcel, 2002). Even though bodily states form important components of emotion experience and can be subjectively experienced, they may also 'linger in the background' (Duncan & Barrett, 2007; Barrett & Bar, 2009). Consequently, we

assume that both states resulting from active introspection (e.g., feeling angry or sad) and states that are not targeted by consciousness can be stored to represent emotional states. Thus, any state, varying from subjective feelings, to undefined arousal, facial expressions, visual input and motor actions, can become part of the representation of an emotion. These states may be re-enacted, without resulting in any conscious experience, when we use emotion knowledge (see Niedenthal et al., 2005a).

The idea that emotion knowledge is embodied has received support (see for an overview Niedenthal et al., 2005a; Winkielman, Niedenthal, & Oberman, 2008). First, research has demonstrated interactions between bodily states and processing emotional stimuli. For instance, approach movements are made faster when positive stimuli (such as emotion faces or words) are processed, whereas avoidance movements are made faster when negative stimuli are processed (Chen & Bargh, 1999; Rotteveel & Phaf, 2004). These results suggest that processing emotional information that is grounded in action interacts with performing that action. Second, emotional states are triggered when people imagine emotional situations. Research has shown that emotional imagery concerning disgust, fear, anger and joy can result in bodily activity (Vrana, 1994; Vrana & Rollock, 2002). Furthermore, areas in the brain that are active during the experience of disgust (i.e., tasting something disgusting) are also active when people imagine a disgusting situation (Jabbi, Bastiaansen, Keysers, 2008). And third, many experiments have demonstrated that people embody other people's emotional reactions, for instance through facial mimicry (Dimberg, 1982; Dimberg, 1990; Hawk, Van Kleef & Fischer, in revision; Hess & Blairy, 2001), or simulation in brain areas associated with emotional experience (Wicker, Keysers, Plailly, Royet, Gallese & Rizzolatti, 2003). This suggests that understanding the emotions of others, or empathizing with the emotions of others, involves simulating the other person's emotional reactions (Bastiaansen, Thouix & Keysers, 2009). Interestingly, the assumption that we understand other

people's emotions by embodying their emotional reactions may extend beyond situations in which we see or hear others, to the more abstract domain of understanding the emotions of others described by language.

Glenberg, Webster, Mouilso, Havas and Lindeman (2009) apply a simulation account to the understanding of emotion language that argues along the same lines as the embodiment perspective proposed by Niedenthal and colleagues (2005a). According to Glenberg and colleagues action simulation, (e.g., movement or expression), simulation of psychophysiological states (e.g., cardiovascular activity) and simulation of subjective states (e.g., feelings of anger or fear) are causal in emotion language comprehension. Thus, in order to be able to understand a sentence describing someone else's fear, a state of fear may be simulated, including congruent motor actions, physiological reactions and subjective feelings. Havas, Glenberg and Rinck (2007) examined whether processing emotion language resulted in simulations of emotional states, by testing whether manipulating bodily states associated with emotion influenced the comprehension of sentences describing emotional states. Participants were asked to put a pen in their mouths in such a way that, unbeknownst to them, their face was either posing a smile, or smiling was prevented. Subsequently, they were asked to judge positive ('*you and your lover embrace after a long separation*') and negative ('*your supervisor frowns as he hands you the sealed envelope*') sentences on valence (pleasant or unpleasant) and sensibility (easy or hard to understand). The findings showed that judgments for positive sentences were faster when participants posed a smile, than when smiling was inhibited. Negative sentences, in contrast, were judged faster when smiling was inhibited. This effect is explained by assuming that we understand emotion sentences by simulating the described emotional states. Hence, a bodily state that is similar to the simulation warranted by the sentences will facilitate comprehension, whereas a bodily state that is different will interfere with comprehending sentences. Importantly, lexical judgments of single words were not influenced by facial manipulations, leading the

authors to assume that simulation will only play a causal role in understanding language when processing content, and not during lexical access.

The previously reviewed studies show bodily simulation when we use emotion knowledge during 'real world' interaction, for example when we try to understand the emotions of others. In addition, bodily simulation is also present in offline processes, for instance when emotional stimuli are symbolically represented (i.e., language) or created in the mind (i.e., imagery). Several studies have specifically targeted simulation processes during offline conceptual emotion tasks. For example, Vermeulen, Niedenthal and Luminet (2007) extended the previously reviewed switching cost effect to the domain of emotion. Participants were asked to verify visual and auditory properties (associated with simulation in visual and auditory systems) of emotion concepts, and to verify affective properties, which, according to embodiment approaches should be associated with simulation in emotion systems. The results showed that switching costs occurred when participants switched between vision (SPIDER can be *black*), audition (BABY can be *babbling*) and affective (VICTIM can be *stricken*) properties, suggesting that affective concepts are simulated in an emotion system, separate from the visual and auditory modalities.

A direct test of bodily simulation during the processing of emotion concepts was performed by Niedenthal, Winkielman, Mondillon and Vermeulen (2009). They demonstrated spontaneous facial activity when participants processed emotion words (see also Foroni & Semin, 2009). For instance, when participants processed the word '*vomit*', the *levator labii* (a muscle associated with facial expressions of disgust) became active. Congruent activation occurred both during processing of concrete emotion concepts (e.g., '*smile*') and abstract emotion concepts (e.g., '*happy*'). Importantly, this activation only occurred when words were processed in terms of their emotional meaning. Participants either judged whether a word was written in uppercase or in lowercase letters (e.g., 'TABLE' versus 'vomit'), or whether a word

was related to an emotion or not. Congruent facial activity was limited to conditions where participants made an emotion judgment, suggesting that (overt) embodiment effects may only be fundamental in processes that access emotional meaning. This idea is supported by the previously discussed finding that bodily states do not influence lexical decisions of emotion words (Havas et al., 2007). Nevertheless, because recent research has also demonstrated covert embodiment effects under minimal processing circumstances (Vermeulen, Mermillod, Godefroid, & Corneille, 2009); the extent to which overt and covert embodiment effects are dependent upon depth of processing is still unclear.

## Overview of the present dissertation

The empirical chapters presented in this dissertation will revolve around one central question: Do bodily states occur when people think about emotion, remember emotional events or process emotion language? Although there is abundant evidence for simulation when people perceive emotions in others, research that specifically examines bodily simulation during *conceptual* emotion processing is less prevalent. Yet, understanding the fundamentals of these emotion processes is important for theoretical reasons, and has implications beyond affective science. Many details about emotional states are transferred through language, not only when we read books and newspapers, but also during digital interactions, for instance when emailing and chatting. An account of the role of the body in language comprehension may enrich our understanding of these processes. In addition, it is important to have insight into the activation of bodily states when we think about emotion, retrieve information from memory, or use emotion language, because this may have important implications for emotion regulation, emotion learning and clinical therapy.

### *Bodily states*

Prior research into embodied emotion concepts has mainly focused on the simulation of facial expressions. Experiments either measured spontaneous

simulation in the face during the processing of emotion concepts (i.e., Niedenthal et al., 2009; Foroni & Semin, 2009) or manipulated facial expressions to examine the links between expression and emotion comprehension (Havas et al., 2007). The question whether spontaneous embodiment effects can also be found when focusing on other bodily states thus remains to be answered. In **Chapter 2** we examine spontaneous expressions in *body posture* during a conceptual emotion task. Participants are asked to generate words about pride and disappointment, which are associated with certain changes in body posture (Riskind, 1984; Stepper & Strack, 1993; Tracy & Robins, 2004). During these word-generation tasks conceptual knowledge is activated because participants think about the content and meaning of these specific emotion concepts. Because we assume that emotion knowledge is embodied, we predict that generating words associated with pride and disappointment will lead to congruent changes in body posture.

Even though Chapter 2 may enrich previous embodiment research by showing spontaneous embodiment effects in body posture, it is important not to limit experimental support for embodiment processes to external activity (i.e., bodily states that can be seen on the 'outside'). So far, the spare research on bodily simulation during conceptual emotion processing has exclusively focused on simulation of facial expressions (Foroni & Semin, 2009; Havas et al., 2007; Niedenthal et al., 2009). Emotional reactions, however, can also occur 'inside' the body. These internal states, such as a state of arousal, have not yet been included in research. This may have potential consequences for the interpretation of simulation during conceptual emotion processing, because facial and postural expressions clearly have a communicative role, whereas other components of emotions are 'hidden', and can only be experienced by the person him or herself. To exclude the possibility that simulation during conceptual emotion processing only occurs in expressive channels, the present dissertation will also incorporate measures that will examine the spontaneous activation of *internal* bodily states. More specifically,

Chapter 3 and Chapter 4 will present studies that measure sympathetic nervous system activity as a readout of internal bodily states that occur when people process conceptual emotion knowledge.

*Emotion memory*

**Chapter 3** explores an embodied account of conceptual emotion knowledge by focusing on the retrieval of emotional information from memory. Retrieving personal memories from episodic memory can result in an intense re-enactment of the states that were experienced during the past event. Thus, it seems fair to assume that episodic memory is embodied (Wilson, 2002). Semantic memory, in contrast, does not hold personal memories, but stores knowledge about the world (Tulving, 1993). Since embodiment theories assume that emotional reactions can accompany the activation of emotion knowledge, it can be predicted that both episodic *and* semantic memory representations result in (bodily) emotion activation. Nevertheless, episodic and semantic memory representations also differ in an important way; episodic memory is intrinsically connected to the self (Wheeler, Stuss, & Tulving, 1997), whereas semantic memory activates general knowledge. Because it has been suggested that self-relevance can influence the strength of embodiment effects (Niedenthal, et al., 2005a; Niedenthal, Roman & Dalle, 2002), it is relevant to explore the possible differences and similarities between episodic and semantic representations. In the study presented in Chapter 3 we will measure bodily states (i.e., electrodermal activity), subjective emotion reports and behavioural reactions. We will contrast the activation of personal fear memories (episodic activation) with the generation of fear words (semantic activation).

*Feeling the body*

Bodily states can manifest themselves in subjectively experienced feeling states. In order to shed light on the question whether bodily simulation during conceptual processing can be accompanied by full-blown subjective experiences, we will combine subjective reports of emotion with measures of bodily reactions in

Chapter 2, 3 and 4. The combination of subjective and bodily measures of emotional states is important within the field of embodied emotion concepts. The involvement of subjective emotional states in offline processing can, theoretically, indicate two different processes; direct emotion induction or simulation. On the one hand offline processing (e.g., imagery, remembering, reading, or thinking) could serve as an emotion induction, because emotional stimuli are simulated *as-if* they are actually present. Consequently, both the subjective emotional states and bodily states that occur during offline processing could be 'genuine' emotional reactions to simulated events. On the other hand, embodied cognition theories predict the simulation of bodily states *and* feeling states (Niedenthal, 2007; Barsalou, 1999; Glenberg et al., 2009; Bastiaansen, Thioux & Keysers, 2009). Thus, the presence of bodily states and subjective emotional states could be embodiment effects in themselves. Although it seems impossible to distinguish between these different processes, an experimental design that activates emotion knowledge without other potentially 'confounding' factors could add to this discussion. In Chapter 4 we aim to do this, by presenting a task that is especially suited to activate emotion knowledge in an implicit way, focusing on verbal processing, without the involvement of subjective emotion activation (Stapel & Koomen, 2000; Innes-Ker & Niedenthal, 2002; Maringer & Stapel, 2007). Consequently, bodily states that occur when performing this task are best explained as direct embodiment effects and not as consequences of emotion state induction. Hence, the study presented in Chapter 4 may be the most uncontroversial test of the embodiment of emotion concepts.

*Consequences of emotion concepts*

The study presented in **Chapter 4** is not only designed to present conceptual emotion knowledge without introducing confounding factors, but also examines a new question concerning the consequences of activating emotion knowledge. Does the activation of emotion knowledge potentiate bodily reactions to new emotional stimuli? Research has never directly examined this possibility. To date, most

research concerning the interaction between emotion knowledge and emotional responding has focused on memory and perception (Halberstadt & Niedenthal, 2001; Halberstadt, Winkielman, Niedenthal & Dalle, 2009; Lindquist, Barrett, Bliss-Moreau & Russell, 2006), subjective judgments of emotional stimuli (Foroni & Semin, 2009), and the subjective experience of emotional states (Lindquist & Barrett, 2008). Although these studies suggest that emotion concepts can influence the encoding or recognition of emotional stimuli, or the interpretation of one's own emotional state, they do not directly target bodily reactions. Yet, based on an embodied account of emotion knowledge, we can predict that emotion knowledge can influence bodily responding, since the activation of conceptual emotion knowledge may be accompanied by bodily simulation. In other words, if emotion concepts are embodied, then the bodily states that result from processing emotion concepts could enhance bodily sensitivity and therefore lead to stronger bodily reactions towards new emotional stimuli. Chapter 4 will seek out to test this prediction.

*Beyond emotion concepts*

In addition to directly measuring spontaneous simulation in the body, we will also approach embodiment indirectly with a paradigm that examines the behavioural consequences of simulation. **Chapter 5** will focus on simulation of internal states presenting data from a switching costs paradigm. Internal states are important components of many different mental states, and incorporated into most theories of embodied cognition (Niedenthal, 2007; Barsalou, 1999; Glenberg et al., 2009; Bastiaansen, Thioux & Keysers, 2009). Nevertheless, simulation of internal states during conceptual processing has been experimentally neglected. The study presented in Chapter 5 examines simulation processes when understanding language describing emotional states and other mental states, such as visceral states (hunger, dizziness) and states classically seen as 'cognitive' (familiarity, intuition, thinking). Although this may seem a slight detour from the main theme of the

present dissertation, simulation of internal states is important beyond emotion concepts, because these states may also be fundamental in grounding linguistic references to other states that have a certain 'feel'. Chapter 5 will contrast sentences inviting simulation of internal states (internal focus) with sentences inviting simulation of visual accessible properties (external focus). We predict that switching costs will occur when participants shift between sentences with an internal focus ('*Hot embarrassment came over her*') and sentences with an external focus ('*She lowered her head in disappointment*').

*Final remarks*

Together, the four empirical chapters in the present dissertation explore the embodiment of emotion concepts using different measures and manipulations. Each chapter represents an independently published or submitted paper; therefore there will be some overlap in content. Since chapters can be read in any particular order, we encourage the reader to choose chapters based on research interests or because the previous overview has sparked curiosity. The final chapter will integrate the empirical findings, discuss the implications for embodiment accounts of emotion concepts and address directions for future research.