UNIVERSITY OF AMSTERDAM

UvA-DARE (Digital Academic Repository)

Moving the mind: embodied emotion concepts and their consequences

Oosterwijk, S.

Publication date
2011
Document Version
Final published version

Link to publication

Citation for published version (APA):
Oosterwijk, S. (2011). *Moving the mind: embodied emotion concepts and their consequences*. [Thesis, fully internal, Universiteit van Amsterdam].

General rights
It is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), other than for strictly personal, individual use, unless the work is under an open content license (like Creative Commons).

Disclaimer/Complaints regulations
If you believe that digital publication of certain material infringes any of your rights or (privacy) interests, please let the Library know, stating your reasons. In case of a legitimate complaint, the Library will make the material inaccessible and/or remove it from the website. Please Ask the Library: https://uba.uva.nl/en/contact, or a letter to: Library of the University of Amsterdam, Secretariat, P.O. Box 19185, 1000 GD Amsterdam, The Netherlands. You will be contacted as soon as possible.

UvA-DARE is a service provided by the library of the University of Amsterdam (https://dare.uva.nl)

Download date:08 Nov 2026

Moving the Mind

Embodied Emotion Concepts and their Consequences

Suzanne Oosterwijk

Moving the Mind

Suzanne Oosterwijk

kurtle

winins

tituut

dissertatiereeks
Kurt Lewin Instituut
2011-07

Moving the Mind:
Embodied Emotion Concepts and their Consequences

ACADEMISCH PROEFSCHRIFT

ter verkrijging van de graad van doctor
aan de Universiteit van Amsterdam
op gezag van de Rector Magnificus
prof. dr. D.C. van den Boom
ten overstaan van een door het college voor promoties
ingestelde commissie,
in het openbaar te verdedigen in de Agnietenkapel
op vrijdag 18 maart 2011, te 14:00 uur

door

Suzanne Oosterwijk

geboren te Amstelveen

Promotor:	Prof. dr. A.H. Fischer
Co-promotor:	Dr. M. Rotteveel
Overige Leden:	Prof. dr. M. Kindt
	Prof. dr. G.R. Semin
	Prof. dr. J.A. Förster
	Dr. D. Pecher
	Dr. R. Holland

Faculteit der Maatschappij- en Gedragswetenschappen

For Flip

And all others with such curiosity

Contents

Chapter 1	Introduction and Overview	7
Chapter 2	Embodied Emotion Concepts: How Generating Words about Pride and Disappointment Influences Posture	27
Chapter 3	Remembering the Self versus Knowing the World: Emotional Consequences of Episodic and Semantic Fear Representations	47
Chapter 4	When the Mind Forms Fear: Embodied Fear Knowledge Potentiates Bodily Reactions to Fearful Stimuli	63
Chapter 5	Mental States Inside Out: Switching Costs for Emotional and Non-emotional Sentences that Differ in Internal and External Focus	83
Chapter 6	General Discussion	97
	Dutch Summary	115
	References	125
	Footnotes	140
	Acknowledgements	141
	KLI Dissertation Series	147

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.

Chapter 2

Embodied Emotion Concepts: How Generating Words About Pride and Disappointment Influences Posture

Embodiment theories predict that activating conceptual knowledge about emotions can be accompanied by re-experiencing bodily states, since simulations of sensory, motor and introspective experiences form the foundation of conceptual representations of emotion (Barsalou, 1999; Niedenthal, 2007). In the present study we examine whether the activation of the specific emotion concepts of pride and disappointment are embodied in the sense that they are accompanied by changes in posture. Participants generated words associated with pride and disappointment while posture height was measured. Results show that during the generation of disappointment words participants decreased their posture height more than when participants generated pride words. This finding suggests that the activation of conceptual knowledge about disappointment can lead to a spontaneous expression of the associated body posture. In contrast to posture changes along the vertical axis, movement along the horizontal axis was not influenced by concept activation. In addition to bodily simulation the data also indicated introspective simulation, since feelings of disappointment increased after generating disappointment words. The current study provides the first evidence for the claim that the activation of conceptual knowledge about emotion can instantiate spontaneous simulations at an behavioral level.

This chapter is based on: Oosterwijk, Rotteveel, Fischer & Hess (2009)

Human knowledge covers not only concrete objects and events, such as household objects, animals, birthday parties or a bike ride, but also abstract concepts such as trust, anger, love and hope. We know what it means to be angry, how we act when we are afraid, what we say when we are in love and what events can lead to frustration and joy. Emotion knowledge is used when we talk to people, write emails or read a book, and it helps us making sense of our own emotions and the emotions of others. Consequently, an important and interesting question is how this knowledge is represented.

Recently, it has been suggested that conceptual knowledge is represented by re-enacting experiences that occur in interaction with the objects that the knowledge refers to (Barsalou, 1999; Gallese & Lakoff, 2005). Conceptual knowledge about emotion seems to be a perfect test case for this idea, because emotional states (i.e., the 'objects' of this knowledge) are accompanied by a broad range of bodily experiences, such as physiological reactions, facial expressions, motor reactions and body postures. Thus, emotion concepts might not be mere symbolic representations (Fodor, 1975), disconnected from what we feel and do when we are experiencing an emotion. In contrast, emotional experiences and bodily reactions may form the foundation of conceptual representations of emotion (Niedenthal, Barsalou, Winkielman, Krauth-Gruber & Ric, 2005; Niedenthal, 2007; Winkielman, Niedenthal, Oberman, 2008).

Embodied emotion

Embodiment theories (Barsalou, 1999; Gallese & Lakoff, 2005) argue that perceptual and bodily states that occur during interactions with certain objects are simulated in sensory-motor areas in the brain to conceptually represent those objects. According to Barsalou, Niedenthal, Barbey and Ruppert (2003) conceptual knowledge is formed by storing sensory, motor and introspective states that co-occur with the experience of events or the interaction with objects. These states are then partially re-enacted when people access memories or think, read and talk about

these objects or events. Barsalou (1999) proposes that simulation also underlies concepts that hold knowledge about more abstract categories such as happiness and anger. In this view, social and emotional concepts are so called situated conceptualizations (Barsalou et al., 2003a). In situated conceptualizations not only the target object or event is simulated, but also settings, actions and introspections, thereby creating an experience of "being there" (Niedenthal et al., 2005b). A situated conceptualization can be seen as a pattern with all kinds of associated representations. According to Barsalou et al. (2003a) parts of this pattern can become activated through an inference process called pattern completion. When a situated conceptualization becomes active, inferences are made about components of this conceptualization that are not necessary directly observed or experienced. Interestingly, Barsalou and colleagues propose that these inferences can go beyond simulations in sensory-motor areas in the brain, initiating actual expressions, overt behavior and even introspective feelings.

Priming effects on behavior (for a review see Förster & Liberman, 2007) serve as a good example of embodiment effects through situated conceptualizations and pattern completion. Bargh, Chen and Burrows (1996), for example, demonstrated that participants walked more slowly after they were presented with conceptual knowledge about elderly people. Niedenthal et al. (2005b) explain this effect by proposing that the situated conceptualization of elderly people holds a simulation of slow movement, which leads to a re-enactment of this action when the concept becomes active. In addition to work on priming effects, several other studies on social interaction and the processing of social information have indicated that processing social stimuli can produce embodied reactions (see Barsalou, Niedenthal, Barbey and Ruppert, 2003 for a review).

The link between embodiment and emotion has also been examined (Niedenthal, 2007). For example, it has been shown that people mimic facial expressions of others, even when these are presented subliminally (Dimberg,

Thunberg & Elmehed, 2000). Furthermore, Wicker, Keysers, Plailly, Royet, Gallese and Rizzolatti (2003) found that brain areas associated with feelings of disgust overlap with brain areas associated with seeing disgust in other people. Support for the interaction between bodily states and cognitive processing of emotion comes from Glenberg, Havas, Becker and Rinck (2005) who show that the unobtrusive manipulation of a happy or angry expression affects the reading speed of positive or negative sentences. In addition, it has also been found that approach or avoidance movements interfere with the categorization of positive and negative stimuli (Neumann & Strack, 2000; Neumann, Förster & Strack, 2003; Rotteveel & Phaf, 2004). Finally, there is extensive support for the idea that the processing of (emotion) concepts is accompanied by simulation in sensory motor areas in the brain (Chao & Martin, 2000; Pecher, Zeelenberg & Barsalou, 2003; Vermeulen, Niedenthal & Luminet, 2007).

Yet, based on the aforementioned experimental work it is not possible to draw conclusions about spontaneous embodiment effects when processing conceptual emotion knowledge as predicted by embodiment theories (Barsalou et al., 2003a, Niedenthal et al., 2005b). First, experiments showing overlap between personal emotions and emotion from others (Wicker et al., 2003) and imitation (Dimberg et al., 2000) do not imply that embodiment effects occur when merely processing conceptual knowledge without an interpersonal component. Second, even though results from facilitation/interference paradigms lend support for the idea that bodily reactions can influence categorization processes; these studies manipulate bodily reactions and therefore no conclusions can be drawn about spontaneous expressions. In contrast, the current study manipulated the activation of emotion knowledge and measures spontaneous embodiment effects as a dependent variable. And third, despite the fact that the brain is undeniably a part of the body, it can not be inferred from studies on simulation in the brain that activation of conceptual emotion knowledge will result in overt bodily expressions.

Barsalou and colleagues (2003a) predict that the activation of conceptual knowledge can lead to "full blown" execution of behavior. Still, experimental evidence for this prediction has, until now, only been found for non-emotional concepts, such as the elderly (Bargh, Chen and Burrows, 1996). Thus, it is still an empirical question whether the activation of conceptual emotion knowledge leads to the execution of overt emotional actions or expressions. In addition, another open question is whether embodiment effects can be extended to re-enactment in the introspective system when emotion knowledge is activated. According to Barsalou (1999) introspective states are central to abstract concepts and might be simulated on a conscious level when situated conceptualizations become active (Barsalou et al., 2003a). The current study is designed to answer these two questions. Following embodiment theories, we hypothesize that the activation of emotion concepts will result in spontaneous expressions of both bodily reactions and subjective states that are typical for the specific emotion.

The embodiment of pride and disappointment

The present experiment aims to test predictions from embodiment theories by focusing on postural changes. Posture is considered as one of the non-verbal components of emotional reactions (De Gelder, 2006) and there is experimental support for the idea that people respond to emotional stimuli with changes in posture (Hillman, Rosengren & Smith, 2004). A strong relation between emotional experience and posture is also evident from postural feedback effects showing that adopting postures can influence affective states (Duclos, Laird, Schneider, Sexter, Stern, & van Lighten, 1989). Two emotions that have been associated with specific body postures are pride and disappointment/sadness. Tracy and Robins (2004) for example, have found that a typical expression of pride is a visibly expanded posture. Moreover, Stepper and Strack (1993) experimentally varied body postures and demonstrated that this influenced feelings of pride. Their results showed that when participants received positive feedback about their performance on a task, they

reported more pride after being in an upright position than in a slumped position. In contrast, emotions linked to disappointment and sadness are associated with a slumped position or a decrease in posture (Riskind, 1984).

Overview of the present study

The question we examine in the present study is whether the activation of the specific emotion concepts of pride and disappointment are embodied in the sense that they are accompanied by specific changes in posture. These concepts will be activated through a word generation task commonly used to activate semantic or conceptual knowledge (Martin & Chao, 2001). We assume that the word generation task in the present study will not access the lexical system, but the conceptual system by producing words referring to mental states, antecedents and events associated with pride and disappointment (Barsalou, Santos, Simmons & Wilson, 2007). We will asses this assumption by exploring the words generated in the two emotion concept tasks. We hypothesize that the concepts of pride and disappointment are represented by experiences associated with the emotions pride and disappointment. Through the process of pattern completion, the activation of these concepts can result in simulations of both bodily responses and subjective states that belong to the situated conceptualizations of pride and disappointment (Barsalou et al, 2003a; Niedenthal et al., 2005b). Therefore we will measure both posture change (along a vertical and horizontal axis) and subjective feelings of pride and disappointment. Our first prediction is that the activation of the concept of pride will lead to an expanded posture and the activation of the concept of disappointment will lead to a slumped posture. Our second prediction is that accessing the concepts of disappointment and pride will result in congruent feelings.

Method

Participants

Sixty-five undergraduate psychology students participated in the study for course credit or a payment of 7 euro. All participants gave informed consent for the

recording and use of audio-video material. Participants were debriefed through email after full completion of the experiment. Five participants were excluded from the posture analysis, because they had moved out of range of the digital video camera. Three participants were excluded because of system failure during the registration of posture. Thus, analyses were performed on fifty-seven participants (52 women).

Design

The experiment was conducted as a complete within-subjects design. Participants completed four different word generation tasks concerning four different concepts: two neutral tasks (bathroom and kitchen) and two emotion tasks (pride and disappointment). Participants always started with a neutral task followed by an emotion task. The specific combination of the neutral and experimental tasks was counterbalanced. (i.e., kitchen - pride, bathroom - disappointment; bathroom - pride, kitchen - disappointment; kitchen - disappointment, bathroom - pride and bathroom - disappointment, kitchen - pride). The dependent measures were vertical and horizontal changes in posture and subjective reports of pride and disappointment.

Materials and procedure

Before the start of the word generation tasks, participants were asked to complete a "wellbeing" scale (Hess & Blairy, 2001). This scale consists of 28 items describing emotional states ('I feel cheerful', 'I feel irritated') and physical sensations ('I have butterflies in my stomach', 'I feel dizzy'). Participants were asked to circle the number best describing their state at that moment. Participants could provide their answer on a scale from 0 (not at all) to 6 (to a strong extent). Two questions targeting pride and disappointment were added to this questionnaire, namely "I feel good about myself" and "I feel bad about myself". We decided not to ask for pride and disappointment ratings directly to prevent priming the target concepts. The wellbeing scale was administered three times: at the beginning of the study, after the

first emotion concept task (pride or disappointment depending on the counterbalance condition) and after the second emotion concept task.

The general instruction and all consecutive instructions for the different concepts were presented on the computer screen. To obscure the goal of the study, participants were explained in the general instruction that the experimenter was looking for words associated with specific categories to generate stimulus material. It was emphasized that both single words and descriptions using multiple words could be generated. Participants were told that the tasks took one minute and a half to complete during which a clock showed the remaining time on the computer screen. Participants wore a headset with a microphone to record the words. Finally, participants were told that at random moments during the four tasks they would be asked to fill in a wellbeing questionnaire. After this general instruction, instructions for the different word generation tasks were given.

Participants were asked 'to generate as many words possible that are associated to kitchen; bathroom; success/pride; failure/disappointment. We decided to use the combination of success/pride and failure/disappointment for two reasons. First, the combination with success and failure made the concepts very self-relevant for the first-year students participating in our study. Since self-relevance can enhance embodiment effects (Niedenthal, Barsalou, Ric & Krauth-Gruber, 2005) we added words associated with personal achievement. Second, most experimental work on posture and feelings of pride and disappointment incorporate task feedback, thereby making a connection with achievement (Roberts & Arefi-Afshar, 2007; Stepper & Strack, 1993). To match these studies we combined the emotion words with achievement antecedents.

After the word generation tasks an exit questionnaire was presented. First, participants were asked some demographic questions. Then they were asked to rate on a scale from 0 (not difficult at all) to 6 (very difficult) the difficulty of the four word generation tasks. To examine the emergence of autobiographical memories

during the word generation task we asked participants to rate on a scale from 0 (not at all) to 6 (to a strong extent) whether autobiographical memories were activated and used when generating words. Finally, participants were asked in an open question about the possible goals of the study. After they finished the exit interview they were thanked and received their course credit or payment.

Posture registration and data reduction

During the word generation tasks participants were seated in a chair that was bolted to the floor. Posture changes could therefore not be attributed to movement of the chair. Participants were wearing a headset for the registration of the audio input. The top of the headset, corresponding to the top of the head of the participant, was marked with a yellow stripe to make objective coding of posture height possible. To ensure that the placement of the headset remained constant during the four tasks, participants were asked not to move their headset or to touch it during the tasks. A digital camera was hidden inside a carton document file planted on a bookshelf standing at a distance of 2.7 meter on the left hand side from where the participant was seated. The camera filmed participants from the side during the four different word generation tasks. The four 90 seconds video files were scored using an in-house developed scoring program. Posture was scored blind to condition by clicking on the highest visible part of the yellow stripe on the head of the participant. The scoring program identified the coordinates in pixels (x, y) belonging to this position. This procedure was repeated every two seconds, resulting in 46 data points representing the horizontal and vertical position of the marked point on the head of the participant over time. These coordinates were taken as an objective measure of both vertical and horizontal movements of the participants during the word generation tasks. Because we unobtrusively placed a grid based "work schedule" on the wall behind the participants it was possible to calibrate changes in pixels to changes in millimeters. Adjusting for the distance between the camera and

the participant and the distance between the camera and the wall, we calculated that a change of 1 pixel corresponds to roughly a change of 1 millimeter in height.

After the collection of 46 data points in all four word generation tasks, data was transformed in two steps. First, we performed a baseline correction in which all 46 data points gathered during the pride and disappointment task were corrected for the average posture height in the last 10 seconds (i.e., 5 data-points) of the preceding neutral task. We decided to perform this baseline correction to be able to see whether generating pride and disappointment words led to any changes in posture compared to the generation of neutral words. This correction resulted in two postural change scores with 46 levels each, representing the change in posture height during the pride task compared to the last part of the preceding neutral task and the change in posture height during the disappointment task compared to the last part of the preceding neutral task. Second, we reduced the number of data points from 46 to 5 by averaging data points 2 to 10, 11 to19, 20 to 28, 29 to 37 and 38 to 46. The first data point was skipped to create equal numbers in every cell. This was done for both the pride and the failure condition and resulted in two postural change scores with 5 levels each, representing the average change in posture height for 18 seconds of word generation. The main analysis for posture height presented in the results section is performed with these postural change scores, the analysis on horizontal movement is based on scores calculated in exactly the same way. Where necessary, *F*-values are corrected for violation of the sphericity assumption using the Greenhouse-Geisser procedure.

Results

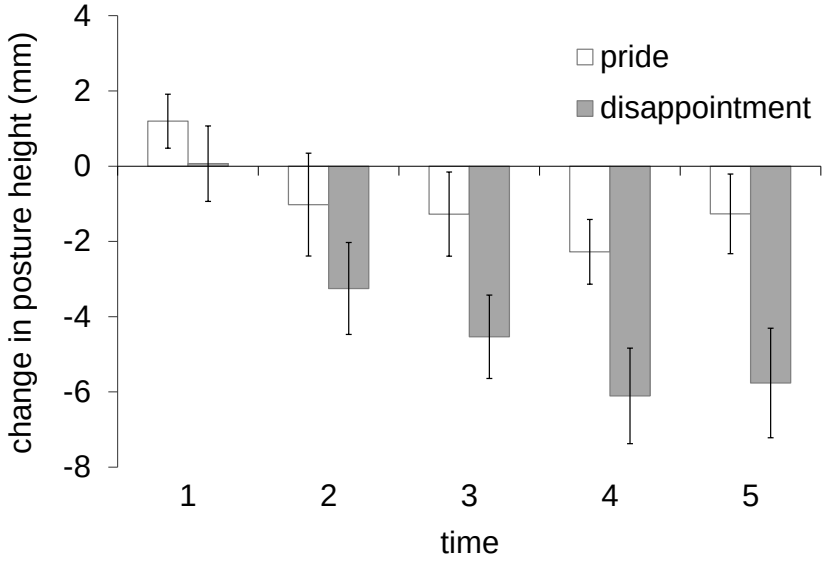
Posture height

A repeated measures analysis was performed with postural change along the vertical axis as the dependent variable and two within factors: *time* (5 levels) and *concept* (two levels: pride and disappointment). This analysis showed a main effect for concept, $F(1, 56) = 5.07$, $p = .028$, $\eta_p^2 = .083$, such that during the disappointment

task participants decreased their posture height significantly more (M = -3.92, SE = 1.12) than during the pride task (M = -.93, SE = .89). Second, there was a main effect for *time* $F(3, 140) = 16.89$, $p < .0001$, partial $\eta_p^2 = .23$, $\varepsilon = .63$, indicated by a general decrease of posture height over time. This general decrease over time was qualified by a significant *concept* x *time* interaction, $F(3, 164) = 2.82$, $p = .042$, $\eta_p^2 = .048$, $\varepsilon = .73$. Simple effects for successive time points indicate a significant decrease in posture height in the disappointment condition between time points 1 and 2 ($p < .001$), 2 and 3 ($p < .05$), and 3 and 4 ($p < .01$) whereas comparisons between these time points did not reach significance in the pride condition. In the disappointment condition participants decreased their posture height up to 6.1 pixels, which corresponds to a decrease in height of 6 millimeters. In the pride condition participants decreased their posture height up to 2.3 pixels, corresponding to a decrease of 2 millimeters.

In line with our expectations the results show that participants decreased their posture height during the generation of disappointment words, whereas contrary to our expectations participants did not increase their posture height when generating pride words. However, note that the first data point for pride in Figure 1 is a positive number, indicating an increase in posture height compared to the final part of the preceding neutral task. To explore this increase further we decided to perform 9 one-sample t-tests (one-tailed) to test whether the first 9 data points in the pride condition (which are underlying the first averaged data point) are significantly larger than zero. Using a stringent p-level of .005 by applying the Bonferroni correction, we found that for point 3 ($t(56) = 2.76$, $p < .004$), corresponding to the 6th second of the pride task, and for point 5 ($t(56) = 2.76$, $p < .004$), corresponding to the 10th second of the pride task, posture height differed significantly from zero, which indicates an increase in posture height.

Figure 1. Average change in posture height (y-axis, in millimeters) over time during the pride and disappointment word generation tasks. Error bars represent standard errors.



Horizontal movement

Participants can move along a vertical axis, indicating posture height, but they can also move along a horizontal axis, indicating movement forward or backward. Since our predictions are specifically about posture height, we expect no differences between the pride and disappointment condition in terms of horizontal movement. This was indeed the case, a repeated measures analysis with horizontal movement as the dependent variable and *time* (5 levels) and *concept* (two levels: pride and disappointment) as within variables showed no main effect of *concept*, $F<1$, and no interaction between *time* and *concept*, $F<1$. The main effect of time, however, was significant, $F(2, 125) = 5.51$, $p = .004$, $\eta_p^2 = .09$, $\varepsilon = .56$, indicating a general movement forward over time.

Subjective reports

Two items in the wellbeing questionnaire specifically targeted pride ("I feel good about myself") and disappointment ("I feel bad about myself"). After correction for the subjective state at baseline, we performed paired sample t-tests to compare mean changes in subjective state after the generation of pride and disappointment words. For the disappointment item we found a significant difference, $t(56) = 1.73$, $p = .045$ (one-tailed), such that participants felt worse about themselves after generating disappointment words ($M = .09$, $SD = 1.24$) than after generating pride words ($M = -.12$, $SD = .98$). The item targeting pride did not show any significant effects. In addition, we looked at the single item "irritation" to control for possible differences in the amount of irritation participants felt during the generation of pride and disappointment words. The paired sample t-test approached significance, $t(56) = 1.94$, $p = .057$. Irritation increased more compared to baseline after generating disappointment words ($M = .26$, $SD = .88$) than after generating pride words ($M = .05$, $SD = .61$).

Because the goal of our study was to find embodiment effects, it is important to rule out that the decrease in posture height after generating disappointment words is caused by changes in emotional states, such as feeling bad about oneself or irritation. We therefore added the scores for these states as covariates to the main analysis on posture height. None of these analyses showed any main effects of the covariates or any interactions between the covariates and the factors *concept* and *time* (all p-values > .2). Furthermore, even though no covariates were significant, adding these covariates to the analyses resulted in highly similar effects as the formerly presented analysis.

Difficulty and autobiographical memory

Participants found it significantly harder to generate pride ($M = 4.04$, $SD = 1.33$) and disappointment ($M = 4.31$, $SD = 1.41$) words than kitchen ($M = 1.73$, $SD = 1.31$) and bathroom ($M = 1.76$, $SD = 1.23$) words (all t's $(44) > 9.00$, $p < .001$). However,

neither the two control tasks nor the two experimental tasks differed from each other in perceived difficulty. Most participants indicated that they had retrieved and used autobiographical memories during the generation of the pride and disappointment words. The two experimental tasks did not differ in the extent to which participants *retrieved* autobiographical memories during word generation. The extent to which participants reported to have actually *used* their memories differed marginally between experimental tasks: in the pride task participants made more use of their memories than in the disappointment task, $t(48) = 2.00$, $p = .053$. There were no significant correlations between task difficulty and postural change and the retrieval and use of autobiographical memories and postural change.

In the exit questionnaire we probed participants for possible ideas about the goal of our study. Importantly, none of the participants made remarks about a relation between the words generated and posture. In addition, none of the participants showed any suspicion about being filmed or the presence of the hidden camera.

Pride and disappointment words

According to Barsalou et al. (2007) properties generated for abstract concept focus mostly on mental states and events. These sort of generated words fall under the category of object-situation responses and are indicative of the use of situated simulations. Consistent with this view we found that most words verbalized by the participants were descriptions of situations, personal attributions, events and reactions associated with pride and disappointment. For pride, participants listed school, sport and university as associated concepts in general, but they also referred to specific antecedents, such as "good marks", "winning a game", "diploma" or simply "did well". Participants also generated words related to consequences of pride and success, such as "applause" or "throwing a party" and words referring to emotional reactions ("feeling happy"). In addition, many participants listed words

associated to self-esteem and most people referred to significant others (parents, friends, family).

For disappointment, most participants listed antecedents of disappointment or failure, either very broad ("doing bad", "losing" or "bad preparation") or more specific ("failing psychophysiology exam" or "getting an F"). More general concepts were also mentioned, such as school, exams and driving test. Similar to pride, words referring to family and self-esteem were also listed. In addition, many participants listed different emotion words, such as "shame", "fear", "feeling angry", "depression" and "crying". Interestingly, some participants referred to the future with expressions such as "better next time", or named potential strategies for future success ("work harder").

Participants did not differ in starting time (in seconds) when generating pride (M = 6.9 sec, SD = 4.0) or disappointment words (M = 7.5 sec, SD = 2.8), $t(55) = 1.08$, $p = .29$, nor did they differ in time when they stopped generating pride (M = 74.6 sec, SD = 19.0) or disappointment words (M = 70.9 sec, SD = 20.4), $t(55) = 1.47$, $p = .15$. In terms of numbers, participants generated significantly more words in the pride condition (M = 12.6, SD = 4.7) than in the disappointment condition (M = 11.3, SD = 5.0), $t(51) = 2.38$, $p < .05$.

Discussion

The results of this study clearly show a decrease in posture height along the vertical axis during the generation of disappointment words, whereas this decrease was absent during the generation of pride words. This finding confirms our prediction that the activation of emotion knowledge about disappointment can lead to the spontaneous adaption of the posture associated with this emotion. In addition to vertical changes in posture, we also examined horizontal changes in posture. In line with our predictions, we did not find horizontal changes during the generation of pride and disappointment words. This suggests that embodied reactions when accessing knowledge about disappointment are specific to changes in height.

Although we can conclude that posture changes were congruent to the activated concept of disappointment, we cannot draw straightforward conclusions about posture changes when activating knowledge about pride. The data did show an increase in posture height during the first moments of the pride task; however this effect was rather weak and should therefore be interpreted with caution. It is an intriguing question why we found a stronger embodiment effect for disappointment than for pride. There are two factors in the current study that might have influenced this finding. First, the general effect of slouching in our experiment, as indicated by the main effect of time, could have inhibited an increase in posture height. Apparently participants relax during the word generation tasks and therefore decrease in height, because they take a more comfortable position in the chair. The finding that this decrease in height was less strong in the pride condition could suggest a weak embodiment effect, which was not strong enough, however, to counter the general slouching. Second, the majority of our participants were women. Since it has been found that proprioceptive effects of upright posture work stronger for men than for woman (Roberts & Arefi-Afshar, 2007) it is possible that men are more sensitive to pride manipulations. Thus, an increase in posture when generating pride words might have occurred when testing only male participants.

The current findings support the core assumption of embodiment theories that conceptual knowledge is represented by simulating bodily states and that accessing this knowledge can lead to re-enactment of these states (Barsalou, 1999; Niedenthal et al., 2005a). The finding that the body posture associated with disappointment (Riskind, 1984) is adopted when people think about this emotion, suggests that bodily states can be spontaneous and overtly re-enacted when accessing emotion concepts. Barsalou and colleagues (2003a) propose that the activation of situated conceptualizations can lead to embodied reactions through the process of pattern completion. In our case this would mean that the activation of the situated conceptualization of disappointment activated associated components, such

as body posture, that were consequently re-enacted. As predicted, we found overt re-enactment in both the body and the introspective system. First of all, the generation of disappointment words resulted in a slumped body posture. Second, our data showed re-enactment of actual feelings of disappointment when thinking about this concept. This was indicated by the finding that participants felt "bad about themselves" to a larger extent after generating disappointment words than after generating pride words. This would be in line with Barsalou's (1999) claim that introspective experiences can be re-enacted in the same way as bodily reactions when conceptual knowledge is activated.

However, since exit data indicated that participants used autobiographical memories in the word generation tasks, the increase in negative feeling after the disappointment task could also be an autobiographical memory effect (i.e., thinking about your own failures makes you feel bad about yourself). If this is the case, this may suggest that it is not the activation of the concept per se, but rather the experience of emotion caused by the emergence of memories that explains the changes in posture. However, because covariance analysis gave no indication that subjective feelings of disappointment were mediating the effect on posture, it is more likely that the feeling state is an embodiment effect in itself (i.e., accessing conceptual knowledge about disappointment does not only decrease your posture, but also makes you feel bad). Research on the postural feedback effect (Duclos et al., 1989; Stepper & Strack, 1993) has demonstrated similar forms of re-enactment, where not the activation of a concept, but the adoption of the bodily posture itself leads to congruent subjective feelings.

Concerning the activation of autobiographical memories; it might not be surprising that the activation of semantic knowledge about emotion activates episodic memories. According to Conway (1990) autobiographical memories play an important role in the conceptual representation of emotion. Furthermore, situated conceptualization are based on real-life experiences (Barsalou et al, 2003a) and thus

it is likely that conceptual knowledge also activates memories about instances when one has experienced events associated to that knowledge. Finally, we deliberately incorporated achievement antecedents in our manipulation to make the activated concepts self-relevant, which could have led to the activation of self-relevant experiences in memory. Nevertheless, it would be relevant to further investigate the extent to which the classic distinction between semantic and episodic memory is applicable to conceptual knowledge about emotion, and how this distinction influences embodiment effects.

There are two points of critique about the current study that we would like to discuss. First of all, it is possible that the act of talking influences posture height. However, since participants verbalized more words in the pride condition than in the failure condition, it is unlikely that the act of talking resulted in the decrease in posture height demonstrated in the disappointment condition. Second, our manipulation consisted of a word generation task, which can rely on lexical associations, instead of the more conceptually oriented property generation task. Nevertheless, the words generated in the present study are not indicative of lexical processing. Participants verbalized words that were associated with situations and events concerning pride and disappointment. In addition, participants often generated words referring to emotional and mental states. According to Barsalou and Wiemer-Hastings (2005) information about situations, events and introspections are central to abstract concepts. Thus, the exploration of the words in the present study indicates that participants generated words by processing conceptual meaning. Consequently, we believe that the words generated in both the pride and disappointment condition are indicative of the activation of situated conceptualizations of pride and disappointment (Barsalou et al., 2003a).

To our knowledge the current study provides the first evidence for the claim that the activation of conceptual knowledge about emotion can instantiate spontaneous simulations at an overt level, leading to actual bodily expressions. Yet,

many questions are still open for investigation concerning the overlap between the knowledge activated when talking, thinking or reading about emotion and the actual experience and expression of emotion itself.

Chapter 3

Remembering the Self versus Knowing the World: Emotional Consequences of Episodic and Semantic Fear Representations

Involvement of the self may be a defining difference between episodic memory, holding personal experiences, and semantic memory, holding general, conceptual knowledge. In the present study we test how the retrieval of episodic and semantic emotion knowledge affects bodily, subjective and implicit measures of emotion. Participants retrieved personal fear memories or generated fear words. Consistent with embodiment perspectives we found that both semantic and episodic memory representations of fear resulted in stronger bodily activation than neutral inductions. Nevertheless, the strength of emotion activation differed between conditions; episodic memory activation evoked stronger bodily activity, stronger subjective reports of fear and stronger implicit fear activation than semantic memory activation. In addition, analyses showed that bodily and subjective components of emotion were differentially correlated within the semantic and episodic condition. These findings are discussed in terms of the influence of self-relevance on embodied reactions during emotion knowledge activation.

This chapter is based on: Oosterwijk, Rotteveel & Fischer (submitted)

Most people know from experience that recalling emotional memories can evoke emotional states. Whenever you remember a fearful event, your bodily state may change, and you may feel fearful again. In the present paper we examined whether emotional states can also be evoked when people think about emotion from a more distant perspective, for example when generating words that describe a fearful event. When people retrieve a personal memory emotion knowledge will be activated that revolves around personal experiences (i.e., episodic memory). When people think of emotions more generally, the activated knowledge does not involve the self, but involves conceptual information about emotional situations, states, actions and feelings (i.e., semantic memory). Although the association between episodic retrieval and emotion elicitation is well-known (Bodenhausen, Kramer, & Süsser, 1994; Phillippot, Schaefer & Herbette, 2003), less is known about the relation between semantic retrieval and emotion elicitation, even though it has been proposed that retrieving semantic knowledge about emotion has emotional consequences (Niedenthal, 2007). Moreover, a direct comparison between the potential of episodic and semantic emotion representations to elicit emotional reactions has never been made. The aim of the present study is to test whether these two forms of emotion activation differ in this respect.

According to Tulving (1993) episodic and semantic memory can be seen as two functionally different systems, even though episodic memory is an extension of semantic memory. Episodic memory consists of experiences unique to the individual that are bound to time and place. Semantic memory, in contrast, holds general, conceptual knowledge about the world and is context-free. Semantic and episodic memory cannot be strictly separated. Indeed, you need concepts to talk about your own experiences (Barrett & Fossum, 2001; Robinson and Clore, 2002). Vice versa, episodic memory is linked with semantic memory, because conceptual knowledge is based on personal experience (Conway, 1990; Barsalou, Niedenthal,

Barbey & Ruppert, 2003). Still, we think it is important to experimentally distinguish between these systems, because Wheeler, Stuss and Tulving (1997) propose one major defining difference between episodic and semantic memory; involvement of the self. According to these authors episodic memory is by definition associated with a subjective sense of self (i.e., 'autonoetic awareness') and will therefore involve conscious re-experiencing (see also Wilson, 2002). Semantic memory, in contrast, holds knowledge about the world. Retrieval from this system will be from the perspective of an observer, not a participant. Translated to the realm of emotion, this could lead to the prediction that the retrieval of episodic emotional memories results in a re-experience of the original emotional state, whereas the retrieval of semantic emotion knowledge does not, because it has no direct connection with the self.

Nonetheless, current embodiment perspectives (Barsalou, 2008; Niedenthal, 2007) would argue that semantic memory activation may also evoke emotional states, because knowledge is grounded in experience. Modality-specific states that normally occur during interactions with objects (such as actions, perceptions and introspections) become part of the conceptual representation of those objects and may be re-enacted (i.e., simulated) when knowledge about these objects is activated (Barsalou, 1999). Since knowledge is used in many different cognitive processes, including memory, language understanding and thinking, simulation may play a fundamental role in both episodic *and* semantic memory retrieval. Indeed, this may also be the case for processes in which emotion knowledge is used, because embodiment accounts of emotion processing argue that the same systems that underlie emotional states also underlie emotion knowledge (Niedenthal, 2007; see also Glenberg, Webster, Mouilso, Havas & Lindeman, 2009). Based on these assumptions it can be predicted that concordant emotional reactions, for example bodily states, can occur both during the retrieval of episodic emotional memories *and* during the retrieval of semantic emotion knowledge. An open question is to what extent these simulations differ as a result of the activation of different

knowledge representations as a function of involvement of the self. Simulations may differ, for example, in terms of strength, or in terms of the extension to different components of emotion (i.e., bodily states, subjective feelings).

Previous experiments have never directly compared the emotional consequences of activating semantic knowledge versus personal emotional memories, although embodiment effects have been demonstrated during conceptual emotion processing (Niedenthal, Winkielman, Mondillon & Vermeulen, 2009; Oosterwijk, Rotteveel, Fischer & Hess, 2009; Oosterwijk, Topper, Rotteveel & Fischer, 2010). Making this comparison is important, however, in order to examine the role of self-relevance in knowledge representations and simulation. It has been proposed that embodiment effects are stronger for knowledge that is self-relevant, rendering stronger simulated states (e.g., Niedenthal, Barsalou, Winkielman, Krauth-Gruber, & Ric, 2005; Niedenthal, Roman & Dalle, 2002). This notion fits nicely with the suggestion by Wheeler and colleagues (1997) that episodic memory, because of its association with the self, is by definition associated with subjective feelings or 'mentally travelling back in time'. Semantic memory, in contrast, does not have this close connection with the self, and may therefore be associated to a lesser extent with subjective emotional experiences. Following these assumptions we propose that, even though simulation may occur during both episodic and semantic retrieval, the strength of re-enactment may differ, especially in terms of subjective experience. In other words, the most prominent difference between the activation of semantic and episodic emotion representations may lie in the extent to which emotional states result in consciously accessible feelings.

We designed the present study to investigate both the differences and similarities between semantic and episodic representations of fear. Participants were asked to retrieve either a personal fear memory (episodic induction) or to generate as many fear related words as possible (semantic induction). We measured emotional reactions at a physiological, subjective and implicit level. During memory

induction we measured electrodermal activity as an indication of arousal (Dawson, Schell & Filion, 2000). This provided us with the possibility to examine differences in bodily states when different fear representations were activated (see for a similar approach Oosterwijk et al., 2010). In addition, we asked participants to report on the extent to which they experienced fear during the memory inductions. Finally, because we are interested in a possible differentiation between semantic and episodic emotion activation in terms of emotional reactions that may not be consciously felt, we incorporated an implicit fear task. Self-report questions concerning emotional experiences may only tap emotional reactions that are explicitly labeled as such. Nonetheless, emotional reactions can also occur without accompanying subjective experiences (Winkielman & Berridge, 2004; Lambie & Marcel, 2002) and may thus be only measured with an implicit task. Accordingly we incorporated an implicit fear task a proposed by Rotteveel, den Daas, Wagenmakers and Zeelenberg (in preparation), that may serve as an indicator for the presence of an emotional state.

We test three hypotheses in the present study. First, we hypothesize in line with embodiment theory that both episodic and semantic fear representations are accompanied by an increase in arousal, as measured by electrodermal activity, compared to activating neutral representations. Second, although we hypothesize that both episodic and semantic fear activation can result in physiological responding, we expect that emotion activation is stronger when fear representations are self-relevant. Accordingly, episodic representations should result in stronger subjectively reported fear, physiological arousal, and implicit fear activation, than semantic representations of fear. And third, because we measure subjective fear, bodily activity and implicit fear in one experiment we can directly examine the correlations among these various dependent variables. We assume that bodily activity and *implicitly* measured fear indicate the strength of an *emotional state*, irrespective of whether this state is consciously experienced (Lambie & Marcel,

2002). Therefore, we hypothesize that bodily activity and implicit fear are positively correlated in both the episodic and semantic condition. We further hypothesize that correlations between bodily activity and *subjective* fear should be more pronounced in the episodic memory condition, since memory activation will be self-relevant and hence the emotional state will be more accessible to consciousness (Wheeler et al., 1997).

Method

Participants and design

Sixty-two female psychology students from the University of Amsterdam (average age 20 years) participated for course credit. Four participants were excluded because of system error; which left a total of 58 participants. Participants gave informed consent and explicit permission for analysis of the collected audio material.

The main factor in the present experiment was varied between participants and consisted of the episodic or semantic memory induction. Participants were randomly assigned to one of two inductions. The first part of the study was organized following a 2 (*induction*: episodic versus semantic; between subjects) x 2 (*emotion*: neutral versus fear; within subjects) mixed design. For the second part of the study (i.e., implicit emotion task) only the between factor *induction* (episodic versus semantic) was relevant for analyses.

Manipulations

Concerning the fear induction, we asked participants to recall either a personal experience (episodic memory), or to generate words about a fearful situation (semantic memory). We specifically instructed participants to talk about fear in an interpersonal context because we aimed to increase the similarities of recalled experiences across participants. All instructions were presented on the computer screen. Participants were first asked to think for one minute about their

response before they were asked to start talking for four minutes. A clock on the computer screen indicated the remaining time. Participants were encouraged to keep talking for the complete duration of the tasks.

Episodic manipulation. In the episodic memory induction participants were asked to retrieve a neutral memory and subsequently a personal fear memory. First, participants were presented with the neutral task that instructed them to describe the journey that they took that day to get from home to university. The instruction suggested that they described means of transport, what they saw during the trip and which buildings and streets they passed. Second, participants were presented with the fear memory induction. In this, we emphasized that participants should not retrieve a traumatic memory, but that we were interested in a fear memory that participants had shared with others before. Participants were instructed to talk about a personal fear memory concerning interpersonal contact, focusing on what they saw, felt and what they did in that situation. Participants shared, for example, experiences with fights, physical attacks and other threatening situations.

Semantic manipulation. In the semantic memory induction participants were asked to generate words about a neutral semantic category and subsequently to generate words about fear (see also Oosterwijk et al., 2009). First, in the neutral task, participants were instructed to generate as many kitchen attributes as possible. They were instructed to think about what the attributes look like, what you can use them for, and how they work. Second, participants were presented with the semantic fear induction that instructed them to generate words that were associated with fear in an interpersonal context. As in the episodic condition, participants were instructed to think about what a person can see, feel and do in a fearful situation. Participants generated words such as 'robbery', 'dark', 'attack', 'rape', 'knife', 'scream' and 'flee'.

Dependent measures

Electrodermal activity. Electrodermal activity was measured using an input device with a sine shaped excitation voltage of 1 Vpp at 50Hz, derived from the mains frequency. The input device connected to two 20 mm by 16 mm Ag/AgCl electrodes that were attached to the medial phalanges of the third and fourth fingers of the non-preferred hand. A signal-conditioning amplifier converted the signal into a linear output range of 0 uS to100 uS (measured as a voltage range of -10 to +10 Volt). The analogue output was digitized at 250 samples per second by a 16-bit AD-converter (Keithley Instruments KPCI-3107). Skin conductance responses (SCR) were calculated during the first minute of the memory induction tasks, since all participants, across all conditions, were talking during that period. During this one-minute period an algorithm searched for spontaneous skin conductance responses by identifying changes in the signal with a minimum amplitude of 0.1 uS together with a minimum trough-to-peak length of 100 ms as a valid response. Mean SCR amplitude was calculated by taking the average of all valid responses.

Implicit emotion task. The implicit emotion task is partially adapted from a task introduced by Zeelenberg, Wagenmakers and Rotteveel (2006). The adapted task presented facial stimuli to avoid any overlap between the linguistic nature of the memory induction and the implicit emotion task. The task presented a neutral target face subliminally, after which participants were asked to identify this face among two answer alternatives. Since the target face was always different than the faces presented as answer alternatives, we specifically tested the presence of a bias towards choosing fear stimuli. All faces (562 x 762 pixels) were selected from the Karolinka Directed Emotional Faces set (Lundqvist, Flykt, & Öhman, 1998). Importantly, the 10 neutral targets displayed different models than the answer alternatives. The answer alternatives always presented the same model with two different facial expressions from four categories (fearful, angry, happy and neutral). The answer alternatives consisted of six different sets: fearful-angry, fearful-happy,

fearful-neutral, happy-angry, happy-neutral and angry-neutral. The left-right positions of the unique faces within these different answer sets were fully counterbalanced.

The implicit emotion task was introduced to participants as a task that would examine whether it was possible to 'intuitively' identify subliminally presented faces. The task was presented using the stimulus presentation software 'Presentation' and consisted of 120 trials. Every trial started with a fixation stimulus ('+') presented for 500 ms. Subsequently, the target was flashed for 13 ms, and masked for 1000 ms. Following a short interval of 200 ms, the two answer alternatives were shown. Participants were instructed to choose between these alternatives using the 'a' and the 'l' key on the keyboard. When participants had chosen one of two alternatives a 2000 ms inter-trial-interval was presented, after which the task continued with the next trial.

Exit interview. The exit interview consisted of demographic questions and several questions concerning the experiment. First of all, participants were asked to retrospectively report on the extent to which they experienced fear during the fear memory induction. Participants reported their subjective feelings of fear on a scale from 0 (*'not al all'*) to 6 (*'very strong'*). We decided to ask for retrospective fear ratings because we did not want to make participants' emotional state salient before the implicit emotion task. In addition, the exit interview consisted of several questions about the goal of the experiment. In this, we asked participants about their suspicions concerning the implicit emotion task[1].

Procedure

All participants were tested by a female experimenter. Participants were seated in a separate room and asked to sign the audio-permission form and informed consent. While seated they were connected to the electrodes and provided with a headset. The experimenter explained the audio recordings, and emphasized that she could not hear the participants in the experimenter room. When the

experimenter had left, the memory tasks were presented. After the memory tasks were finished and the experimenter had removed the electrodes, the implicit emotion task was presented. The experiment was completed with the exit interview. Participants were debriefed and thanked for their participation and received their credit. In addition, they received a chocolate bar (Isen, Daubman & Nowicki, 1987) to neutralize possible mood effects elicited by the fear induction.

Results

Subjective fear

A retrospective question tapped subjective feelings of fear when participants talked about semantic or episodic fear representations. As expected, participants reported more fear following the episodic induction compared to the semantic induction, $F(1, 57) = 4.87$, $p < .05$, $\eta_p^2 = .08$. Means are shown in Table 1.

Electrodermal activity

A repeated measures analysis with emotion (control versus fear) as within factor and induction (episodic versus semantic) as between factor was performed on the mean skin conductance response while participants were talking. This analysis demonstrated the expected main effect of emotion, $F(1, 56) = 4.86$, $p < .05$, $\eta_p^2 = .08$. Participants showed stronger mean SCR while talking about fear ($M = .55$; $SD = .33$) compared to talking about a neutral subject ($M = .47$; $SD = .33$). Furthermore, a significant main effect of induction, $F(1, 56) = 4.42$, $p < .05$, $\eta_p^2 = .07$, indicated that, overall, mean SCR during the episodic induction ($M = .60$; $SE = .06$) was higher than mean SCR during the semantic induction ($M = .44$; $SE = .05$). There was no interaction between emotion and memory induction.

Table 1. Mean SCR and subjective fear during the episodic and semantic induction while thinking and talking about neutral subjects and fear. Standard deviations are in parentheses.

	SCR (in uS)		Subjective fear
Induction	Controle	Fear	
Episodic	.57 (.41)	.63 (.35)	2.67 (1.9)
Semantic	.39 (.23)	.48 (.31)	1.65 (1.6)
Total	.47 (.33)	.55 (.33)	2.12 (1.8)

Implicit emotion task

For clarity, and because we are specifically interested in fear, we will not present the data concerning the sets that did not involve fear faces. The implicit emotion task tested whether participants demonstrated a bias towards choosing fear faces. A bias was present when a certain face was chosen significantly more often than 50%. First, one-sample t-tests (test-value 50%) examined whether participants showed a bias for fearful faces (mean percentages are presented in Table 2). Overall, we found a bias towards fear faces (59%), $t(57) = 4.85$, $p < .001$, when fear and angry faces were combined. When fear faces were combined with happy faces, fear faces were chosen significantly less often (45%), $t(57) = 2.35$, $p < .05$, indicating a bias towards happy faces. When fear faces were combined with neutral faces, the percentage of chosen fear faces (46%) did not differ significantly from 50%, $t(57) = 1.79$, $p = .08$, indicating that fear and neutral faces were chosen equally often.

When we examined the percentages of chosen fear faces within the different memory inductions (see Table 2), we found a bias towards fear faces after both the episodic (63%), $t(26) = 5.08$, $p < .001$, and the semantic induction (56%), $t(30) = 2.20$, $p < .05$, when fear and angry faces were presented together. Thus, when choosing between angry and fearful faces, participants in both conditions demonstrated a bias

towards fear faces. To test whether fear faces were chosen more often after the episodic induction compared to the semantic induction we performed a face (fear-angry, fear-happy, fear-neutral) x induction (episodic versus semantic) repeated measures analysis. As expected, this analysis showed a main effect of induction, $F(1, 56) = 7.87$, $p < .01$, $\eta_p^2 = .12$, indicating a higher percentage of fear faces chosen after episodic induction (54%) compared to after semantic induction (47%). In addition, this analysis demonstrated a main effect of face, $F(2, 55) = 17.76$, $p < .001$, $\eta_p^2 = .24$. Simple effects revealed again that fear faces were chosen significantly ($p < .001$) more often when combined with angry faces (59%), than when combined with happy (45%) or neutral faces (46%).

Table 2. Mean percentage that a fear face is chosen while combined with an angry, happy or neutral face. Standard deviations are in parentheses. ** differs significantly from test value 50 ($p < .05$); *** differs significantly from test value 50 ($p < .01$)

	Fear face chosen (mean %) combined with:		
Induction	Angry	Happy	Neutral
Episodic	63.1*** (13.5)	47.7 (15.2)	51.5 (15.1)
Semantic	55.7** (14.5)	43.3** (15.2)	41.2*** (17.5)
Total	59.2*** (14.2)	45.3** (15.2)	46.0 (17.1)

Correlations

We found the expected correlation between the number of chosen fear faces (within the combination fear-angry) and the mean skin conductance response during talking about fear in both conditions ($r = .29$, $p < .05$). In other words, the stronger the physiological reactions while talking about fear, the more participants demonstrated a bias towards fear faces. When these correlations were examined separately within each memory condition, the strength of the correlations was

comparable, although lack of power restricted significance levels (episodic: r = .20, p = .16; semantic: r = .28, p = .07, one-tailed). We found no correlation between subjectively reported fear and the number of chosen fear faces.

In addition, we examined correlations between the physiological reactions and the subjective experience of fear reported by the participants in both conditions. We found a significant correlation between these two dependent measures (r = .27, p < .05). As expected, this pattern was different when we examined the episodic and semantic inductions separately. In the episodic condition the correlation between reported fear when talking about a fearful episode and the mean SCR measured during talking was significant (r = .33, p = .05, one-tailed). Within the semantic induction, however, this correlation was absent (r = .09, p = .32, one-tailed).

Discussion

The present study demonstrated that both semantic and episodic memory representations of fear resulted in stronger bodily activation than neutral inductions. When participants talked about fear, whether it was a personal fear memory, or the generation of words associated with fear, electrodermal activity was stronger than when participants talked about a neutral memory, or generated neutral words.

The present study also demonstrated interesting differences between episodic and semantic memory inductions. Episodic memory activation evoked stronger electrodermal activity overall, stronger subjective reports of fear and a stronger bias towards fear faces compared to the semantic memory induction. In addition, in the episodic condition the strength of electrodermal activity during the fear induction was positively correlated with subjectively reported fear. This correlation was absent in the semantic condition. In both conditions, the bias towards fear faces was positively correlated with electrodermal activity during memory retrieval.

The present findings concerning electrodermal activity support embodiment accounts (Barsalou, 2008; Niedenthal, 2007) by showing that not only episodic memories, but also semantic representations of fear can result in fear-related bodily

activity. Furthermore, our results indicate that episodic memory representations lead to stronger bodily reactions (i.e., arousal) than semantic representations. Thus, even though semantic fear representations result in embodied reactions, these reactions are weaker compared to when personal fear memories are activated. These results emphasize the importance of self-relevance in facilitating embodiment effects (Niedenthal et al., 2005a) and support the idea that retrieval from episodic memory leads to a re-experience of the past event in terms of bodily reactions (Wheeler, Stuss & Tulving, 1997). Re-enactment of bodily states may be associated with episodic memory in general, since we found that the difference in bodily activity between the episodic and semantic induction was independent of emotional or neutral content. This finding could suggest that any memory that implies the self is accompanied by simulations (Wilson, 2002), and that the mental activity associated with these simulations is accompanied by an increased state of arousal (Barrett & Bliss-Moreau, 2009).

Wheeler and colleagues (1997) propose that retrieval from episodic memory is prone to be accompanied by subjective feelings, or 'autonoetic awareness'. This occurrence of self-awareness is supported by our finding that more fear was reported after episodic compared to semantic fear activation. The positive correlation between subjective fear and bodily activity in the episodic condition (but not in the semantic condition) suggests that bodily states and subjective experiences are connected during episodic retrieval to form a multi-component re-experience of the past event. As such, episodic retrieval may result in an *emotional experience*, in which the self-focus implied by the memory activation enhanced conscious experience of bodily activity (Lambie & Marcel, 2002). Bodily activation during semantic retrieval, in contrast, could be seen as an indication of an *emotional state* (Lambie & Marcel, 2002), caused by automatic simulation processes that do not (necessarily) lead to conscious experience (Barsalou et al., 2003a, see for similar findings Oosterwijk et al., 2010).

Finally, we will address the findings from the implicit fear task. We found a significant bias for fear faces after recalling a personal fear memory, and after generating fear words. It is important to note, however, that the relative strength of the bias in the semantic condition remains unclear, because we do not have a no-fear baseline comparison. Nonetheless, the bias for fear faces was significantly stronger after episodic compared to semantic retrieval. Following the notion that the bias task can serve as an implicit emotion measure (Rotteveel et al., in preparation), this finding indicates, in line with our subjective and physiological findings, that the retrieval of personal fear memories is accompanied by stronger emotion activation than semantic retrieval. Interestingly, the bias for fear faces was positively related to bodily activity across conditions, but not to subjectively reported fear. This suggests that the implicit emotion task presented in the present study taps into emotion processes that have not reached consciousness (see Winkielman & Berridge, 2004; Lambie & Marcel, 2002).

The subjective, bodily and implicit measures taken in the present study suggest that activating personal emotion memories can result in a 'full-blown' emotional experience (Barsalou et al., 2003a; Lambie & Marcel, 2002), whereas different components of emotion remain disconnected when general, semantic emotion knowledge is accessed. Involvement of the self may be the factor that either integrates different emotion components, or facilitates subjective or introspective simulation (Barsalou, 1999), when retrieving episodic memories.

Chapter 4

When the Mind Forms Fear: Embodied Fear Knowledge Potentiates Bodily Reactions to Fearful Stimuli

In the present study we tested whether conceptual fear knowledge can 1) evoke bodily reactions, and 2) enhance subsequent bodily reactions to fearful stimuli. Participants unscrambled neutral or fear sentences, and subsequently viewed fearful and neutral pictures in combination with startle sounds. As predicted, we found embodied reactions (i.e., increased electrodermal and corrugator activity) while participants unscrambled fear sentences. Importantly, these embodied reactions occurred in the absence of a subjective fear experience. In addition, we found increased electrodermal activity while viewing fear pictures, and a stronger startle modulation effect, after fear concept activation. Finally, concerning electrodermal activity, our results demonstrated that the effect of concept activation on subsequent emotional responding was fully mediated by participants' embodied reactions. These findings extend recent research on emotion concepts by showing that embodied emotion knowledge potentiates subsequent emotional responding.

This chapter is based on: Oosterwijk, Topper, Rotteveel, & Fischer (2010)

Language can be powerful in eliciting emotion. Our responses to love letters, horror stories, newspaper articles, or dramatic novels are real-life examples of how language can spark emotional reactions. Scientific research supports this link between conceptual processes, such as language, and emotion (Havas, Glenberg & Rinck, 2007; Niedenthal, Winkielman, Mondillon & Vermeulen, 2009; Oosterwijk, Rotteveel, Fischer & Hess, 2009). Still, we know very little about how, or under what conditions, conceptual emotion knowledge changes our reactions to *new* emotional stimuli. Do people respond differently to a spider on the wall after having read a horror story? Intuitively, one might answer this question with 'yes'. Curiously, however, few studies have experimentally tested whether conceptual emotion knowledge affects subsequent emotional responding.

Embodied Emotion Concepts

Fundamental to the link between emotional reactions and conceptual knowledge are theories of grounded cognition (Barsalou, 2008). According to Barsalou (1999), conceptual knowledge is represented through modality-specific simulations of perceptual, sensory-motor and introspective states, which are re-enacted when conceptual knowledge becomes active. Similarly, the Indexical Hypothesis (Glenberg & Robertson, 2000) proposes that simulation of action and perception is causal in language comprehension. Applying these ideas to the domain of emotion knowledge, this means that the same neural and bodily mechanisms activated during emotional experiences may become partially active when emotion concepts are processed (Niedenthal, Barsalou, Winkielman, Krauth-Gruber & Ric, 2005). In addition, these simulations in neural and physiological emotion systems may be a necessary component in emotion language comprehension (Glenberg, Webster, Mouilso, Havas & Lindeman, 2009). Consequently, the essence of understanding a story that describes a fearful experience *is* the very basic re-enactment of fear. In some cases this re-enactment might never reach consciousness (Barsalou, Niedenthal, Barbey & Ruppert, 2003),

but in other cases reading could lead to a raised heart rate, goose bumps, or even a hint of fear.

The embodiment hypothesis that processing emotion concepts produces convergent emotional reactions has gained some experimental support. For instance, Niedenthal et al. (2009) demonstrated that processing emotion words can result in congruent facial activity (see also Foroni & Semin, 2009). Further, embodiment effects were demonstrated in body posture while generating disappointment words (Oosterwijk, et al., 2009), and body movements while reading angry or sad sentences (Mouilso, Glenberg, Havas & Lindeman, 2007). Support was also found for the hypothesis that emotion simulation influences emotion language understanding. For example, Havas et al. (2007) demonstrated that manipulations of facial expressions interact with the comprehension of sentences describing emotion. Taken together, these results suggest that thinking about emotion, using emotion concepts, or processing emotion language can result in simulations of reactions that typically coincide with emotional states.

The activation of emotion concepts can also guide our interpretation of ambiguous stimuli. For example, Maringer and Stapel (2007; but see also Innes Ker & Niedenthal, 2002) demonstrated that conceptual emotion knowledge, activated through a scrambled sentences task, influenced social judgments. Foroni and Semin (2009) further showed that subliminally presented action verbs associated with smiling (i.e., 'to smile') affected judgments about the funniness of cartoons. Furthermore, studies on face perception demonstrated that emotion concepts affect memory for ambiguous faces (Halberstadt & Niedenthal, 2001). And finally, Lindquist and Barrett (2008) demonstrated that knowledge about fear resulted in a different experience of negative affect. Participants who were primed with fear knowledge were more inclined to interpret a negative high-arousal state as evidence that the world was threatening than participants who had been primed with anger knowledge. Thus, these studies show that emotion concepts can serve as important

contextual cues in the search for emotional meaning (Barrett, Lindquist & Gendron, 2007).

Aims of the present research

Most of the previous studies tested how conceptual emotion knowledge affects emotional responding by examining direct embodiment effects during concept activation or subsequent *judgments* of ambiguous stimuli (i.e., morphed faces, undefined arousal). None of these studies tested whether the activation of emotion knowledge can enhance *bodily* reactions to subsequently presented, non-ambiguous, emotional stimuli (such as emotional sounds or pictures). Moreover, previous studies examining embodiment effects (e.g., Niedenthal et al., 2005; Foroni & Semin, 2009) have mainly focused on motor responses (i.e., facial expressions), but emotion concepts may also result in other forms of bodily simulation, such as heart rate changes or electrodermal activity (Glenberg et al., 2009; Niedenthal, 2007). We will therefore examine whether activating conceptual emotion knowledge affects the sympathetic nervous system.

In the present study we focus on fear, primarily because previous research (Bradley, Codispoti, Cuthbert & Lang, 2001) showed that processing fearful stimuli elicits electrodermal activity, which indicates sympathetic nervous system activity (Dawson, Schell & Filion, 2000), and activation of the corrugator supercilii, a muscle involved in frowning (Dimberg, 1986). The first question that we examine is whether electrodermal activity and corrugator activity also occur when people are executing a conceptual fear task. To activate conceptual knowledge about fear, we draw upon the previously used scrambled sentences paradigm (Bargh, Chen & Burrows, 1996; Innes Ker & Niedenthal, 2002). Several characteristics of this task highlight its suitability for activating conceptual emotion knowledge, without introducing additional, confounding processes. First and foremost, previous studies demonstrated that scrambled sentences tasks do not induce emotional states or moods (Stapel & Koomen, 2000; Innes-Ker & Niedenthal, 2002; Maringer & Stapel,

2007). Thus, we assume that this task will not confound the activation of emotion knowledge with the activation of a subjective emotional state. We will test this assumption in a pilot study. Second, the scrambled sentences task activates knowledge in an implicit way (Bargh, et al., 1996). This means that, in contrast to studies in which emotional meaning is made explicit (i.e., Niedenthal et al., 2009; Velten, 1968), the present task will not hold any reference to feelings or emotional meaning. And third, since we do not want to confound the activation of conceptual emotion knowledge with active mental imagery (see for instance Holmes & Mathews, 2005; Jabbi, Bastiaansen & Keysers, 2008; Vrana, 1995), we chose the scrambled sentences task as a linguistic task that focuses on verbal processing.

To demonstrate that the activation of conceptual knowledge about fear can potentiate bodily reactions to fear stimuli, we present neutral and fearful pictures in combination with startle sounds (Bradley et al., 2001) after the scrambled sentences manipulation. During picture presentation, we will measure electrodermal activity, and the startle response (i.e., orbicularis oculi activity), as indicators of fearful responding (Bradley et al., 2001; Vrana, 1995). It is important to note that electrodermal activity is also associated with other negative emotions. For the goal of this study, however, it is not necessary to differentiate between negative emotions; we are interested in a relative difference in the sensitivity to fearful stimuli. Thus, even though the presently used physiological measures are typical (but not specific) for fear, they do offer the potential for testing whether scrambled sentences tasks increase or decrease bodily reactions to fearful stimuli.

In sum, we first aim to show the basic embodiment effect that unscrambling fear sentences compared to neutral sentences will result in 1) stronger skin conductance responses and, 2) stronger corrugator activity. Second, we predict that the activation of fear knowledge will potentiate subsequent bodily reactions leading to 1) stronger skin conductance responses while viewing fear pictures, and, 2) a stronger startle modulation effect. Finally, we propose that bodily reactions to fear

stimuli are potentiated by the prior activation of fear knowledge, *because* of the embodied responses that accompany fear concepts (see also Barrett et al., 2007; Niedenthal, 2007). By measuring embodied responses during concept activation *and* bodily reactions to new stimuli in one experimental design, it is possible to test this link through mediation analyses.

Method

Participants

Ninety students (73 % female, mean age 21.5 years) from the University of Amsterdam participated for course credit or a reward of 7 Euro. Participants gave informed consent and were debriefed through e-mail.

Design

The experiment had a 2x2 mixed design. The between factor, *concept*, manipulated the content of the scrambled sentences (fear versus neutral). The within factor, *picture*, referred to the two categories of pictures (fearful and neutral) presented in the picture viewing task. We measured electrodermal activity and activation of the corrugator supercilii muscle during the scrambled sentences task. During picture viewing we measured electrodermal activity and activity of the orbicularis oculi muscle (startle response).

Materials

Scrambled sentences task. To activate conceptual emotion knowledge about fear, we designed a scrambled sentences task (Bargh et al., 1996; Innes-Ker & Niedenthal, 2002). Although previous research demonstrated that scrambled sentences tasks do not elicit subjective emotional experiences (Stapel & Koomen, 2000; Innes-Ker & Niedenthal, 2002; Maringer & Stapel, 2007), we performed a pilot study to exclude the possibility that the activation of fear knowledge would be confounded with the elicitation of a subjective fear experience. In this pilot study, presented to a different sample of participants, we compared a scrambled sentences task with the presently-used fear sentences with a scrambled sentences task

presenting neutral sentences (i.e., sentences describing farm scenes). Both the twenty-five fear sentences and neutral sentences were mixed with fifteen neutral fillers. After participants (N = 74) had completed the scrambled sentences task, they were asked to subjectively rate their current emotional state, using the Differential Emotions Scale (Izard, Dougherty, Bloxom, & Kotsch, 1974). We calculated a fear score averaging the items afraid, fearful, nervous, tense and worried (range 1 *'not at all'* to 5 *'very strong'*, Cronbach's alpha = .88) and performed an ANOVA to compare this fear score between conditions. We found no difference in fear state between participants who had unscrambled fear sentences (M = 1.42, SD = .511) and participants who unscrambled neutral sentences (M = 1.57, SD = .626), $F(1, 72) = 1.32$, p = .25. As may be apparent from the means, hardly any fear was felt by the respondents.

The scrambled sentences task presented forty scrambled sentences consisting of four words with an added (congruent) filler word. In the fear condition, twenty-five fear sentences described fearful situations ('He bleeds to death (battlefield)'). In the neutral condition twenty-five sentences described neutral situations in and around the house ('She reads a magazine (photo)'). To obscure the fear theme of the task, each condition also contained fifteen neutral filler sentences ('He grabs his towel (shower)'). The sentences were presented in random order using the stimulus presentation software package 'Presentation'. Each trial started with a fixation image that appeared for 1000 ms ('XXXXXXX XXXXXXX'), followed by a scrambled sentence in capitals (Arial, size 16) for 7000 ms (for example: 'BITE POISONOUS IS THE DEATH'). During this time participants were instructed to determine which word did not belong to the sentence; after 7 seconds they were prompted to press the corresponding button. Trials were separated by a variable inter-stimulus-interval of 14, 15, or 16 seconds. In order to strengthen the activation of the concepts, we followed a method introduced by Maringer and Stapel (2007). Participants were instructed to complete fifty sentences, but were interrupted after finishing forty

sentences with the message that time was up and that the task should be completed at a later moment. Participants were informed that most other participants also completed forty sentences.

Picture viewing task. After the scrambled sentences task the picture viewing task was presented. Pictures were selected from the International Affective Pictures System (Lang, Bradley, & Cuthbert, 1995). Thirty-five fearful pictures (e.g., attacking animals, weapons, and accidents) and thirty-five neutral pictures were selected. Pictures were randomly presented using the stimulus presentation software package 'Presentation'. Trials started with a 500 ms fixation cross, followed by a picture shown for 7000 ms, followed by a variable inter-stimulus-interval (14, 15, or 16 sec.). During picture presentation, an acoustic startle probe (a 104 dB, 50 ms burst of white noise) was presented at either 4, 5, or 6 seconds after stimulus onset. Ten trials (five in each category) contained no startle probe at all.

Ratings. In order to check our stimulus material we asked participants to rate the sentences in terms of their association with fear and the pictures in terms of experienced fear and arousal. Ratings were made on a continuous scale (slider) with a minimum score of 0 ('*not at all'*) and a maximum score of 700 ('*very much'*). This task occurred after the main part of the experiment had been completed, using the program 'Authorware'.

Data Collection and Reduction

Skin conductance responses. Electrodermal activity was measured using an input device with a sine shaped excitation voltage of 1 Vpp at 50Hz, derived from the mains frequency. Two 20 mm by 16 mm Ag/AgCl electrodes were attached to the medial phalanges of the third and fourth fingers of the non-preferred hand. A signal-conditioning amplifier converted the signal into a linear output range of 0 uS to100 uS (measured as a range of -10 to +10 Volt). The analogue output was digitized at 250 samples per second by a 16-bit AD-converter (Keithley Instruments KPCI-3107). Skin conductance responses were calculated during the first 7000 ms of

scrambled sentence presentation and the first 4000 ms of picture presentation by searching for troughs and peaks in the signal. Minimum amplitude of 0.02 uS together with a minimum trough-to-peak length of 100 ms was considered a valid response. The data was square root transformed to reduce the impact of extreme values and to normalize the data.

Corrugator supercilii and orbicularis oculi. Facial electromyography (EMG) was collected from the *corrugator supercilii* and *orbicularis oculi* with a personal computer running Vsrrp98 version 6.4 on Windows XP, using two Ag/AgCl mini-electrodes placed below the right eye and near the eyebrow on the left side of the face (Fridlund & Cacioppo, 1986). Data was amplified using a gain of 10.000 and band pass filtered with a setting of 1 – 1500 Hz. The data was integrated using a true-RMS converter ('contour-follower') with a time constant of 25 ms.

Concerning the scrambled sentences task, we measured corrugator activity 0.5 seconds before stimulus onset to obtain baseline values and subsequently for seven 0.5-second epochs, starting at stimulus onset. We decided upon this 3.5-second time frame because we aimed to measure corrugator activity while participants were unscrambling the sentence, and not while participants were determining which button corresponded to the filler word. First, values above or below three standard deviations from the individual mean were removed. Next, change scores were calculated as the activity during every post-stimulus epoch relative to baseline activity. Then another z-transformation was performed. Based on this transformation, we excluded five participants, because three or more data points (out of seven) deviated three standard deviations or more from the general mean. Finally, corrections were made if the assumption of sphericity was violated; the Greenhouse-Geisser epsilon is reported in the results section.

The orbicularis signal was sampled at 250 Hz, starting 50 ms before startle probe onset (baseline) until 200 ms after probe onset. Startle response were identified allowing a start epoch between 10-120 ms and a peak epoch of 20-200 ms,

after stimulus onset. Startle blink *magnitudes* (in microVolts) were baseline corrected and then calculated by subtracting the average EMG during baseline from the maximum peak of integrated EMG. Data was square root transformed. Seven participants were excluded from analysis because more than 50% of their data points were missing or more than 30% of their values deviated three standard deviations or more from the individual mean.

Results

Manipulation Checks

An ANOVA performed on the sentence ratings showed that fear sentences (M = 405, SD = 121) were significantly more associated with fear than neutral sentences (M = 29, SD = 29), $F(1, 88) = 406.96$, $p < .001$, $\eta_p^2 = .82$. Analyses of the picture ratings showed that fear pictures were judged as more fear evoking (M = 283, SD = 164) than neutral pictures (M = 31, SD = 52), $F(1, 87) = 230.95$, $p < .001$, $\eta_p^2 = .73$ and as more arousing (M = 266, SD = 158) than neutral pictures (M = 35, SD = 56), $F(1, 87) = 205.73$, $p < .001$, $\eta_p^2 = .70$. We found no significant effects of concept activation on the fear and arousal ratings of the pictures (all F-values < 1).

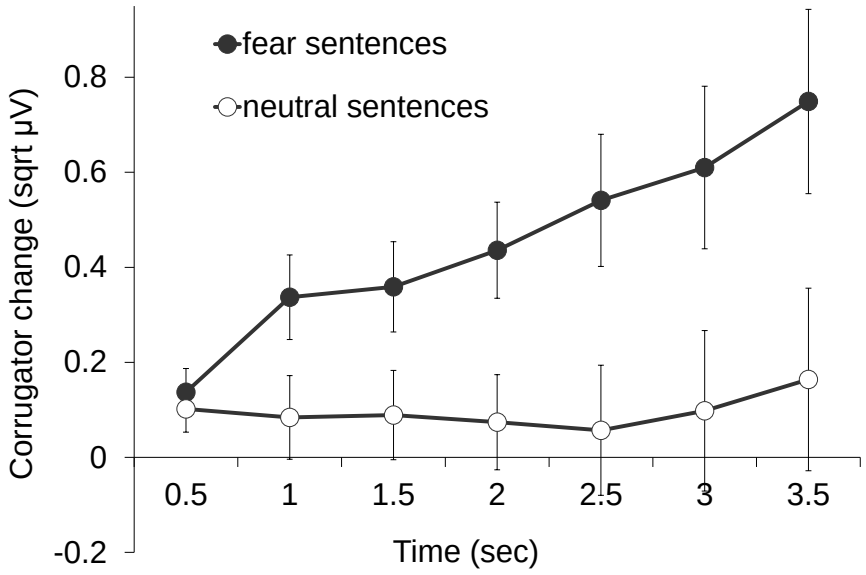
Scrambled Sentences Task

Electrodermal activity. An ANOVA comparing mean SCR for participants unscrambling fear sentences and neutral sentences showed a significant effect of *concept*, $F(1, 89) = 6.99$, $p = .010$, $\eta_p^2 = .07$. Unscrambling fear sentences (M = .513, SD = .396) was associated with stronger SCR than unscrambling neutral sentences (M = .314, SD = .311). To exclude the possibility that stronger SCR in the fear condition was non-specific to fear sentences, we compared fear sentences with neutral fillers within the fear condition. A paired sample t-test showed stronger SCR for fear sentences (M = .513, SD = .396) compared to neutral filler sentences (M = .469, SD = .378), $t(44) = 2.51$, $p = .016$.

Corrugator activity. A mixed-model repeated measures analysis with *concept* as between factor and *time* (7 epochs) as repeated factor demonstrated the expected

main effect of *concept*, $F(1, 83) = 5.65$, $p = .020$, $\eta_p^2 = .06$. Mean corrugator activity was stronger while unscrambling fear sentences ($M = .453$, $SE = .106$) than while unscrambling neutral sentences ($M = .098$, $SE = .105$). The *concept* x *time* interaction approached significance, $F(6, 498) = 2.87$, $p = .061$, $\eta_p^2 = .03$, $\varepsilon = .32$. As illustrated in Figure 2, corrugator activity for fear sentences increased over time, $F(1, 78) = 2.84$, $p = .015$, $\eta_p^2 = .18$, whereas this was not the case for neutral sentences, $F < 1$. To exclude the possibility of a non-specific increase in corrugator activity in the fear condition, we contrasted averaged corrugator activity for fear sentences with averaged corrugator activity for neutral fillers. As expected, we found stronger corrugator activity for fear sentences ($M = .453$, $SD = .671$) than for neutral fillers ($M = .269$, $SD = .492$) within the fear condition, $t(41) = 2.60$, $p = .013$.

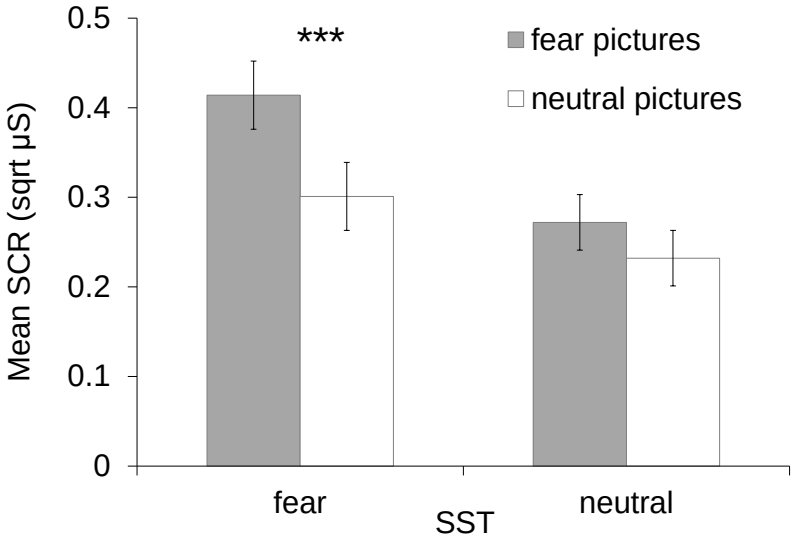
Figure 2. Mean change scores for corrugator supercilii indicate a difference in corrugator activity over time comparing fear and neutral sentences. Vertical bars represent standard errors.



Picture Viewing Task[2]

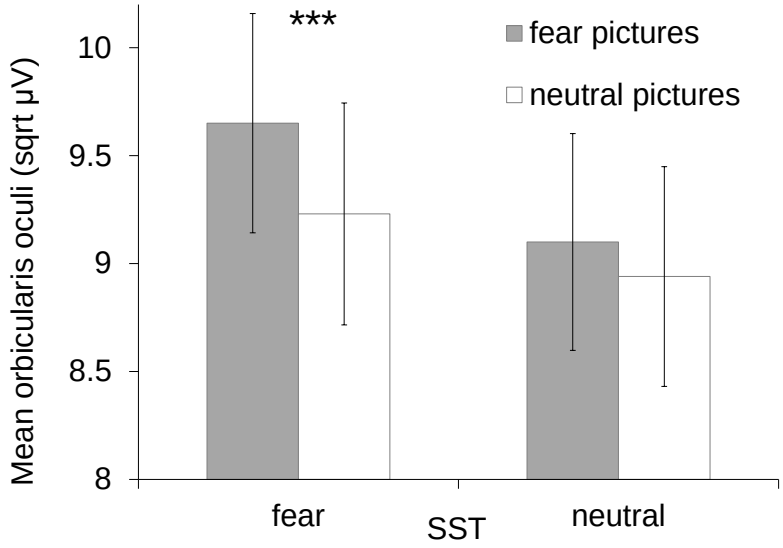
Electrodermal activity. In line with our expectations, skin conductance activity while viewing pictures was modulated by the former activation of fear knowledge. As illustrated in Figure 3, the difference in mean SCR towards fearful and neutral pictures was larger after unscrambling fear sentences compared to neutral sentences. A 2 (*concept*) by 2 (*picture type*) analysis showed a significant main effect of *picture type*, $F(1, 88) = 24.79$, $p < .001$, $\eta_p^2 = .22$, with a stronger SCR for fear pictures ($M = .342$, $SE = .027$) than for neutral pictures ($M = .271$, $SE = .022$), which was qualified by an interaction between *picture type* and *concept*, $F(1, 88) = 5.05$, $p = .027$, $\eta_p^2 = .05$. As expected, simple effects demonstrated a stronger mean SCR towards fear pictures after fear concept activation compared to a neutral concept, $F(1, 88) = 7.07$, $p = .010$, $\eta_p^2 = .07$. Furthermore, simple effects revealed that SCR toward fear pictures ($M = .414$, $SD = .278$) was significantly larger than towards neutral pictures ($M = .310$, $SD = .205$) in the fear condition, $F(1, 88) = 26.10$, $p < .001$, $\eta_p^2 = .23$, whereas this difference ($M = .271$, $SD = .228$ versus $M = .232$, $SD = .214$) only approached significance in the neutral condition, $F(1, 88) = 3.74$, $p = .056$, $\eta_p^2 = .04$. Finally, our data suggested that general arousal was elevated after unscrambling fear sentences. A significant main effect of *concept*, $F(1, 88) = 5.51$, $p = .021$, $\eta_p^2 = .06$, indicated stronger SCR in the fear condition ($M = .362$, $SE = .033$) than in the neutral condition ($M = .252$, $SE = .033$).

Figure 3. Mean skin conductance responses while viewing fearful and neutral pictures show that in the fear condition the response towards fear pictures is significantly larger than in the neutral condition. Vertical bars represent standard errors. *** p < .01



Startle modulation. The expected startle modulation effect was demonstrated by a main effect of *picture type*, $F(1, 81) = 20.94$, $p < .001$, $\eta_p^2 = .21$, indicating larger startle responses while viewing fear pictures ($M = 9.38$, $SD = 3.28$) than neutral pictures ($M = 9.09$, $SD = 3.24$). In line with our expectations, this startle modulation effect was significantly stronger after fear concept activation compared to neutral concept activation (see Figure 4), as demonstrated by a significant interaction between *picture type* and *concept*, $F(1, 81) = 4.09$, $p = .047$, $\eta_p^2 = .05$. Simple effects confirmed that in the fear condition the startle modulation effect was significant, $F(1, 81) = 22.03$, $p < .001$, $\eta_p^2 = .21$, compared to a marginal effect in the neutral condition, $F(1, 81) = 3.22$, $p < .076$, $\eta_p^2 = .04$.

Figure 4. Mean change scores for orbicularis oculi (right) indicate a significantly larger startle response while viewing fearful compared to neutral pictures (startle modulation) only in the fear condition. Vertical bars represent standard errors.
*** p < .01

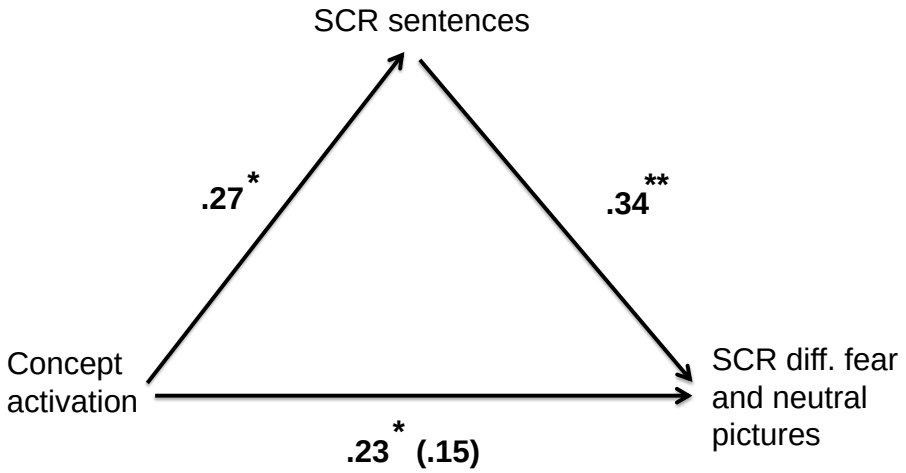


Correlations and Mediation Analysis

We assumed that the embodied responses that accompanied conceptual fear knowledge played an important role in the potentiation of subsequent bodily reactions to fearful stimuli. This assumption would be supported if the effect of concept activation on the response towards pictures would be mediated by the extent to which participants respond physiologically while unscrambling sentences. To examine this possible mediation effect, we dummy coded the independent variable *concept* and calculated a SCR difference score by subtracting SCR towards neutral pictures from SCR towards fear pictures. Regression analyses confirmed that this difference score was significantly predicted by concept activation and the SCR towards sentences (see Figure 5). As expected, controlling for the SCR towards sentences reduced the direct path from concept activation to non-significance, indicating full mediation, Sobel Z = 1.94, p = .026, one-tailed. In addition, we

examined correlations between the other physiological variables. We found a positive correlation between mean corrugator activity during unscrambling of fear sentences and the startle response (r = .28, p = .038, one-tailed). This correlation was absent in the neutral condition (r = .08, ns.).

Figure 5. Mediation model presenting standardized regression coefficients. Full mediation is shown by a reduction in the direct path from concept activation to the difference in electrodermal reactions between fear and neutral pictures, when electrodermal reactions to scrambled sentences are added to the prediction.



Discussion

The findings of the present study provide initial support for the prediction that embodied emotion concepts can enhance subsequent bodily reactions. First, the predicted embodied responses during fear knowledge activation were reflected in increased electrodermal activity and corrugator supercilii activity when participants unscrambled fear sentences, compared to neutral sentences. As demonstrated by our

pilot study, these embodied responses occurred in the absence of a subjective experience of fear. Second, as expected, we found increased electrodermal activity towards fear pictures and a stronger startle modulation effect after participants had unscrambled fear sentences, compared to neutral sentences. Third, the effect of the scrambled sentences task on electrodermal activity towards fearful pictures was fully mediated by electrodermal activity during the scrambled sentences task.

These results expand our knowledge about emotion concept activation in several ways. Grounded cognition theories predict that processing conceptual or linguistic information about emotion may be accompanied by bodily simulations (Barsalou, 2008; Niedenthal et al., 2005a; Glenberg et al., 2009). Our finding that unscrambling sentences about fear activated bodily states supports these views. These results add to former studies that focused mainly on the measurement or manipulation of motor responses, such as facial expressions, body postures or arm movements (Niedenthal et al., 2009; Foroni & Semin, 2009; Oosterwijk et al, 2009; Havas et al, 2007; Rotteveel & Phaf, 2004). Yet, simulations of other physiological states associated with emotion, such as heart rate, hormonal changes, and electrodermal activity, may also occur (Glenberg et al., 2009). The present finding that electrodermal activity increases while fear sentences are unscrambled suggests indeed that bodily simulation goes beyond expressive channels. This is an important extension of the current knowledge of spontaneous embodiment effects while processing emotion concepts.

Moreover, the present study demonstrates for the first time that bodily reactions towards fearful sounds and pictures are expressed stronger when people unscrambled fear sentences (compared to neutral sentences). In other words, the activation of conceptual knowledge about fear *potentiates* bodily reactions to new emotional stimuli. Our data suggests that this potentiation effect may be best understood in terms of the embodied responses that accompany the activation of fear knowledge. Although this link has been proposed before (Niedenthal, 2007;

Barrett et al, 2007), the present study is the first to experimentally test whether embodied responses mediate the influence of conceptual emotion knowledge on subsequent emotional responding. Because our mediation analysis concerned electrodermal activity, and electrodermal activity is an indicator of sympathetic nervous system activity (more commonly called 'arousal'), we can only draw conclusions about the possible role of arousal in the presently found potentiation effect. Importantly, however, we *do* interpret this arousal pattern as a form of simulation (Glenberg et al., 2009). Accordingly, we propose that simulation processes that occur while processing conceptual fear knowledge, prepare the body for fear signals, resulting in a heightened bodily sensitivity to fearful stimuli.

Previous studies have also found that bodily states can influence the way people respond to emotional stimuli. These studies, however, activated bodily states either directly or through manipulations other than linguistic or conceptual procedures. For instance, there is some resemblance between our findings and the well-established excitation transfer effect (Zillmann, Katcher, & Milavsky, 1972). In this effect the activation of arousal, for instance through exercise, 'spills over' and strengthens emotional reactions when participants encounter a new emotional situation. Although not related to arousal, we also see similarities with the so-called afferent feedback effects. These effects demonstrate a relationship between bodily states (such as emotion-related postures and facial expressions) and processing emotional information (Stepper & Strack, 1993; Strack, Martin & Stepper, 1988; Havas et al., 2007). Our findings complement and extend work on afferent feedback and the excitation transfer effect, because in contrast to the direct manipulation of bodily states in the former studies, our study examined spontaneously-produced bodily states while participants processed conceptual emotion knowledge.

Importantly, these bodily states occurred without the involvement of active mental imagery or a subjective emotional experience of fear. In contrast to studies that instructed emotional imagery (Holmes & Mathews, 2005; Jabbi, et al., 2008;

Vrana, 1995), our task focused on verbal processing of conceptual fear knowledge. Further, and in line with previous studies (Stapel & Koomen, 2000; Innes-Ker & Niedenthal, 2002; Maringer & Stapel, 2007), our pilot study clearly demonstrated that unscrambling fear sentences does not lead to a subjective experience of fear. The finding that embodied responses can occur in the absence of a subjective experience of fear is in accordance with embodiment theory. Just as motor simulations may not always initiate actual actions; simulation in the body may not necessarily be accompanied by full-blown subjective experiences (Barsalou et al., 2003a). Nevertheless, we cannot exclude the possibility that participants did experience a diffuse subjective state of arousal during the scrambled sentences task. This does not pose a problem for an interpretation in terms of embodied processes, however. If participants experienced a subjective state of arousal, this may either be a result of bodily simulation or, since embodiment theory predicts introspective simulation during concept activation, a form of simulation in itself (Barsalou et al., 2003; see also Oosterwijk et al., 2009). Either way, it would be interesting to further examine when bodily and experiential simulation occur in parallel during conceptual emotion processing, and whether this depends upon contextual factors such as depth of processing, or current goals (Winkielman, Niedenthal & Oberman, 2009).

Another interesting avenue for further research is to examine how the present finding that fear knowledge potentiates bodily reactions to fearful stimuli relates to suggestions that emotion language may create a context to regulate emotional responding (Niedenthal, Rohmann & Dalle, 2003). For instance, studies have demonstrated that labeling emotional stimuli in terms of their emotional meaning can decrease emotional reactions (Lieberman, Eisenberger, Crockett, Tom, Pfeifer, & Way, 2007; Tabibnia, Lieberman, & Craske, 2008). Future research should examine whether these contrasting results tap into different processes, or whether there is common ground, in order to define the specific conditions under which conceptual emotion knowledge increases or decreases emotional reactions.

In sum, the present study opens up new areas of investigation concerning the effects of conceptual emotion knowledge activation. This may provide new insights in how our current knowledge of emotions may affect subsequent emotional reactions.

Chapter 5

Mental States Inside Out: Switching Costs for Emotional and Non-emotional Sentences that Differ in Internal and External Focus

Mental states, such as thinking, remembering, feeling angry, happy, or dizzy, have a clear internal component. We *feel* a certain way when we are in these states. These internal experiences may be simulated when people understand conceptual references to mental states. However, mental states can also be described from an 'external' perspective, for example when referring to 'smiling'. In those cases, simulation of visible outside features may be more relevant for understanding. In a switching costs paradigm, we presented semantically unrelated sentences describing emotional and non-emotional mental states while manipulating their "internal" or "external" focus. Results show that switching costs occur when participants shift between sentences with an internal and external focus. This suggests that different forms of simulation underlie understanding these sentences. In addition, these effects occurred for both emotional and non-emotional mental states, suggesting that they are grounded in a similar way -- through the process of simulation.

This chapter is based on: Oosterwijk, Winkielman, Pecher, Zeelenberg, Rotteveel & Fischer (submitted)

Everyday language contains many words that refer to people's mental states, such as, anger, exhaustion, or recognition. How do we understand such concepts? Mental states are often accompanied by internal experiences; we may feel something when we are angry, exhausted, or experience a sense of familiarity. These internal experiences may play an important role in understanding conceptual references to mental states, and may even be partly activated when these abstract concepts are processed (Barsalou, 1999).

Grounded cognition theories suggest that conceptual understanding involves the simulation of sensory states (Barsalou, 1999; Gallese & Lakoff, 2005). Importantly, Barsalou (1999) specifically proposes that simulation underlies the representation of abstract concepts, such as 'doubt', 'love' or 'anger' (see also Barsalou, Niedenthal, Barbey & Ruppert, 2003). On this account the representation of abstract concepts involves complex, multi-modal simulations, with a central role for the simulation of introspective experiences. Furthermore, several authors recently proposed that simulation of bodily states and feeling states may be causal in understanding emotion language (Glenberg, Webster, Mouilso, Havas, & Lindeman, 2009) and the use of emotion concepts (Niedenthal, 2007). Taken together, these views suggest that simulations of internal experiences, such as affective states, interoceptive states, and states that result from active self-observation (i.e., introspection), ground conceptual representations of mental states.

Take an emotion term, such as anger. Anger is associated with certain internal sensations, such as a perception of a raise in body temperature (feeling hot). This bodily sensation may be simulated when knowledge about anger is activated (Wilkowski, Meier, Robinson, Carter & Feltman, 2009). Mental states are multimodal concepts, however, and may not only be understood through simulation of internal states. Anger, for example, is also associated with external manifestations on the face (frown) or body (clenched fists) – information that is "on the outside". A focus on external components of anger may therefore involve the simulation of relevant

perceptual features in the visual system. Thus, simulation of mental states may be different depending on the context in which the mental state is situated (Barsalou, Niedenthal, Barbey, & Ruppert, 2003). When a mental state is described in terms of internal experiences, simulation of introspectively accessible features may be relevant to understanding. When a mental state is described in terms of external, expressive manifestations, however, simulation in the visual system may be more relevant.

The link between understanding mental states and simulation has been explored mostly through studies of emotion (Havas, Glenberg, & Rinck, 2007; Niedenthal, Winkielman, Mondillon, & Vermeulen, 2009; Oosterwijk, Rotteveel, Fischer, & Hess, 2009; Wicker, Keysers, Plailly, Royet, Gallese, & Rizzolatti, 2003; for a review see Winkielman, Niedenthal, & Oberman, 2008). Nonetheless, internal states (e.g., subjective feelings, interoceptive activity) also characterize other mental states, such as experiences of visceral states (hunger, dizziness) and states classically seen as 'cognitive' (familiarity, intuition, thinking). For instance, thinking and recalling can feel easy or difficult, as reflected in subjective ratings and physiological indices of effort (Schwarz & Clore, 2007; von Helversen, Gendolla, Winkielman, & Schmidt, 2008). In another example, some propose that interoceptive states of valence and arousal are an intrinsic part of basic processes such as perception (Barrett & Bar, 2009; Barrett & Bliss-Moreau, 2009), recognition (Winkielman & Cacioppo, 2001), and memory (Phaf & Rotteveel, 2005). In addition, Craig (2002, 2009) reviewed evidence that the insula, a brain region associated with interoception, is involved in processing of many different mental experiences, varying from basic visceral states (pain, coldness, hunger) to emotional states (disgust, anger, sadness) and cognitive states (sudden insight, feeling of knowing). All of this evidence suggests that simulation of internal states may also play an important role in the understanding of linguistic references to emotional as well as non-emotional mental states. Accordingly, we propose that the distinction between

internal and external focus can be made for both emotional and non-emotional mental terms. For instance, '*he retrieved the memory from his mind*' invokes an internal experience, whereas '*her face was pale with exhaustion*' invokes an external perspective.

In the present study we examined whether understanding sentences describing mental states via simulation of internal components can be distinguished from understanding sentences describing mental states via simulation of external components. If so, then processing sentences about mental states with different foci should result in switching costs. We further examined whether such switching effects can be obtained across emotional and cognitive domains. If so, this would suggest a similarity in the representation of emotional and cognitive content. Finally, we examined whether there are differences between emotional and non-emotional sentences in the ability to induce (prime) an internal or external focus.

Previous research has found switching costs when properties of verified concepts come from different modalities, rather than the same modality (Pecher, Zeelenberg, & Barsalou, 2003; Marques, 2006; Van Dantzig, Pecher, Zeelenberg, & Barsalou, 2008; Vermeulen, Niedenthal, & Luminet, 2007). For instance, Pecher, Zeelenberg, and Barsalou demonstrated that people verify that *an apple is shiny* more quickly after verifying that *a flag is striped*, than after verifying that *an airplane is noisy*. This effect is explained by flexible simulations in the modalities relevant for verifying the different properties. For example, in order to verify that *an apple is shiny*, the conceptual system will use the visual modality to simulate seeing an apple, whereas in order to verify that *an airplane is noisy*, the conceptual system will use the auditory modality to simulate hearing an airplane. If these different modality specific features are represented by their respective sensorimotor systems, a switching cost is predicted because attention has to switch between different systems (cf. Spence, Nicholls, & Driver, 2000).

The present research investigated whether switching effects occur when

people process sentences with an internal or external focus. Instead of examining simulation in the classic sensory modalities (vision, audition, smell, taste and touch) while processing concrete concepts, we examine interoceptive and visual simulation while processing sentences describing abstract mental states. To do so, we contrasted sentences inviting simulation of internal states (internal focus) with sentences inviting visual simulation (external focus). This distinction between sentences with internal focus and external focus was tested in a pilot study. Subsequently, we presented these sentences in a switching cost experiment and predicted that processing sentences describing mental terms in the same modality should be faster than processing sentences describing mental terms that cross modalities.

Furthermore, we hypothesized that conceptual knowledge about emotional and non-emotional states relies on similar processes. Therefore, we presented sentences about emotional and non-emotional mental terms in the same switching cost experiment. If switching costs across these domains are found, this would support a counterintuitive notion that "emotional" and "cognitive" mental states are understood via similar mechanisms of representation.

Pilot

Participants

The pilot study was conducted on 51 students from the University of California, San Diego, who participated for course credit. Half of the participants rated the sentences on internal focus (n = 23), and the other half rated the sentences on external focus (n = 28).

Materials and Procedure

We created 200 sensible sentences referring to 10 emotional states (i.e., *guilt*, *shame*, *disappointment*, *sadness*, *fear*, *anger*, *disgust*, *pride*, *happiness* and *love*) and 10 non-emotional states (i.e., *meditation*, *dizziness*, *intuition*, *doubt*, *hunger*, *thinking*, *remembering*, *tired*, *puzzled* and *visualization*) and varied the internal or external focus

of these sentences. The total set consisted of the following four subsets: Fifty non-emotion sentences with internal focus (*he was famished by the end of the race*, *the phone number came back to her in a flash*), fifty non-emotion sentences with external focus (*she shook her head in doubt*, *after spinning, she lost her balance*), fifty emotion sentences with internal focus (*hot embarrassment came over her*, *being at the party filled her with happiness*), and fifty emotion sentences with external focus (*his nose wrinkled with disgust*, *she lowered her head with disappointment*). Internal and external sentences incorporated the same, previously specified, set of 10 abstract concepts to ensure that sentences with different foci did not differ in terms of the mental states they described.

Participants rated all sentences on either internal or external focus using Excel spreadsheets. Internal/external focus was introduced as "the extent to which a sentence describes internal/external aspects of an experience". For internal focus it was emphasized that internal aspects of experiences can only be observed by the person himself, whereas for external focus it was emphasized that external aspects can be observed by outsiders. Internal and external focus were rated on a scale from 1 ("no internal/external focus at all") to 5 ("very high in internal/external focus").

Results

As can be seen in Table 3, internal sentences had higher internal focus than external sentences, in both the emotion category, $t(22) = 5.43$, $p < .001$, and the non-emotion category, $t(22) = 6.44$, $p < .001$. External focus was significantly higher for external sentences compared to internal sentences, for both emotion sentences, $t(27) = 8.81$, $p < .001$, and non-emotion sentences, $t(27) = 9.52$, $p < .001$.

Table 3. Internal and External Focus Rating for the Eight Different Sentence Categories (Standard Deviations in Parentheses) in the Pilot Study.

		Sentence category	
Rating dimension	Sentence focus	Emotion	Non-emotion
Internal	Internal	4.4 (.38)	3.7 (.66)
	External	3.7 (.82)	2.8 (.62)
External	Internal	2.2 (.73)	1.8 (.61)
	External	3.7 (.59)	3.7 (.67)

In short, our pilot study established that one can successfully create emotional and non-emotional sentences that refer to the same mental states, but differ in terms of subjectively rated internal and external focus. This sets the stage for the main experiment exploring processing costs when sentences with internal and external focus are contrasted.

Main Experiment

Participants and design

In total, 169 students from the University of California, San Diego participated for course credit. The experiment had a 2x2x2 design. The first two factors were varied within participants and manipulated internal versus external focus (*target focus*) and same versus different focus (*switching*). The third factor was varied between participants and manipulated whether emotion sentences served as primes and non-emotion sentences as targets, or vice versa (*order*).

Procedure

In the main experiment we randomly combined the 200 pilot-tested sentences to form prime-target pairs. The resulting 100 experimental pairs were crossed on the

same-different dimension and the external-internal dimension, creating four groups (i.e., internal-internal, external-internal, external-external, and internal-external). Prime and target sentences were fully counterbalanced over groups and sentences in different groups were matched on length. In addition, we also fully counterbalanced the content of the prime and target sentences within the experimental pairs in terms of the mental states described in the sentences. Emotion sentences and non-emotion sentences served either as targets or primes. Half of the participants were presented with the emotion sentences as primes and the non-emotion sentences as targets, and the other half were presented with the non-emotion sentences as primes and the emotion sentences as targets.

As in previous research with sentences, participants were asked to judge sensibility (Glenberg & Kaschak, 2002). Sensible sentences were mixed with non-sensible sentences ("*the curtains were dry with fear*"). Participants made responses using the "sensible" (m) or the "non-sensible" (z) key. To balance the number of sensible and non-sensible responses, we mixed the experimental pairs with 200 filler pairs. In order to obscure the fact that the sentences were systematically paired, these fillers were combined into 50 sensible-nonsensible, 50 nonsensible-sensible, and 100 nonsensible-nonsensible filler pairs.

Participants first completed 12 practice trials, followed by 300 experimental trials. Every trial started with a fixation stimulus (*****) presented for 500 ms, followed by the prime sentence. The prime sentence was removed from the screen when the participant gave a response or after 4500 ms. After a 1000 ms inter stimulus interval, the fixation stimulus was presented again followed by the target sentence. The target sentence remained on screen until a response was made (but no longer than 4500 ms). Response times (RTs) were measured from the onset of the target sentence. Participants received feedback when they made an error ("incorrect") or responded slower than 4500 ms ("too slow").

Before data analyses, we excluded participants who made more than 20%

errors (twenty-three participants; 14%), indicating that they were not performing the task as instructed or had poor reading skills. The analyses were performed on the remaining 146 participants. It is important to note that we chose this stringent exclusion rate considering the fact that 37% of UCSD students do not speak English as their native language (http://www.ucsd.edu/explore/about/facts.html). Nonetheless, a less stringent exclusion rate of 35% errors or more (leaving out 6 participants) did not change the pattern of our results. Mean RTs were computed for each condition. RTs for trials with incorrect responses to prime or target sentence or RTs more than 3 standard deviations from the participant's mean were excluded.

Results

We predicted that participants would be faster judging subsequently presented unrelated sentences within the same focus (internal-internal or external-external focus) than across focus (internal-external or external-internal). A repeated measures ANOVA showed the expected switching effect, $F(1, 144) = 6.51$, $p = .01$, $\eta_p^2 = .04$. RTs to non-switch trials ($M = 1673$ ms) were faster than RTs to switch trials ($M = 1696$ ms). The interaction between switching (switch, no-switch) and target focus (internal, external) was not significant, $F(1, 144) < 1$, $p = .87$. This indicates that the switching effect was equally strong for targets with an internal and external focus (see Table 4).

We were also interested in whether emotional or non-emotional sentences differed in their ability to prime focus. Although numerically the switching effect was larger for non-emotional targets (31 ms) than emotional targets (16 ms), statistically the interaction between switching and the order of emotional and non-emotional sentences was not significant, $F(1, 144) < 1$, $p = .41$. In addition, there was a theoretically uninteresting main effect of target focus, $F(1, 144) = 20.74$, $p < .001$, $\eta_p^2 = .13$. RTs were faster to internal than external targets (1665 ms vs. 1704 ms). Finally, no switching cost effect was present in the error rates, $F(1, 144) = .88$, $p = .35$.

Table 4. Mean Reaction Times in Milliseconds (RT) and Percent Errors (PE) for Sensibility Judgments in No Switch and Switch Conditions (Standard Deviations in Parentheses).

Condition	RT	PE
Internal target sentence		
No switch	1654 (328)	7.12 (5.8)
Switch	1675 (327)	7.18 (5.6)
Switching cost	21	0.06
External target sentence		
No switch	1690 (355)	7.94 (6.2)
Switch	1714 (341)	7.07 (5.9)
Switching cost	24	-0.87

Discussion

The present study explored whether modality focus effects extend beyond the classic sensory-motor domains into the domain of internal and external aspects of emotional and non-emotional knowledge. The pilot study showed that we successfully created emotional and non-emotional sentences that referred to the same mental states, but differed in terms of subjectively rated internal and external focus. The main experiment demonstrated that sentences describing internal aspects of mental states were judged faster when primed with sentences with the same focus (internal) than when primed with sentences with a different focus (external). A similar switching effect was present for sentences with an external focus.

The presence of switching costs suggests that understanding internal aspects of both emotional and non-emotional states relies on a different process than understanding external aspects of emotional and non-emotional states. Hence we propose, in accordance with theories of grounded cognition (Barsalou, 1999;

Glenberg & Robertson, 2000), that internal and external sentences are understood through simulation in different systems. While external sentences may be associated with simulation in visual systems, internal sentences may be associated with simulation in systems associated with feeling states and interoception, such as the insular cortex (Craig, 2002, 2009). Consequently, the present results may be interpreted as support for an interoceptive or introspective "modality" (Barsalou, 1999). This extends previous work on switching effects that have mainly focused on the classic sensory modalities (Pecher, Zeelenberg, & Barsalou, 2003; Marques, 2006; Van Dantzig, Pecher, Zeelenberg, & Barsalou, 2008; but see Vermeulen, Niedenthal, & Luminet, 2007).

Most concepts, including abstract concepts, are multi-modally represented. Take the example of anger. Anger is associated with internal states (e.g., high arousal, raised body temperature) *and* external features (e.g., clenched fists, a frowning face). As such, both internal and external simulations could underlie understanding this concept. This is consistent with our pilot study that indicated that our sentences were not exclusively internal or external. Hence, the complete simulation that accompanies sentence understanding may be multi-modal (i.e., a mix of different modalities). Nevertheless, the switching cost found in the present study suggests that within this mix of simulations, simulation in one modality is most pronounced. We propose that the internal or external focus of the presently used sentences draws attention to internal or external components of the presented concepts, and that simulation consequently occurs predominantly in the most relevant modality (see also Conell & Lynott, 2009).

The results of this study fit well with the existing literature on emotion and embodiment. Several authors propose that simulation of internal bodily states may be important in the conceptual representation of abstract mental states such as emotions (Glenberg, Webster, Mouilso, Havas, & Lindeman, 2009; Niedenthal, 2007). Our findings provide further support for this proposal and are also in line

with findings that processing conceptual knowledge of emotion activates 'internally-accessible' bodily states, as reflected for example, in electrodermal activity (Oosterwijk, Topper, Rotteveel, & Fischer, 2010).

In addition to supporting embodied processes in emotion concepts, the present results suggest that simulation also underlies the understanding of conceptual references to non-emotional mental states, such as experiences of thinking, remembering, hunger and thirst (Barsalou, Niedenthal, Barbey, & Ruppert, 2003). Although there may be differences between emotional and non-emotional terms (valence, arousal, etc.), our studies point out to important similarities. Most notably, our findings indicate that understanding conceptual references to internal components of both emotional *and* non-emotional states involves internal simulation. This is consistent with the recent suggestion that both emotional states (disgust, anger and other forms of emotional awareness) and cognitive operations (feeling of knowing, sudden insight, decision making) are associated with activity in the anterior insular cortex (AIC), a brain area associated with feeling states and interoception (Craig, 2002, 2009). Hence, an interesting and important avenue for further research is to test whether understanding sentences describing internal components of emotional and non-emotional mental states is accompanied by activity in the AIC. Such a finding would be an important addition to brain imaging studies that demonstrated activity in 'classic' modality-specific areas when people verify perceptual properties (Goldberg, Perfetti, & Schneider, 2006; Kan, Barsalou, Solomon, Minor, & Thompson-Schill, 2003).

In short, our findings highlight two important points. First, switching between sentences about mental states with internal and external focus has processing costs. This suggests that internal states are simulated in a separate "modality" (Barsalou, 1999; Craig, 2009). Second, although important aspects of diverse mental states, such as anger, exhaustion, and remembering, are processed

uniquely, their processing may rely on a shared simulation mechanism. This mechanism allows us to grasp mental states from inside out.

Chapter 6

General Discussion

'Take as much care with words expressing your sentiments, as you will crafting your doctoral dissertation' (Marisha Pessl, 2006, pp. 390).

In the present dissertation we aimed to increase insight in the fundamental issue of how people create emotional meaning when they read, think or talk about emotional events or states. In order to understand the evolvement of emotional meaning in these processes, we have to start with a theoretical account of how emotion concepts are represented.

Emotion concepts hold knowledge about emotional situations, reactions, states and experiences (Niedenthal, 2008). According to amodal views on conceptual representation concepts are represented by abstract symbols that re-describe perceptual, bodily and experiential states (Fodor, 1975; Pylyshyn, 1984; Phillippot & Schaefer, 2001; Teasdale, 1999). In this view, emotion concepts are symbolic representations that are disconnected from what we feel and do when we are experiencing an emotion. Yet, emotions are associated with a great variety of states, including bodily states such as facial and postural expressions, changes in sympathetic nervous system activity and approach and avoidance tendencies (Ekman, 2007; De Gelder, 2006; Chen & Bargh, 1999; Rotteveel & Phaf, 2004; Levenson, 2003; Mauss, Levenson, McCarter, Wilhelm & Gross, 2005). If these states are central to the experience of emotion, and thus represent what emotions *are,* it seems inevitable to incorporate these states into a model of how emotion concepts are represented.

Embodiment perspectives propose that the same neural and bodily mechanisms activated during emotional experiences also underlie emotion concepts (Barsalou, 1999; Niedenthal, 2007; Niedenthal, Barsalou, Ric, & Krauth-Gruber, 2005; Gallese & Lakoff, 2005; Glenberg, Webster, Mouilso, Havas & Lindeman, 2009). During emotional experiences or interactions with emotional stimuli, perceptual (e.g., vision, audition, smell), motor (e.g., actions, expressions), interoceptive (e.g., arousal) and introspective (e.g., feeling angry or sad) states are 'captured' and stored to represent knowledge about emotions (Barsalou, 1999; Niedenthal, 2007). When emotion concepts are activated, meaning arises by simulating these states in the

brain and body. From these theoretical assumptions, it can be predicted that re-enactment of bodily states, for instance as indicated by facial muscle activity or sympathetic nervous system activity, accompanies conceptual tasks in which emotion knowledge is utilized. The presence of such embodiment effects is examined in this dissertation.

We focused on one central question: Do bodily states occur when people think about emotion, remember emotional events or process emotion language? Evidence for the occurrence of bodily states in these tasks would support the core assumption of embodiment perspectives that simulations of emotional states ground emotion concepts (Niedenthal, 2007; Niedenthal, et al., 2005a). Moreover, evidence for embodiment effects during these tasks would imply that embodiment effects occur beyond 'real' interactions. In contrast to research that examines embodiment effects in interpersonal contexts, where it may be directly relevant to 'catch' other people's emotions (Bastiaansen, Thouix & Keysers, 2009; Hawk, Van Kleef & Fischer, in revision), the conceptual tasks in the present dissertation do not present 'real world' emotional stimuli, but activate emotion knowledge offline (Wilson, 2002; Niedenthal, Barsalou, Winkielman, Grauth-Gruber, & Ric, 2005b). Hereby, the present findings forward new insights into the processes that underlie the retrieval of emotion knowledge from someone's own mind or the symbolic representation of emotion through language.

Embodied processes in emotion: Language, thinking and remembering

We will start with an overview of the experimental findings and address how the experimental chapters support and extend embodiment theories. In this overview we will organize the discussion according to content. As such, some parts of the results presented in Chapter 3 and Chapter 4 will be discussed in the following paragraph, whereas other results forwarded by these chapters will be presented in separate sections. Following the overview of the experimental findings

we will briefly touch on the possible limitations concerning an embodied view on emotion concepts and address the broader implications.

Bodily states

The present dissertation clearly demonstrates that our body responds spontaneously when we think about emotion. **Chapter 2** assessed spontaneous changes in body posture when participants thought about the concepts of pride and disappointment. Both pride and disappointment are associated with changes in posture; pride is associated with an upright, expanded posture (Tracy & Robins, 2004; Stepper & Strack, 1993) and disappointment is associated with a slumped posture (Riskind, 1984). Following embodiment views, we predicted that the activation of knowledge about these emotions should result in the spontaneous activation of congruent bodily expressions (Barsalou, 1999; Niedenthal, 2007; Niedenthal et al., 2005a). As expected, the results of this study demonstrated a decrease in posture height during the generation of disappointment words, whereas this decrease was absent during the generation of pride words. The finding that the body posture associated with disappointment is adopted when people think about this emotion, suggests that bodily states can be spontaneous and overtly re-enacted when accessing emotion concepts.

In addition to bodily expressions that can be seen on the 'outside', such as changes in body posture, the present dissertation also incorporated the measurement of 'internal' bodily states. Until now experiments examining the embodiment of emotion concepts have mainly focused on manipulating or measuring facial expressions (Niedenthal et al., 2009; Foroni & Semin, 2009; Havas, et al., 2007). Nevertheless, internal or interoceptive cues from the body (e.g., endocrine or autonomic reactions) are a basic component of emotional experience (Duncan & Barrett, 2007). Consequently, internal states may be captured and stored during emotional experiences to represent knowledge about those emotions (Niedenthal, 2007; Glenberg et al., 2009; Barsalou, 1999). Following this assumption,

it can be predicted that in addition to simulation of facial expressions, internal states may also be simulated when emotion knowledge is utilized in conceptual emotion tasks. This is indeed what we found. **Chapter 3** demonstrated that both episodic fear activation (i.e., retrieving a personal fear memory) and semantic fear activation (i.e., generating fear words) resulted in sympathetic nervous system activity (i.e., arousal); a reaction that is generally associated with fearful experiences. The latter finding that a state of arousal is present when people generate fear words, replicates the findings from Chapter 2 with a non-expressive dependent measure and a different emotion concept.

Both Chapter 2 and Chapter 3 demonstrate that people embody emotional states when they generate emotion words. These results support embodiment perspectives that predict that the use of emotion knowledge in conceptual tasks is accompanied by bodily simulation (Niedenthal, 2007; Glenberg et al., 2009; Niedenthal, et al., 2005a). There is an alternative explanation for these findings, however, that we would like to address. Although the tasks presented in Chapter 2 and 3 are conceptual in nature (Martin & Chao, 2001), and we took great care to instruct our participants to 'just' generate words, some may assume that these tasks worked as direct emotion manipulations, comparable to, for instance the Velten technique (Velten, 1968). If that would be the case the bodily states resulting from the experimental manipulations may not have reflected simulation processes, but 'genuine' emotional reactions resulting from the (mild) subjective experiences of fear and disappointment reported in these studies. Our data does not support this explanation, since we found no correlations between bodily states and subjective experiences when people generated emotion words. Nevertheless, support for bodily simulation during conceptual tasks would be stronger when using a task that would not activate subjective emotional experiences. In **Chapter 4** we report an experiment in which we used a scrambled sentences task, which activates emotion knowledge without the presence of subjective feelings (see also Stapel & Koomen,

2000; Innes-Ker & Niedenthal, 2002; Maringer & Stapel, 2007). We found activity of the sympathetic nervous system (i.e., arousal) and facial muscle activity when people unscrambled fear sentences, without any indication that unscrambling fear sentences resulted in a reportable, subjective state of fear. These findings provide important evidence for spontaneous, multi-component bodily simulations during conceptual emotion tasks (Niedenthal, 2007; Glenberg et al., 2009; Niedenthal et al., 2005a), without the possible objection that these bodily states are 'just' a consequence of the presence of subjective emotional experiences.

The fact that we found bodily reactions in the absence of subjective emotional experience is in accordance with embodiment theory. Conceptual processing will, in most cases, result in automatic simulations that occur outside of consciousness (Barsalou, Niedenthal, Barbey, & Ruppert, 2003). Even though bodily states can be subjectively reflected upon (Duncan & Barrett, 2007), the *simulation* of these states is partial, and may not involve subjective experience (Barsalou, et al., 2003a). Nevertheless, because we found reports of subjective feelings states in the studies presented in Chapter 2 and 3 of the present dissertation, it is important to discuss when bodily and experiential simulation may occur in parallel during conceptual emotion processing, and whether this depends upon contextual factors (Winkielman, Niedenthal & Oberman, 2009). It is to this subject that we will turn next.

The brain, the body and the self

Embodied states can be manifested as patterns of activity in modality specific areas in the brain, as overt bodily reactions or even as subjective experiences that are accessible to consciousness (Bastiaansen, Thioux & Keysers, 2009; Niedenthal, 2007; Barsalou, 1999). On most occasions simulation will be partial, without resulting in full blown subjective experiences or even a measurable bodily state (Barsalou, 1999). For example, reading the word 'kick' leads to neural simulation, but not to an actual kicking movement (Hauk, Johnsrude & Pulvermuller, 2004). On other occasions

simulations may 'rise to the surface', such that conceptual tasks are accompanied by bodily simulations. For example, the body may take on a certain posture, or a heightened state of arousal while reading or thinking about emotions (see Chapter 2, 3 & 4). On yet other occasions conceptual emotion processing may result in subjectively experienced emotion. People may feel anger when they think about a certain emotional event, or become genuinely afraid while reading a story. For instance, in Chapter 2 people reported feelings of disappointment after thinking about this concept.

Some may argue that the presence or absence of subjective experiences is not specifically relevant for embodiment theory, because the occurrence of subjective experiences indicate a 'genuine' emotional response, and not a re-enactment of an emotional state. We disagree with this view, because embodiment accounts predict that introspective experiences (i.e., feeling states) can be simulated during conceptual emotion processing or emotion language understanding (Niedenthal, 2007; Barsalou, 1999; Glenberg et al., 2009; Bastiaansen, Thioux & Keysers, 2009). Because it is assumed that these simulations will occur within the same (neural) systems that are also active during 'genuine' emotional experience (Bastiaansen, Thioux & Keysers, 2009; Niedenthal, 2007; Niedenthal, et al., 2005b), it is quite difficult to differentiate a 'genuine' emotional experience from a re-enactment. Nevertheless, the potential presence of these states during conceptual processing is interesting because it informs us about the power of thought and language. Simply calling these experiences 'actual' emotional responses does not provide us with an explanation about why these experiences occur during conceptual processing in the first place. Embodiment theories, in contrast, provide us with an underlying, testable mechanism that explains these effects.

Embodiment effects are seen as flexible (Winkielman et al, 2009) and dynamic (Barsalou et al., 2003a). Hence, contextual factors and task demands may influence the extent to which embodiment effects are bodily and experientially manifested.

The present dissertation forwards evidence that suggests that self-relevance is a factor that influences the strength of embodiment effects, and more specifically whether the activation of emotion knowledge results in subjective experience (see also Niedenthal, Barsalou, Winkielman, Krauth-Gruber, & Ric, 2005; Niedenthal, Roman & Dalle, 2002). We manipulated self-relevance during the activation of conceptual emotion knowledge in **Chapter 3**, by asking people to retrieve information from semantic and episodic memory. Wheeler, Stuss and Tulving (1997) propose that episodic memory, because of its association with the self, is by definition associated with subjective feelings. Semantic memory, in contrast, does not have this close connection with the self, and may therefore be associated to a lesser extent with subjective emotional experiences. Chapter 3 supports this idea. When people retrieved a personal fear memory, we found stronger electrodermal activity, subjective reports of fear, and implicit fear, compared to when people generated fear words. Moreover, correlation analyses demonstrated a positive correlation between subjectively reported fear and bodily activity during episodic retrieval, whereas this correlation was absent when accessing semantic knowledge. This suggests that bodily states and subjective experiences are connected during episodic retrieval to form a multi-component re-experience of the past event. Accordingly, personal emotion memories may activate 'full-blown' emotional experiences (Barsalou et al., 2003a; Lambie & Marcel, 2002), whereas activating semantic emotion knowledge may not (necessarily) lead to consciously experienced states (see also Chapter 4).

In addition to self-relevance, the present dissertation provides us with other clues to the identification of task characteristics that may potentially influence embodiment effects. First, subjective embodiment effects may more readily occur when people actively retrieve information from their minds, compared to when information is presented *to* them. The present dissertation demonstrated bodily simulation and mild activation of subjective states when people actively accessed

emotion concepts through the generation of emotion words (Chapter 2 & 3). In these situations processing may be deeper and more meaningful (Niedenthal et al., 2005b) than when people process words or sentences provided by the experimenter (as in Chapter 4 & 5). Thus, processing conditions that involve an active search for emotion knowledge may result in 'full blown' simulation (Barsalou et al., 2003a), whereas other conditions, in which emotion knowledge is used more implicitly, may 'just' induce bodily simulation without an accompanying subjective experience. Moreover, under minimal processing conditions (see Vermeulen Mermillod, Godefroid, & Corneille, 2009) simulation may only involve activation in modality specific areas in the brain, without this activation 'leaking through' into the body. Although highly speculative, this could suggest that there are inhibitory links between modality specific simulation, the production of actual bodily activity and subjective experiences. The possible presence of these inhibitory links, and the contextual factors that may influence the activation and deactivation of these inhibitions is an interesting and important avenue for further research.

On a similar note, it can be predicted that simulation processes may be prominent in tasks where meaning is not clear, for example when processing ambiguous stimuli. If embodied processes are underlying the formation of meaning (Glenberg et al., 2009; Zwaan & Madden, 2005; Barsalou, 1999), than bodily and possibly subjective simulation may be most relevant in tasks where meaning needs to be constructed online. This hypothesis awaits further research. In addition, it may also be interesting to further pursue the issue of self-involvement concerning the strength and manifestation of embodiment effects (Niedenthal, et al., 2005a ; Niedenthal, Roman & Dalle, 2002). In the present dissertation we differentiated episodic and semantic memory in terms of self-involvement. Nevertheless, even though self-involvement is seen as a defining characteristic of episodic memory (Wheeler et al., 1997), it may also be possible to 'infuse' semantic processes with the self. For example, self-involvement may affect embodied reactions during active

imagery or perspective taking when processing emotion language. Although it has been demonstrated that imagery cannot explain covert embodiment effects, such as those underlying switching costs (Pecher, van Dantzig, & Schifferstein, 2009), it has never been tested whether active imagery can play a role in the extent to which embodiment effects are *subjectively* manifested. Such research may add to our understanding of why some may feel pangs of fear while reading a book, whereas others simulate on a 'lower level' and never have such experiences. Furthermore, since it has been found that the tendency to become absorbed in fiction predicts social abilities, including empathy (Mar, Oatley, Hirsch, dela Paz & Peterson, 2006; Mar & Oatley, 2008), a thorough analysis of when and how people simulate during reading may be important for educational purposes (Glenberg, 2010) and social learning (Zwaan, 2009).

Emotion concepts potentiate emotional reactions

In addition to demonstrating embodiment effects *during* conceptual processing, the present dissertation examined whether the activation of emotion concepts influences *subsequent* emotional responding. This examination provided us with an important new insight concerning the consequences of activating emotion concepts. In **Chapter 4** we demonstrated that processing conceptual fear knowledge enhances bodily reactions to subsequently presented emotional stimuli. We demonstrated stronger electrodermal activity towards fear pictures and a stronger startle modulation effect when participants had unscrambled fear sentences, compared to neutral sentences. These results are consistent with our prediction that embodied emotion concepts can potentiate bodily reactions at a later time. Importantly, a mediation analysis indicated that this potentiation effect may be best understood in terms of the embodied responses that accompany the activation of fear knowledge. The analysis demonstrated that the effect of the scrambled sentences task on electrodermal activity towards fearful pictures was fully mediated by electrodermal activity during the scrambled sentences task. Based on this result

we propose that bodily reactions are potentiated *because* emotion concepts are embodied, and therefore create a state in the individual that influences bodily sensitivity. This finding is consistent with previous suggestions that embodied emotion knowledge can play an important role in how we perceive and respond to the emotional world (Barrett, Lindquist & Gendron, 2007; Barrett & Lindquist, 2008; Niedenthal, 2007).

Embodied emotion concepts may influence emotional responding in a similar way as directly manipulated bodily states. Previous research has, for example, demonstrated that manipulating a certain body posture or facial expression can influence information processing and evaluation (Stepper & Strack, 1993; Strack, Martin & Stepper, 1988). Furthermore, a state of arousal, activated by physical exercise, can influence how people respond to emotional material (Zillmann, Katcher, & Milavsky, 1972). The crucial distinction between these effects and the findings in Chapter 4 is that we did not directly manipulate a bodily state. In contrast, bodily states were a spontaneous consequence of the conceptual task performed by the participants. Although the results from the mediation analysis support the idea that these bodily changes drive the effect of emotion knowledge activation on emotional responding, other interpretations are also possible. For example, the presently found effect could potentially be caused by a change in interpretation or appraisal of the subsequently presented stimuli. Further research, for instance measuring subjective reports, may shed light on this issue. Moreover, it would be relevant to examine whether conceptual emotion knowledge influences other processes, such as for example attention for emotional stimuli, or whether other emotion concepts, such as disgust or joy, have similar effects on subsequent emotional responding.

It is important to note that bodily reactions were potentiated after emotion knowledge was activated in an implicit way. In contrast to previous research that demonstrated startle modulation after emotional imagery (Vrana, 1995; Vrana,

1994), the present manipulation did not instruct emotional imagery, nor made emotional meaning salient (see also Bargh, Chen & Burrows, 1996; Innes-Ker & Niedenthal, 2002). Consequently, our findings indicate that emotion concepts, even when activated linguistically without an active focus on emotional meaning, still have the potential to influence how people respond to the world. This can have important methodological implications. For example, instructions incorporating emotion words, or words referring to bodily states, may influence emotional reactions at a later time, simply because participants activate embodied representations while processing these words. Furthermore, our finding may have implications for the influence of emotion knowledge in natural settings. People encounter many instances of emotion concepts, for instance while reading a newspaper or having a conversation, without necessarily being fully aware of the emotional content. In these situations, especially when embodied reactions occur outside of consciousness, (Barsalou et al., 2003a; Niedenthal, 2005b), the activation of knowledge may still influence sensitivity to emotional events. The time-course and strength of these effects is an important avenue for further research.

Switching costs

Until now, we have not discussed the results of Chapter 5. The reason for this is that this chapter, although highly relevant for embodiment perspectives, differs from the other experimental chapters with respect to the dependent measure. In this chapter we did not measure bodily states directly, but examined simulation with a switching costs paradigm (Pecher, Zeelenberg, & Barsalou, 2003). In a switching costs paradigm people are asked to verify modality specific properties of concepts (e.g., *'an apple is green'* or *'an airplane is loud')*. If these conceptual judgments are associated with simulation in different systems (e.g., the visual system or the auditory system), then switching costs should occur when people switch from one modality to the other.

Chapter 5 explored whether modality switching effects extend beyond the classic sensory-motor domains of vision, audition, touch, smell and taste. So far, switching effects have been demonstrated when verifying perceptual properties (Marques, 2006; Pecher, Zeelenberg, & Barsalou, 2003; Van Dantzig, Pecher, Zeelenberg, & Barsalou, 2008), or general affective properties (Vermeulen, Niedenthal, & Luminet, 2007). The study presented in Chapter 5 opens up a new domain by examining whether switching costs occur when people switch between visual verification and verification of properties associated with internal states. In this study we focused on emotional (e.g., anger, fear, happiness) and 'non-emotional' mental states (e.g., hunger, dizziness, familiarity, thinking), since all these states involve subjective feelings or interoceptive cues from the body (Craig, 2002; 2009). In line with embodiment theory (Barsalou, 1999; Glenberg, et al., 2009; Niedenthal, 2007), we proposed that these internal experiences are simulated when people process sentences that describe mental states from an 'internal perspective' (i.e., describing feelings and internal bodily states). In contrast, when mental states are described from an 'external' perspective (i.e., describing expressions or actions), simulation of visible outside features may be more relevant for understanding. Evidence for such a process would be forwarded by the presence of switching costs when processing these sentences.

As expected, we found that sentences describing internal aspects of mental states were judged faster when primed with sentences with the same focus (internal) than when primed with sentences with a different focus (external). A similar switching effect was present for sentences with an external focus. These findings suggest that focusing attention on internal or external descriptions of mental states is associated with simulations in different neural systems. For example, understanding sentences describing internal states (e.g., arousal, subjective feelings) may be accompanied by simulation in brain areas associated with feeling states and interoception, such as the insula (e.g., Craig, 2002, 2009). Such an hypothesis could

be tested with a follow-up fMRI experiment that examines the active brain areas during internal and external sentence processing. In addition, further research could also examine whether internal sentence processing results in the simulation of internal states on a bodily level (e.g., cardiovascular changes, electrodermal activity) or in the re-enactment of actual subjective feelings. Because we did not perform the necessary measurements to draw such conclusions it is, for now, impossible to say whether processing internal sentences will result in a similar spontaneous activation of internal states as demonstrated, for instance, in Chapter 3 and 4.

Modal versus amodal views

The present dissertation examined the activation of emotion knowledge from an embodiment perspective. Even though the results of the experimental chapters are indeed supportive of embodiment theories, it is important to ask whether embodiment accounts exclusively explain the present findings. Embodiment accounts predict bodily simulation during conceptual tasks ad hoc, and forward a theoretical explanation for the underlying mechanism (Barsalou, 1999; Barsalou et al., 2003a). Still, amodal accounts may also be able to explain the present findings. Amodal accounts assume that concepts are abstract, 'transduced' representations in brain areas separate from areas that are associated with modality specific states (Fodor, 1975; Pylyshyn, 1984; Phillippot & Schaefer, 2001; Teasdale, 1999). This, however, does not necessarily mean that there are no connections between amodal areas and areas that represent and control perceptual, experiential and bodily states. For example, Mahon and Caramazza (2008) propose that activity can spread from amodal areas, where concepts are amodally represented, to modality-specific areas, resulting in bodily, perceptual or motor activity during conceptual tasks. Importantly, Mahon and Caramazza assume that this 'spreading of activation' is not fundamental or causal to conceptual representation, but may only enrich conceptual understanding. In other words, these authors criticize embodied explanations of conceptual processing by assuming that simulation is not fundamental to conceptual

and linguistic processing, but may be better interpreted as a 'by-effect' or an epiphenomenon.

Recently, a transcranial magnetic stimulation (TMS) study performed by Pobric, Jefferies and Lambon Ralph (2010) has shed more light on this issue. This study demonstrated that stimulation of the anterior temporal lobe (ATL; an area indicated in amodal semantic representation) generates a category-general impairment in naming pictures. In other words, when this area is stimulated all conceptual categories are affected. When, in contrast, the inferior parietal lobule (IPL) was stimulated, which is an area associated with handling tools, a specific impairment was generated in naming pictures that represented manipulable objects. These results suggest that concepts reflect both amodal representations (i.e., abstract redescriptions) in the ATL *and* modality specific representations in the respective modality specific areas (e.g., the IPL). As such, concepts are not represented in modality specific areas alone (i.e., the strong embodiment hypothesis) nor only as amodal, abstract representations (i.e., the amodal hypothesis). In contrast, both ways of representation contribute to conceptual understanding.

With these results in mind, we do not think that the effects found in the present dissertation are 'by-effects' that do not tell us anything about the nature of emotion representation. The findings of Pobric and colleagues (2010) suggest that modality specific simulation is crucial for concepts that involve experiences associated with a particular modality. Following this logic, we assume that emotion concepts, because they are intrinsically linked to perceptual, bodily and experiential states, may be especially dependent upon modality specific representations. For now, much more research is needed to be able to draw strong conclusions about the specific mechanisms that underlie conceptual emotion representations. Nevertheless, even when emotion concepts reflect a combination of amodal and modality specific representation, it is still of major importance to answer the question under what circumstances modality specific simulations represent

emotional meaning, and how these neural simulations result in spontaneous bodily reactions and subjective experiences to aid understanding.

Broader implications

The main goal of the present dissertation was to find evidence for the embodiment of emotion concepts. Our findings, however, are relevant beyond the question of how emotion knowledge is represented. First of all, the embodiment of emotion concepts may have important consequences for emotion regulation. According to Niedenthal, Roman and Dalle, (2003) emotion language may create a context to regulate emotional responding. Some studies have found support for such a proposal by demonstrating that labeling emotional stimuli in terms of their emotional meaning can decrease emotional reactions (Lieberman, Eisenberger, Crockett, Tom, Pfeifer, & Way, 2007; Tabibnia, Lieberman, & Craske, 2008). These results can be contrasted with the findings of Chapter 4 that demonstrate that the activation of emotion knowledge can enhance bodily reactions. At the moment it is unclear whether these different results can be addressed by one theoretical explanation. For instance, it is possible that a trial-by-trial application of an emotion label will result in decreased emotional reactions (see Lieberman et al., 2007), whereas the general activation of emotion knowledge will increase emotional reactions. In other words, actively labelling a single emotional stimulus in terms of its emotional quality may result in emotion regulation, whereas priming emotion knowledge without directly linking it to the stimulus may increase bodily sensitivity. In addition, it may also be possible that emotion knowledge will have a differential effect on emotional responding depending on whether participants are asked to subjectively judge emotional stimuli (as in the labelling tasks) or when physiological reactions are examined without active introspection or subjective report (as in Chapter 4). This question can be answered by examining whether the activation of fear knowledge leads to emotion regulation when participants are asked to subjectively rate their emotional state. In short, in order to define the

specific conditions under which conceptual emotion knowledge increases or decreases emotional reactions further experimental research is warranted.

Another important avenue for further research concerns the implications of embodied processes for emotional learning. Emotion concepts are important in the transfer of potentially dangerous situations (Niedenthal, 2008). This has been shown experimentally in a study that simply told participants that a neutral stimulus would be paired with a shock (Phelps, Connor, Gatenby, Gore, Grillon & Davis, 2001). The results demonstrated that telling people about the possible emotional consequences of a stimulus resulted in similar brain activity as actually pairing the stimulus with a shock. This effect was replicated in a study that showed that participants responded with a fear reaction (i.e., electrodermal activity) when they learned through observation that a stimulus predicted a shock and when they were verbally told that the stimulus predicted a shock (Olsson & Phelps, 2004). Even though it is quite reasonable to assume that embodied representations may play a role in these effects, the role of simulation in the transfer of knowledge about potentially emotion evoking events has not yet been the subject of experimental investigation.

Finally, the present findings are relevant for how we theoretically view cognition and emotion. More specific, the present dissertation bids the question whether it is necessary to draw a strict line between cognition and emotion when embodied views are taken into account (see also Duncan & Barrett, 2007). The tasks presented in the previous chapters are classically seen as cognitive tasks because they involve memory, conceptual representation and language. Yet, these processes result in states that are similar to those that occur during emotional experiences. As such, a differentiation between 'hot' and 'cold' processing of emotion may not be appropriate (Schaefer, Collette, Philippot, Van der Linden, Laureys, Delfiore, Degueldre, Maquet, Luxen & Salmon, 2003; see also Phillippot & Schaefer, 2001). In addition, bodily states may not be uniquely important to emotions, but may also

underlie cognitive processes such as thinking, memory, and concentration (see Chapter 5). We therefore support a view that does not separate emotion and cognition, but sees them as psychological constructs that are ultimately based on the same underlying systems (Duncan & Barrett, 2007; Barrett, & Bliss-Moreau, 2009).

Conclusion

The experiments presented in this dissertation support, enrich and extend embodiment accounts of emotion concepts. With this we gained more insight into the representation of emotion knowledge, and the crucial role of the body herein. Our bodies form Rosetta's Stones that enable us to understand emotions transferred through abstract symbols written down in letters, books and chat windows. Moreover, since bodily states are a fundamental part of emotion concepts, it seems impossible to separate our thoughts from our body. When thinking about emotion the body may respond *as if* in an actual emotional state. Thus, we can assume that JK Rowling mimicked Harry Potter's emotional and bodily states when she wrote down his adventures. Just as millions of others while reading her books. As such, even though we do not live in a magical world and have never fought Voldemort, we can still physically join Harry '*as he walked through the castle for the last time, out into the grounds and into the forest*'.

Dutch Summary | Nederlandse Samenvatting

Emotieconcepten en Belichaming

Emotieconcepten spelen een rol in tal van dagelijkse activiteiten en gebeurtenissen. We lezen over de angstige avonturen van ons favoriete fictieve personage; we reageren op een chat bericht waarin iemand een woede-uitbarsting beschrijft; we denken na over onze teleurstellingen of proberen met woorden over te dragen hoe blij en trots we zijn. Met dit proefschrift wordt getracht inzicht te verkrijgen in de fundamentele vraag hoe emotionele betekenis ontstaat wanneer mensen lezen, denken, of praten over emoties.

Kennis over de wereld ligt opgeslagen in het conceptuele systeem. Een concept is de meest basale eenheid in dit systeem en representeert een bepaalde categorie, bijvoorbeeld een fiets, een kat of een emotie. Concepten spelen een rol in alle cognitieve processen, zoals perceptie, herkenning, herinneren, nadenken en het begrijpen van taal (Barsalou, Simmons, Barbey, & Wilson, 2003). Emotieconcepten representeren kennis over emotie. Deze concepten bevatten informatie over hoe emoties teweeg worden gebracht (situaties), welk gedrag er met emoties is geassocieerd (acties) en welke subjectieve ervaringen en lichamelijke reacties kunnen optreden wanneer iemand in een emotionele toestand verkeert (Niedenthal, 2008). Er bestaan verschillende theorieën over de werking van het conceptuele systeem.

Volgens amodale theorieën worden concepten gevormd door abstracte symbolen die lichamelijke, perceptuele en subjectieve toestanden herbeschrijven (Fodor, 1975; Pylyshyn, 1984; Phillippot & Schaefer, 2001; Teasdale, 1999). Met andere woorden, volgens deze theorieën zijn emotieconcepten symbolische representaties die zijn losgekoppeld van wat we voelen en doen wanneer we een emotionele toestand ervaren. Emoties zijn echter geassocieerd met een grote verscheidenheid aan lichamelijke toestanden, zoals bijvoorbeeld gezichtsexpressies, lichaamshoudingen, veranderingen in het sympatische zenuwstelsel en neigingen om ergens naartoe of vanaf te bewegen (Ekman, 2007; De Gelder, 2006; Chen & Bargh, 1999; Rotteveel & Phaf, 2004; Levenson, 2003; Mauss, Levenson, McCarter,

Wilhelm & Gross, 2005). Als deze toestanden centraal staan in onze emotionele ervaringen, en dus onderdeel zijn van wat een emotie *is*, dan lijkt het onvermijdelijk om deze toestanden te incorporeren in een model dat beschrijft hoe emoties conceptueel zijn gepresenteerd.

Belichamingstheorieën gaan er van uit dat het lichaam een belangrijke rol speelt in de wijze waarop kennis is gerepresenteerd en als gevolg daarvan in het ontstaan van betekenis (Barsalou, 1999; Barsalou, 2008; Gallese & Lakoff, 2005; Glenberg, 2010; Niedenthal, 2007). Deze theorieën veronderstellen dat dezelfde neurale en lichamelijke mechanismen die worden geactiveerd tijdens het ervaren van een emotionele toestand ook het fundament vormen van emotieconcepten (Barsalou, 1999; Niedenthal, 2007; Niedenthal, Barsalou, Ric, & Krauth-Gruber, 2005; Gallese & Lakoff, 2005; Glenberg, Webster, Mouilso, Havas & Lindeman, 2009). Tijdens emotionele ervaringen wordt de toestand waarin iemand op dat moment verkeert 'gevangen' en opgeslagen in modaliteitspecifieke gebieden in het brein (Barsalou, 1999; Niedenthal, 2007). Deze patronen van activatie kunnen vervolgens worden geheractiveerd of *gesimuleerd* om kennis over emotie te representeren. Percepties (bv. visuele, auditieve of tactiele ervaringen), motor acties (bv. bewegingen of expressies), interoceptieve reacties (bv. een verhoging van de hartslag of een verandering in de hormoonhuishouding) en introspectieve ervaringen (bv. subjectieve gevoelens van angst of boosheid) vormen dus een intrinsiek onderdeel van emotieconcepten. Met andere woorden, emotieconcepten zijn *belichaamd*.

Op basis hiervan kan worden voorspeld dat taken waarin emotieconcepten worden gebruikt, gepaard gaan met lichamelijke activiteit. De focus van dit proefschrift ligt op het aantonen van deze belichamingseffecten wanneer mensen lezen, denken, of praten over emoties.

Emotieconcepten en belichaming

Dit proefschrift laat zien dat het lichaam spontaan reageert wanneer mensen nadenken over emoties. **Hoofdstuk 2** onderzocht of er spontane veranderingen in lichaamshouding optraden wanneer proefpersonen nadachten over trots en teleurstelling. Zowel trots en teleurstelling zijn geassocieerd met veranderingen in lichaamshouding. Trots is geassocieerd met een opgerichte houding (Tracy & Robins, 2004; Stepper & Strack, 1993) en teleurstelling is geassocieerd met een in elkaar gezakte houding (Riskind, 1984). In navolging van belichamingstheorieën voorspelden we dat het activeren van kennis over deze emoties zou leiden tot een spontane en congruente lichamelijke expressie (Barsalou, 1999; Niedenthal, 2007; Niedenthal et al., 2005a). Zoals verwacht toonden de resultaten aan dat proefpersonen een meer in elkaar gezakte lichaamshouding aannamen wanneer ze woorden genereerden die met teleurstelling te maken hadden, dan wanneer ze woorden genereerden die met trots te maken hadden.

Lichamelijke reacties zijn echter niet altijd af te lezen aan het lichaam, zoals lichaamshouding. Sommige lichamelijke reacties vinden 'van binnen' plaats en zijn alleen te ervaren door de persoon zelf. Tot nu toe richtten belichamingsexperimenten zich vooral op het meten of manipuleren van gezichtsexpressies (Niedenthal, Winkielman, Mondillon & Vermeulen, 2009; Foroni & Semin, 2009; Havas, Glenberg & Rinck, 2007). Maar interne, of interoceptieve, signalen van het lichaam vormen een fundamenteel component van emotionele toestanden (Duncan & Barrett, 2007). Het is dus goed mogelijk dat deze reacties worden gesimuleerd wanneer emotionele kennis wordt gebruikt in conceptuele taken (Niedenthal, 2007; Glenberg et al., 2009; Barsalou, 1999). In **Hoofdstuk 3** werd dit inderdaad aangetoond. Zowel tijdens het ophalen van een autobiografische angstherinnering, als tijdens het genereren van woorden die met angst te maken hadden, vonden we verhoogde activiteit van het sympatische zenuwstelsel; een reactie die normaal gesproken gepaard gaat met angstige ervaringen.

In Hoofdstuk 4 toonden we dit effect opnieuw aan, maar nu met een zogenaamde 'vervormde-zinnentaak'. Het belangrijkste kenmerk van deze taak is dat uit eerder onderzoek is gebleken dat deze taak emotionele kennis activeert zonder ook een subjectieve emotionele ervaring op te wekken (zie ook Stapel & Koomen, 2000; Innes-Ker & Niedenthal, 2002; Maringer & Stapel, 2007). In de vervormde-zinnentaak verwerkten proefpersonen ofwel neutrale zinnen, ofwel zinnen die met angst te maken hadden. Proefpersonen vertoonden sterkere activiteit van het sympatische zenuwstelsel, en een verhoogde activiteit in de fronsspier, tijdens het verwerken van angstzinnen dan tijdens het verwerken van neutrale zinnen. Uit een pilotstudie kwam echter geen enkele indicatie naar voren dat het verwerken van angstzinnen ook een rapporteerbare, subjectieve angst toestand tot gevolg had. Deze bevindingen vormen belangrijke ondersteuning voor de aanwezigheid van spontane lichamelijke simulaties tijdens conceptuele emotietaken (Niedenthal, 2007; Glenberg et al., 2009; Niedenthal et al., 2005a), zonder de mogelijke tegenwerping dat de toestanden 'slechts' een gevolg zijn van de aanwezigheid van een subjectieve emotionele ervaring.

Het brein, het lichaam en het zelf

Belichamingstheorieën beamen dat lichamelijke reacties kunnen worden gesimuleerd zonder dat mensen daarbij een subjectieve ervaring hebben. Al kunnen lichamelijke reacties tot uitdrukking komen in de subjectieve beleving van een emotionele toestand (Duncan & Barrett, 2007), de *simulatie* van deze reacties is partieel en kan buiten het bewustzijn plaatsvinden (Barsalou, Niedenthal, Barbey, & Ruppert, 2003). Belichaming kan zich dus manifesteren als een modaliteitspecifiek patroon in het brein, als een lichamelijke reactie, of als een subjectieve ervaring waar men zich bewust van is (Bastiaansen, Thioux & Keysers, 2009; Niedenthal, 2007; Barsalou, 1999). Belichamingseffecten zijn flexibel en dynamisch (Winkielman et al, 2009; Barsalou et al., 2003a) en dit proefschrift suggereert dat zelfrelevantie de kracht van belichamingseffecten kan beïnvloeden, en dan met name de mate waarin

belichamingseffecten subjectief worden ervaren (zie ook Niedenthal, Barsalou, Winkielman, Krauth-Gruber, & Ric, 2005; Niedenthal, Roman & Dalle, 2002).

In **Hoofdstuk 3** werd de zelfrelevantie van geactiveerde emotiekennis gemanipuleerd door proefpersonen een persoonlijke angstherinnering te laten ophalen (episodische conditie), of angstwoorden te laten genereren (semantische conditie). Volgens Wheeler, Stuss en Tulving (1997) is het episodische geheugen, omdat het zo sterk verbonden is met het zelf, per definitie geassocieerd met subjectieve gevoelens. Voor het semantisch geheugen, oftewel het conceptuele systeem, zal dit niet gelden omdat het semantische geheugen algemene, globale kennis bevat. Hoofdstuk 3 biedt inderdaad ondersteuning voor de aanname dat episodische en semantische representaties op deze wijze van elkaar kunnen worden onderscheiden. Wanneer proefpersonen een persoonlijke angstige herinnering ophaalden vond er sterkere activatie van het sympatische zenuwstelsel plaats, sterkere subjectieve rapportage van angst, en sterkere impliciete angst reacties dan wanneer mensen angst woorden genereerden. Tevens bleek er een positieve correlatie te bestaan tussen subjectief gerapporteerde angst en lichamelijke activiteit in de episodische conditie, terwijl deze correlatie niet aanwezig was in de semantische conditie. Deze bevinding suggereert dat lichamelijke toestanden en subjectieve ervaringen verbonden zijn tijdens episodische activatie en tezamen een herbeleving van de eerder ervaren gebeurtenis vormen. Met andere woorden, persoonlijke emotionele herinneringen activeren een 'full-blown' emotionele ervaring (Barsalou et al., 2003a; Lambie & Marcel, 2002). Tijdens de activatie van semantische kennis is de kans daarentegen groter dat simulaties van lichamelijke emotiecomponenten plaatsvinden zonder dat mensen een emotionele toestand ervaren (zie ook Hoofdstuk 4).

Emotieconcepten versterken emotionele reacties

Naast het aantonen van belichamingseffecten, werd in dit proefschrift ook onderzocht of het activeren van emotieconcepten invloed heeft op reacties ten

opzichte van *nieuw* aangeboden emotionele stimuli. In **Hoofdstuk 4** werd via een vervormde-zinnentaak conceptuele kennis over angst of neutrale kennis geactiveerd. Zoals al eerder werd genoemd, lieten de resultaten zien dat het verwerken van angstzinnen belichaamd was: proefpersonen vertoonden sterkere lichamelijke reacties tijdens angstzinnen dan tijdens neutrale zinnen. Nadat proefpersonen deze zinnen hadden verwerkt, werden hen angst-plaatjes aangeboden die gepaard gingen met een korte uitbarsting van witte ruis. De resultaten demonstreerden een sterkere reactie van het sympatische zenuwstelsel ten opzichte van de angst-plaatjes en een sterker schrikreflex ten opzichte van de witte ruis wanneer proefpersonen angstzinnen hadden verwerkt, dan wanneer ze neutrale zinnen hadden verwerkt. Daarnaast toonde een mediatie-analyse aan dat dit effect het best kan worden begrepen in termen van de belichamingsreacties die plaatsvonden tijdens het activeren van kennis over angst. Deze analyse liet zien dat het effect van de vervormde-zinnentaak op de lichamelijke reacties tijdens het bekijken van angst-plaatjes volledig werd gemedieerd door de lichamelijke reacties tijdens het verwerken van de zinnen. Dit suggereert dat lichamelijke reacties worden versterkt *omdat* emotieconcepten belichaamd zijn.

De resultaten uit Hoofdstuk 4 hebben overeenkomsten met onderzoek waarin wordt aangetoond dat het manipuleren van lichamelijke toestanden (bijvoorbeeld een staat van opwinding of een bepaalde houding of expressie) reacties ten opzichte van nieuwe emotionele situaties kan beïnvloeden (Zillmann, Katcher, & Milavsky, 1972; Stepper & Strack, 1993; Strack, Martin & Stepper, 1988; Havas et al., 2007). Onze bevindingen hebben echter een belangrijke meerwaarde ten opzichte van deze studies, omdat in ons geval de lichamelijke toestand niet direct werd gemanipuleerd, maar een spontaan gevolg is van het activeren van conceptuele kennis over angst. Ook is het belangrijk om te onderstrepen dat in de huidige studie het concept angst op impliciete wijze werd geactiveerd. Met andere woorden, de focus van de vervormde-zinnentaak lag op verbale verwerking: nergens werd

gerefereerd aan emotionele betekenis (zie ook Niedenthal et al., 2009), of aan actief gebruik van het voorstellingsvermogen (Holmes & Mathews, 2005; Jabbi, Bastiaansen & Keysers, 2008; Vrana, 1995). Tevens kwam uit een pilotstudie duidelijk naar voren dat het verwerken van angstzinnen *niet* leidt tot een subjectieve emotionele toestand (zie ook Stapel & Koomen, 2000; Innes-Ker & Niedenthal, 2002; Maringer & Stapel, 2007).

De resultaten van Hoofdstuk 4 hebben belangrijke methodologische implicaties. Instructies die bijvoorbeeld gebruik maken van emotiewoorden, zouden emotionele reacties op een later tijdstip kunnen beïnvloeden, alleen omdat proefpersonen belichaamde representaties activeren tijdens het verwerken van deze instructies. Daarnaast kunnen deze resultaten implicaties hebben voor de invloed van emotionele kennis in dagelijkse situaties. Mensen komen overal emotieconcepten tegen, bijvoorbeeld tijdens het lezen van de krant, tijdens een gesprek met iemand, of tijdens het bezoek aan een sociale website. Deze verwerking van emotionele kennis zou mogelijk de emotionele sensitiviteit op een later moment kunnen beïnvloeden. Toekomstig onderzoek zou de precieze omstandigheden waaronder dit effect optreedt verder moeten uitwijzen.

Schakelen tussen modaliteiten

In **Hoofdstuk 5** werden lichamelijke reacties niet direct gemeten, maar werd gebruik gemaakt van een zogenaamd 'schakelkosten' paradigma (Pecher, Zeelenberg, & Barsalou, 2003). In een schakelparadigma wordt proefpersonen gevraagd om te verifiëren of concepten bepaalde modaliteitspecifieke kenmerken bezitten (bv. '*een appel is groen*' of '*een vliegtuig is lawaaig*'). Verondersteld wordt dat deze conceptuele beoordelingen gepaard gaan met simulaties in de betreffende modaliteitspecifieke systemen (voor '*een appel is groen*' het visuele systeem; voor '*een vliegtuig is lawaaig*' het auditieve systeem). Hieruit volgt dat proefpersonen langzamer zouden moeten zijn in de beoordeling van een auditief kenmerk na een visueel kenmerk, dan in de beoordeling van een visueel kenmerk na een visueel

kenmerk. 'Schakelkosten' reflecteren de tijd die het kost om van de ene modaliteit naar de andere modaliteit te schakelen. Tot nu toe zijn schakelkosten alleen aangetoond wanneer mensen klassiek zintuiglijke kenmerken beoordeelden (visueel, auditief, tactiel, reuk en smaak; Marques, 2006; Pecher, et al., 2003; Van Dantzig, Pecher, Zeelenberg, & Barsalou, 2008), of algemene affectieve kenmerken (Vermeulen, Niedenthal, & Luminet, 2007). Hoofdstuk 5 beschrijft een experiment dat onderzoekt of schakelkosten ook plaatsvinden wanneer mensen schakelen tussen visuele kenmerken en kenmerken die geassocieerd zijn met interne toestanden.

Het experiment onderzocht conceptuele verwijzingen naar emotionele toestanden (bv. boosheid, angst of trots) en niet-emotionele toestanden (bv. honger, duizeligheid of nadenken). Zowel emotionele als niet-emotionele toestanden gaan gepaard met subjectieve gevoelens en met interoceptieve signalen van het lichaam (Craig 2002, 2009). In navolging van belichamingsperspectieven (Barsalou, 1999; Glenberg, et al., 2009; Niedenthal, 2007), veronderstelden we dat deze interne ervaringen worden gesimuleerd wanneer mensen zinnen verwerken die mentale toestanden beschrijven vanuit een 'intern perspectief' (bv. '*Hij was uitgeput aan het einde van de wedstrijd*' en '*Ze schaamde zich diep*'). Wanneer mentale toestanden echter worden beschreven vanuit een 'extern perspectief' verwachtten we dat de simulatie van visuele kenmerken relevanter zou zijn voor het begrijpen van de zin (bv. '*Vertwijfeld schudde ze haar hoofd'* en '*Haar wangen waren rood van schaamte*'). Ondersteuning voor verschillende vormen van simulatie tijdens het verwerken van 'interne' en 'externe' zinnen zou geboden worden door het optreden van schakelkosten.

Zoals verwacht, vonden we dat zinnen die interne aspecten van een mentale toestand beschreven sneller werden beoordeeld wanneer deze voorafgegaan werden door interne zinnen dan door externe zinnen. Een vergelijkbaar schakeleffect was aanwezig voor de externe zinnen; externe zinnen werden sneller beoordeeld

wanneer ze werden voorafgegaan door externe dan door interne zinnen. Deze bevindingen suggereren dat het richten van de aandacht op interne of externe beschrijvingen van mentale toestanden is geassocieerd met simulatie in verschillende neurale systemen. Het verwerken van zinnen die interne reacties beschrijven, zoals subjectieve gevoelens, zou gepaard kunnen gaan met simulatie in de insula, een gebied in het brein dat geassocieerd wordt met interoceptie (e.g., Craig, 2002, 2009). Verder onderzoek zal moeten uitwijzen of interoceptie inderdaad kan worden gezien als een aparte 'modaliteit' (Barsalou, 1999). Daarnaast suggereren de resultaten van dit hoofdstuk dat het verwerken van linguïstische beschrijvingen van diverse mentale toestanden, zoals boosheid, vermoeidheid en herinneren, fundamenteel afhankelijk is van hetzelfde onderliggende simulatie mechanisme.

Conclusie

De experimenten die zijn beschreven in dit proefschrift ondersteunen, verrijken en verruimen een belichamingsperspectief op emotieconcepten. Hiermee worden nieuwe inzichten verkregen in de wijze waarop emotionele kennis is gerepresenteerd en de cruciale rol die het lichaam hierin speelt. Het lichaam dient als een 'Steen van Rosetta', die het mogelijk maakt om emoties te begrijpen wanneer deze worden overgedragen via abstracte symbolen, zoals brieven, boeken en chatberichten. En dat niet alleen. Door te laten zien dat lichamelijke reacties op fundamentele wijze zijn verbonden met onze emotionele gedachten, lijkt het onmogelijk om ons verstand los te koppelen van ons lichaam.

References

Bastiaansen, J.A.C.J., Thouix, M., & Keysers, C. (2009). Evidence for mirror systems in emotions. *Philosophical Transactions of the Royal Society B, 364*, 2391-2404.

Bargh, J.A., Chen, M., & Burrows, L. (1996). Automaticity of social behavior: direct effects of trait construct and stereotype activation on action. *Journal of Personality and Social Psychology*, 65, 272-281.

Barrett, L.F. (2006). Solving the emotion paradox: categorization and the experience of emotion. *Personality and Social Psychology Review, 10*, 20-46.

Barrett, L.F. & Bar, M. (2009). See it with feeling: affective predictions during object perception.

Barrett, L.F., & Fossum, T. (2001). Mental representations of affect knowledge. *Cognition and Emotion*, 15, 333-363.

Barrett, L. F., & Lindquist, K. (2008). The embodiment of emotion. Chapter in G. Semin & E. Smith (Eds.). *Embodied grounding: Social, cognitive, affective, and neuroscience approaches* (p. 237-262). New York: Cambridge University Press.

Barrett, L.F., Lindquist, K.A., & Gendron, M. (2007). Language as a context for the perception of emotion. *Trends in Cognitive Sciences*, 11, 327-332. *Philosophical Transactions of the Royal Society B, 364*, 1325-1334.

Barrett, L.F., & Bliss-Moreau, E. (2009). Affect as a psychological primitive. In M.P. Zanna (Ed.), *Advances in Experimental Social Psychology*, (Volume 41, pp. 167-218). Burlington: Academic Press.

Barsalou, L.W. (1999). Perceptual symbol systems. *Behavioral and Brain Sciences*, 22, 577-660.

Barsalou, L.W. (2008). Grounded cognition. *Annual Review of Psychology*, 59, 617-645.

Barsalou, L.W., Niedenthal, P.M., Barbey, A.K., & Ruppert, J.A. (2003a). Social Embodiment. In B.H. Ross (Ed.), *The Psychology of Learning and Motivation*, Vol. 43 (pp. 43-92). San Diego, CA: Academic Press.

Barsalou, L.W., Santos, A., Simmons, W.K., & Wilson, C.D. (2007). Language and simulation in conceptual processing. In De Vega, M., Glenberg, A.M., &

Graesser, A.C. (Eds.). *Symbols, embodiment and meaning*. Oxford: Oxford University Press.

Barsalou, L.W., Simmons, W.K., Barbey, A.K., & Wilson, C.D. (2003b). Grounding conceptual knowledge in modality-specific systems. *Trends in Cognitive Sciences, 7*, 84-91.

Barsalou, L.W. & Wiemer-Hastings, K. (2005). Situating abstract concepts. In Pecher, D. & Zwaan, R.A. (Eds.), *Grounding cognition: The role of perception and action in memory, language and thinking* (pp. 129-163). Cambridge: Cambridge University Press.

Bodenhausen, G.V., Kramer, G.P., & Süsser, K. (1994). Happiness and stereotypic thinking in social judgment. *Journal of Personality and Social Psychology*, 66, 621-632.

Bradley, M. M., Codispoti, M., Cuthbert, B.N., & Lang, P.J. (2001). Emotion and Motivation I: Defensive and Appetitive reactions in picture processing. *Emotion*, 1, 276-298.

Cacioppo, J.T., Priester, J.R., & Berntson, G.G. (1993). Rudimentary determinants of attitudes. II: Arm flexion and extension have differential effects on attitudes. *Journal of Personality and Social Psychology, 65*, 5-17.

Chao, L. L., & Martin, A. (2000). Representation of manipulable man-made objects in the dorsal stream. *NeuroImage*, *12*, 478-484.

Chen, M., & Bargh, J.A. (1999). Consequences of automatic evaluation: Immediate behavioral predispositions to approach or avoid the stimulus. *Personality and Social Psycholoy Bulletin, 25*, 215-224.

Conell, L., & Lynott, D. (2009). What is big and fluffy but can't be seen? Selective unimodal processing of bimodal property words. In N. A. Taatgen & H. van Rijn (Eds.), *Proceedings of the 31st Annual Conference of the Cognitive Science Society* (pp. 1465-1470). Austin, TX: Cognitive Science Society.

Conway, M. A. (1990). Conceptual representation of emotions: the role of autobiographical memories. In Gilhooly, K. J., Keane, M. T. G., Logie, R. H., & Erdos, G. (Eds.), *Lines of thinking: Reflections on the psychology of thought. Volume 2. Skills, emotion, creative processes, individual differences and teaching thinking* (pp. 133-143). Chichester, England: John Wiley & Sons.

Craig, A.D. (2002). How do you feel? Interoception: the sense of the physiological condition of the body. *Nature Reviews Neuroscience, 3*, 655-666.

Craig, A.D. (2009). How do you feel, now? The anterior insula and human awareness. *Nature Reviews Neuroscience, 10*, 59-70.

Crawford, L.E. (2009). Conceptual metaphors of affect. *Emotion Review, 1*, 129-139.

Dawson, M. E., Schell, A. M., & Filion, D.L. (2000). The electrodermal system. In: J. T. Cacioppo, L.G. Tassinary & G.G. Bernston (Eds). *Handbook of Psychophysiology*, 2nd edition (pp. 200–223). Boston: Cambridge University Press.

Dimberg, U. (1982). Facial reactions to facial expressions. *Psychophysiology, 19*, 643-647.

Dimberg, U. (1986). Facial reactions to fear-relevant and fear-irrelevant stimuli. *Biological Psychology*, 23, 153-161.

Dimberg, U. (1990). Facial electromyography and emotional reactions. *Psychophysiology, 27*, 481-494.

Dimberg, U., Thunberg, M., & Elmehed, K. (2000). Unconscious facial reactions to emotional facial expressions. *Psychological Science, 11*, 86-89.

Duclos, S. E., Laird, J. D., Schneider, E., Sexter, M., Stern, L., & Van Lighten, O. (1989). Emotion specific effects of facial expressions and postures on emotional experience. *Journal of Personality and Social Psychology*, *57*, 100-108.

Duncan, S., & Barrett, L. F. (2007). Affect as a form of cognition: A neurobiological analysis. *Cognition and Emotion* 21, 1184-1211.

Ekman, P. (2007). The directed facial action task. Emotional response without appraisal. In J.A. Coan & J.J.B. Allen (Eds.), *Handbook of Emotion Elicitation and Assessment* (pp. 47-53). New York: Oxford University Press.

Fehr, B., & Russell, J.A. (1984). Concept of emotion viewed from a prototype perspective. *Journal of Experimental Psychology: General, 113*, 464-486.

Fodor, J. (1975). *The language of thought*. Cambridge, MA: Harvard University Press.

Foroni, F., & Semin, G.R. (2009). Language that puts you in touch with your bodily feelings. The multimodal responsiveness of affective expressions. *Psychological Science*, 20, 974-980.

Förster, J., & Liberman, N. (2007). Knowledge activation. In Higgins, E. T. & Kruglanski, A. W. (Eds.), *Social Psychology: Handbook of basic principles* (2nd edition, pp. 201-231). New York: Guilford.

Fridlund, A.J., Cacioppo, J.T. (1986). Guidelines for human electromyographic research. *Psychophysiology*, 23, 567-589.

Gallese, V., & Lakoff, G. (2005). The brain's concepts: The role of the sensory-motor system in conceptual knowledge. *Cognitive Neuropsychology*, *22*, 455-479.

Gelder, B. de (2006). Towards the neurobiology of emotional body language. *Nature Reviews Neuroscience, 7*, 242-249.

Glenberg, A.M. (2010). Embodiment as a unifying perspective for psychology. Wiley Interdisciplinary Reviews: Cognitive Science.

Glenberg, A. M. & Kaschak, M. P. (2002). Grounding language in action. *Psychonomic Bulletin & Review*, *9*, 558-565.

Glenberg, A.M. & Robertson, D.A. (2000). Symbol grounding and meaning: A comparison of high-dimensional and embodied theories of meaning. *Journal of Memory and Language*, 43, 379-401.

Glenberg, A.M., Webster, B.J., Mouilso, E., Havas, D., & Lindeman, L.M. (2009). Gender, emotion, and the embodiment of language comprehension. *Emotion Review*, 1, 151-161.

Glenberg, A. M., Havas, D., Becker, R., & Rinck, M. (2005). Grounding Language in Bodily States: The Case for Emotion. In R. Zwaan and D. Pecher (Eds.), *Grounding cognition: The role of perception and action in memory, language, and thinking* (pp. 115-128). Cambridge: Cambridge University Press.

Goldberg, R.F., Perfetti, C.A., & Schneider, W. (2006). Perceptual knowledge retrieval activates sensory brain regions. *The Journal of Neuroscience, 26*, 4917-4921.

Halberstadt, J., Winkielman, P., Niedenthal, P. M., & Dalle, N. (2009). Emotional conception: How embodied emotion concepts guide perception and facial action. *Psychological Science, 20, 1254-1261.*

Halberstadt, J.B., & Niedenthal, P.M. (2001). Effects of emotion concepts on perceptual memory for emotional expressions. *Journal of Personality and Social Psychology*, 81, 587-598.

Harnard, S. (1990). The symbol grounding problem. *Physica, 42*, 335-346.

Hauk, O., Johnsrude, I., & Pulvermüller, F. (2004). Somatotopic representation of action words in human motor and premotor cortex. *Neuron, 41*, 301-307.

Hauk, O., Shtyrov, Y., & Pulvermuller, F. (2008). The time course of action and action word comprehension in the human brain as revealed by neurophysiology. *Journal of Physiology - Paris, 102*, 50-58.

Havas, D.A., Glenberg, A.M., & Rinck, M. (2007). Emotion simulation during language comprehension. *Psychonomic Bulletin & Review*, 14, 436-441.

Hawk, S.T., Fischer, A.H., & Van Kleef, G.A. (in revision). Face the noise: Embodied responses to nonverbal vocalizations of discrete emotions.

Hess, U. & Blairy, S. (2001). Facial mimicry and emotional contagion to dynamic emotional facial expressions and their influence on encoding accuracy. *International Journal of Psychophysiology*, *40*, 129-141.

Hillman, C. H., Rosengren, K. S., & Smith, D. P. (2004). Emotion and motivated behavior: postural adjustments to affective picture viewing. *Biological Psychology*, *66*, 51-62.

Holmes, E.A., & Mathews, A. (2005). Mental imagery and emotion: A special relationship? Emotion, 5, 489-497.

Innes-Ker, Å.H. & Niedenthal, P.M. (2002). Emotion concepts and emotional states in social judgment and categorization. *Journal of Personality and Social Psychology,* 83, 804-816.

Isen, A.M., Daubman, K.A., & Nowicki, G.P. (1987). Positive affect facilitates creative problem solving. *Journal of Personality and Social Psychology, 52*, 1122-1131.

Izard, C.E., Dougherty, F.E., Bloxom, B.M., & Kotsch, W.E. (1974). *The differential emotions scale: A method of measuring the subjective experience of discrete emotions*. Unpublished Manuscript, Vanderbilt University, Nashville, Tennessee.

Jabbi, M., Bastiaansen, J. & Keysers, C. (2008). A common anterior insula representation of disgust observation, experience and imagination shows divergent functional connectivity pathways. *PLoS ONE* 3(8): e2939.

Kan, I.P., Barsalou, L.W., Solomon, K.O., Minor, J.K., & Thompson-Schill, S.L. (2003). Role of mental imagery in a property verification task: fMRI evidence for perceptual representations of conceptual knowledge. *Cognitive Neuropsychology, 20*, 525-540.

Lakoff, G., & Johnsson, M. (1980). *Metaphors we live by*. Chicago, IL: University of Chicago Press.

Lambie, J.A., & Marcel, A.J. (2002). Consciousness and the varieties of emotion experience: A theoretical framework. *Psychological Review, 109*, 219-259.

Lang, P.J., Bradley, M.M., & Cuthbert, B.N. (1995). *International affective pictures System (IAPS): Technical manual and affective ratings*. Technical Report A-4. Gainsville, FL: The Research Center for Research in Psychophysiology, University of Florida.

Levenson, R.W. (2003). Blood, sweat and fears: the autonomic architecture of emotion. In P. Ekman, J.J. Campos, R.J. Davidson, & F.B.M. de Waal (Eds.), *Emotions inside out* (pp. 348-366). New York: The New York Academy of Sciences.

Lieberman, M.D., Eisenberger, N.I., Crockett, M.J., Tom, S.M., Pfeifer, J.H., & Way, B.M. (2007). Putting feelings into words. Affective labeling disrupts amygdala activity in response to affective stimuli. *Psychological Science*, 18, 421-428.

Lindquist, K.A., & Barrett, L. F. (2008). Constructing Emotion. The experience of fear as a conceptual act. *Psychological Science*, 19, 898-903.

Lindquist, K., Barrett, L. F., Bliss-Moreau, E., & Russell, J. A. (2006). Language and the perception of emotion. *Emotion*, 6, 125-138.

Lundqvist, D., Flykt, A., & Öhman, A. (1998). The Karolinska Directed Emotional Faces - KDEF, CD ROM from Department of Clinical Neuroscience, Psychology section, Karolinska Institutet.

Mahon, B.Z., & Caramazza, A. (2008). A critical look at the embodied cognition hypothesis and a new proposal for grounding conceptual content. *Journal of Physiology - Paris, 102*, 59-70.

Mar, R.A., & Oatley, K. (2008). The function of fiction is the abstraction and simulation of social experience. *Perspectives on Psychological Science*, 3, 173-192.

Mar, R.A., Oatley, K., Hirsh, J. Dela Paz, J., & Peterson, J.B. (2006). Bookworms versus nerds: Exposure to fiction versus non-fiction, divergent associations with social ability, and the simulation of fictional social worlds. *Journal of Research in Personality*, 40, 694-712.

Maringer, M., Stapel, D. (2007). Unfinished business: How completeness affects the impact of emotional states and emotion concepts on social judgment. *Journal of Experimental Social Psychology,* 43, 712-718.

Marques, J. F. (2006). Specialization and semantic organization: Evidence for multiple semantics linked to sensory modalities. *Memory and Cognition, 34*, 60-67.

Martin, A. & Chao, L. L. (2001). Semantic memory and the brain: structure and processes. *Current opinion in Neurobiology*, *11*, 194-201.

Mauss, I.B, Levenson, R.W., McCarter, L., Wilhelm, F.H., & Gross, J.J. (2005). The tie that binds? Coherence among emotional experience, behavior and physiology. *Emotion*, 5, 175-190.

Meier, B.P., Robinson, M.D., & Clore, G.L. (2004). Why good guys wear white: Automatic inferences about stimulus valence based on brightness. *Psychological Science, 15*, 82-87.

Meier, B.P., & Robinson, M.D. (2004). Why the sunny side is up: Associations between affect and vertical position. *Psychological Science, 15*, 243-247.

Mouilso, E., Glenberg, A. M., Havas, D. A., & Lindeman, L. M. (2007). Differences in action tendencies distinguish anger and sadness after comprehension of emotional sentences. In D. S. McNamara & J. G. Trafton (Eds.), Proceedings of the 29th Annual Cognitive Science Society (pp. 1325-1330). Austin, TX: Cognitive Science Society.

Neumann, R., Förster, J., & Strack, F. (2003). Motor compatibility: the bidirectional link between behavior and evaluation. In Klauer, K. C., & Musch, J. (Eds.), *The psychology of evaluation: affective processes in cognition and emotion* (pp. 371-391). Mahwah, NJ: Erlbaum.

Neumann, R., & Strack, F. (2000). Approach and Avoidance: the influence of proprioceptive and exteroceptive cues on encoding of affective information. *Journal of Personality and Social Psychology*, *79*, 39-48.

Niedenthal, P.M. (2007). Embodying emotion. *Science*, 316, 1002-1005.

Niedenthal, P.M. (2008). Emotion concepts. In M. Lewis, J.M. Haviland-Jones, & L.F. Barrett (Eds.). *Handbook of Emotion* (3rd edition, pp. 587-600). New York: Guilford Press.

Niedenthal, P. M., Barsalou, L. W., Ric, F., & Krauth-Gruber, S. (2005a). Embodiment in the acquisition and use of emotion knowledge. In Barrett, L. F., Niedenthal, P. M., & Winkielman, P. (Eds.), *Emotion and consciousness* (pp. 21-50). New York: Guilford Press.

Niedenthal, P. M., Barsalou, L. W., Winkielman, P., Krauth-Gruber, S., & Ric, F. (2005b). Embodiment in attitudes, social perception and emotion. *Personality and Social Psychology Review*, *9*, 184-211.

Niedenthal, P.M., Rohmann, A., & Dalle, N. (2003). What is primed by emotion concepts and emotion words? In J. Musch & K.C. Klauer (Eds.), *The psychology of evaluation: Affective processes on cognition and emotion* (pp. 307-333). Mahwah, NJ: Lawrence Erlbaum.

Niedenthal, P. M., Winkielman, P. Mondillon, L., & Vermeulen, N. (2009). Embodiment of emotional concepts: Evidence from EMG measures. *Journal of Personality and Social Psychology,* 96, 1120-1136.

Olsson, A., & Phelps, E.A. (2004). Learned fear of 'unseen' faces after Pavlovian, observational and instructed fear. *Psychological Science, 15*, 822-828.

Oosterwijk, S., Rotteveel, M., & Fischer, A.H. (submitted). Remembering the self versus knowing the world: Emotional consequences of episodic and semantic fear representations.

Oosterwijk, S., Rotteveel, M., Fischer, A.H., & Hess, U. (2009). Embodied emotion concepts: How generating words about pride and disappointment influences posture. *European Journal of Social Psychology, 39*, 457-466.

Oosterwijk, S., Topper, M., Rotteveel, M., & Fischer, A.H. (2010). When the mind forms fear: Embodied fear knowledge potentiates bodily reactions to fearful stimuli. *Social Psychological and Personality Science, 1*, 65-72.

Oosterwijk, S., Winkielman, P., Pecher, D., Zeelenberg, R., Rotteveel, M., & Fischer, A.H. (submitted). Mental States Inside Out: Switching Costs for Emotional and Non-emotional Sentences that Differ in Internal and External Focus.

Pecher, D., van Dantzig, S., & Schifferstein (2009). Concepts are not represented by conscious imagery. *Psychonomic Bulletin & Review, 16*, 914-119.

Pecher, D., Zeelenberg, R., & Barsalou, L. W. (2003). Verifying different-modality properties for concepts produces switching costs. *Psychological Science, 14*, 119-124.

Pessl, M. (2006). *Special Topics in Calamity Physics*. New York: Viking Penguin.

Phaf, R.H., & Rotteveel, M. (2005). Affective modulation of recognition bias. *Emotion*, 5, 309-318.

Phelps, E.A., Connor, K.J., Gatenby, J.C., Gore, J.C., Grillon, C., Davis, M. (2001). Activation of the left amygdala to a cognitive representation of fear. *Nature Neuroscience, 4*, 437-441.

Philippot, P., & Schaefer, A. (2001). Emotion and memory. In T. J. Mayne & G. A. Bonanno (Eds.), *Emotion: Current issues and future directions* (pp. 82–122). New York: Guilford Press.

Phillippot, P., Schaefer, A., & Herbette, G. (2003). Consequences of specific processing of emotional information: Impact of general versus specific autobiographical memory priming on emotion. *Emotion, 3*, 270-283.

Pobric, G., Jefferies, E., & Lambon Ralph, M.A. (2010). Category-specific versus category-general semantic impairment induced by transcranial magnetic stimulation. *Current Biology, 20*, 964-968.

Pylyshyn, Z.W. (1984). *Computation and cognition*. MIT Press.

Riskind, J. H. (1984). They stoop to conquer: guiding and self-regulatory functions of physical posture after success and failure. *Journal of Personality and Social Psychology*, *47*, 479-493.

Roberts, T., & Arefi-Afshar, Y. (2007). Not all who stand tall are proud: Gender differences in the proprioceptive effects of upright posture. *Cognition and Emotion, 21*, 714-727.

Robinson, M.D., & Clore, G.L. (2002). Episodic and semantic knowledge in emotional self-report: Evidence for two judgment processes. *Journal of Personality and Social Psychology, 83*, 198-215.

Rotteveel, M., den Daas, C., Wagenmakers, E.J., Zeelenberg, R. (In preparation). Bias in the eye of the beholder: Emotion congruent bias for emotion words.

Rotteveel, M., & Phaf, R.H. (2004). Automatic affective evaluation does not automatically predispose for arm flexion and extension. *Emotion*, 4, 156-172.

Rowling, J.K. (2007). *Harry Potter and the Deathly Hallows*. London: Bloomsbury Publishing.

Schwarz, N., & Clore, G. L. (2007). Feelings and phenomenal experiences. In E. T. Higgins & A. Kruglanski (eds.), *Social psychology. Handbook of basic principles* (2nd ed.; pp. 385-407). New York: Guilford.

Searle, J. (1980). Minds, brains and programs. *Behavioral and Brain Sciences, 3*, 417-424.

Spence, C., Nicholls, M.E.R., & Driver, J. (2000). The cost of expecting events in the wrong sensory modality. *Perception & Psychophysics, 63,* 330–336.

Stapel, D.A. & Koomen, W. (2000). How far do we go beyond the information given? The impact of knowledge activation on interpretation and inference. *Journal of Personality and Social Psychology*, 78, 19-37.

Stepper, S., & Strack, F. (1993). Proprioceptive determinants of emotional and nonemotional feelings. *Journal of Personality and Social Psychology*, 64, 211-220.

Strack, F., Martin, L.L., & Stepper, S. (1988). Inhibiting and facilitating conditions of the human smile: A nonobtrusive test of the facial feedback hypothesis. *Journal of Personality and Social Psychology*, 54, 768-777.

Tabibnia, G., Lieberman, M.D., & Craske, M.G. (2008). The lasting effects of words on feelings: Words may facilitate exposure effects to threatening images. *Emotion*, 8, 307-317.

Teasdale, J.D. (1999). Multi-level theories of cognition-emotion relations. In T. Dalgleish and M. Power (Eds.) *Handbook of cognition and emotion*. (pp. 665-681). Chichester, England: Wiley.

Tracy, J. L., & Robins, R. W. (2004). Show your pride: Evidence for a discrete emotional expression. *Psychological Science*, *15*, 194-197.

Tulving, E. (1993). What is episodic memory? *Current directions in Psychological Science, 2*, 67-70.

Van Dantzig, S., Pecher, D., Zeelenberg, R., & Barsalou, L. W. (2008). Perceptual processing affects conceptual processing. *Cognitive Science, 32*, 579-590.

Velten, E. (1968). A laboratory task for the induction of mood states. *Behavior Research and Therapy*, 6, 473-482.

Vermeulen, N., Mermillod, M., Godefroid, J., & Corneille, O. (2009). Unintended embodiments of concepts into percepts: Sensory activation boosts attention for same-modality concepts in attentional blink paradigm. *Cognition, 112*, 467-472.

Vermeulen, N., Niedenthal, P.M., & Luminet, O. (2007). Switching between sensory and affective systems incurs processing costs. *Cognitive Science, 31*, 183-192.

Von Helversen, B., Gendolla, G. H. E, Winkielman, P., & Schmidt, R.E. (2008). Exploring the hardship of ease: Subjective and objective effort in the ease-of-processing paradigm. *Motivation and Emotion, 32*:1–10.

Vrana, S. R. (1994). Startle reflex response during sensory modality specific disgust, anger, and neutral imagery. *Journal of Psychophysiology, 8*, 211-218.

Vrana, S.R. (1995). Emotional modulation of skin conductance and eyeblink responses to a startle probe. *Psychophysiology*, 32, 351-357.

Vrana, S.R., & Rollock, D. (2002). The role of ethnicity, gender, emotional content, and contextual differences in physiological, expressive, and self-reported emotional responses to imagery. *Cognition and Emotion, 16*, 165-192.

Wheeler, M.A., Stuss, D.T., & Tulving, E. (1997). Toward a theory of episodic memory: the frontal lobes and autonoetic consciousness. *Psychological Bulletin, 121*, 331-354.

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

Wiezbierca, A. (1992). Defining emotion concepts. *Cognitive Science, 16*, 539-581.

Wilde, O. (1891). *The Picture of Dorian Gray*. New York: Barnes & Noble Classics.

Wilkowski, B.M., Meier, B.P., Robinson, M.D., Carter, M.S., & Feltman, R. (2009). "Hot-headed" is more than an expression: the embodied representation of anger in terms of heat. *Emotion, 9*, 464-477.

Wilson, M. (2002). Six views of embodied cognition. *Psychonomic Bulletin & Review, 9*, 625-636.

Winkielman, P., & Berridge, K.C. (2004). Unconscious emotion. *Current Directions in Psychological Science, 13*, 120-123.

Winkielman, P., & Cacioppo, J. T. (2001). Mind at ease puts a smile on the face: Psychophysiological evidence that processing facilitation increases positive affect. *Journal of Personality and Social Psychology, 81*, 989-1000.

Winkielman, P., Niedenthal, P., & Oberman, L. (2008). The embodied emotional mind. In Semin, G. R., & Smith, E. R. (Eds.) *Embodied grounding: Social, cognitive, affective, and neuroscientific approaches*. (pp. 263-288). New York: Cambridge University Press.

Zeelenberg, R., Wagenmakers, E.J., & Rotteveel, M. (2006). The impact of emotion on perception. Biased or enhanced processing? *Psychological Science, 17*, 287-291.

Zillmann, D., Katcher, A.H., Milavsky, B. (1972). Excitation transfer from physical exercise to subsequent aggressive behavior. *Journal of Experimental Social Psychology*, 8, 247-259.

Zwaan, R.A. (2009). Mental simulation in language comprehension and social cognition. *European Journal of Social Psychology*, 39, 1142-1150.

Zwaan, R.A. & Madden, C.J. (2005). Embodied sentence comprehension. In Pecher, D. & Zwaan, R.A. (Eds.) *Grounding cognition: The role of perception and action in memory, language, and thinking.* (pp 224-245). Cambridge University Press, Cambridge, UK.

Zwaan, R.A., & Taylor, L.J. (2006). Seeing, acting, understanding: Motor resonance in language comprehension. *Journal of Experimental Psychology: General*, *135*, 1-11.

Footnotes

1 Based on the exit questions we identified seventeen participants who were suspicious about the bogus nature of the implicit emotion task. None of the results changed when we ran our analyses without these participants.

2 An analysis of corrugator supercilii activity during the picture viewing task revealed the expected interaction between *picture type* and *time*, $F(6, 504) = 4.64$, $p = .002$, $\eta_p^2 = .05$, $\varepsilon = .61$. Corrugator activity increased over time during fearful pictures and remained stable during neutral pictures. We found no effects of *concept*, indicating that corrugator activity while viewing pictures was not influenced by concept activation.

Acknowledgements | Dankwoord

'The advantage of the emotions is that they lead us astray, and the advantage of science is that it is not emotional' (Oscar Wilde, 1891, pp. 43).

Although I agree that emotions can sometimes cause us to wander from known paths, I do not share Oscar Wilde's view on emotions and science. In my experience practicing science is an emotional rollercoaster. In the years that I worked on my dissertation I have experienced overwhelming joy (when a paper got accepted); overwhelming disappointment (when a paper got rejected); nervousness (two weeks before a talk); fear, or to be exact, a flight response (two minutes before a talk); anger (directed at Word for making lay-out decisions by itself); pride (getting that complicated code to run, without errors, in one go); disgust (going through the IAPS database, for the n^{th} time); doubt (when hovering with the mouse over the 'submit' button) and intense curiosity (when viewing the first output table in SPSS). These years have been busy, exciting, worrisome and joyful, and there are quite some people that I would like to thank for their support, enthusiasm and wisdom, or for simply being there.

Ten eerste natuurlijk Mark en Agneta, mijn begeleiders. Agneta, bedankt voor je scherpe opmerkingen, je kennis van zaken en je humor. Ik heb heel veel geleerd in de afgelopen jaren, en niet alleen omdat je me de mogelijkheid hebt geboden om mijn eigen weg te gaan in mijn promotieonderzoek, maar ook omdat je me op de juiste momenten een zetje in de goede richting hebt gegeven. Mark, wij gaan al zo lang terug, en al die tijd heb je een constante bijdrage geleverd aan mijn ontwikkeling als wetenschapper. Bedankt voor alle goede gesprekken over onderzoek, analyses en wilde ideeën, en bedankt voor je onvoorwaardelijke steun wanneer het een keer niet meezat.

Second, many thanks to my international collaborators Ursula Hess and Piotr Winkielman. Piotr, I really enjoyed staying in your lab in San Diego. Thank you for your wit, your knowledge and your hospitality. René en Diane, ik ben blij dat onze

paden elkaar toevallig hebben gekruist in San Diego. Ik vond het geweldig om met jullie te leren surfen en om samen onderzoek te doen. Ik heb veel van jullie geleerd!

En dan mijn collega's van de vakgroep sociale psychologie aan de UvA, bedankt voor jullie feedback door de jaren heen en natuurlijk voor de gezellige borrels in Kriterion. Marleen, Daniela en Juliane bedankt voor jullie gezelschap! Elise, met jou wordt een simpele wandeling door de bossen al snel een diepgaande, wetenschappelijke discussie. Dankjewel voor je input en je vriendschap. Dianne, ik deel met niemand een passie voor chocolade en sushi zoals met jou; bedankt voor de fijne avonden. Andries, bedankt voor je hulp met programmeren en voor de opbeurende én inspirerende gesprekken tijdens het koffiedrinken. Aukje, Marieke en Marina, wat was dat een geweldige avond in Volterra! Loran, thank you for challenging me to think about my scientific career and for showing me the perfect combination of science and fun. Job and Skyler, my academic siblings, thank you for your support, it was fun to be in this together! Skyler, you have been such a good friend, thank you for your pep-talks, and your well-timed brownies and hugs!

Ik wil ook graag alle studenten die ik in de loop van de tijd heb begeleid bedanken. In het bijzonder Edith, Maurice en Oscar, bedankt voor jullie bijdrage aan mijn onderzoek. En dan Marcus, Nico en Bert van de Audiovisuele Dienst. Ondanks het feit dat ik tot vervelens toe langskwam met vragen die varieerden van mogelijke aanpassingen in de software tot een stoel die met een bout in de vloer moest worden vastgezet, jullie hebben altijd de tijd genomen om mij te helpen. Heel erg bedankt! En ten slotte, Marco, ik vond het een groot plezier om met jou de Authorware cursus te geven en zo nu en dan samen een kop koffie te drinken.

Maar er zijn ook mensen buiten de universiteit die er de afgelopen jaren voor mij zijn geweest. Mijn lieve vriendinnen Judith, Kim en Lara, bedankt voor jullie steun! And thanks to Zoe, not only for being such an inspiring yoga teacher, but also for being my friend. Bert, dankjewel voor al die gesprekken op de fiets en voor je oprechte nieuwsgierigheid naar wat ik doe. Je bent mijn lievelingsoom! En mijn

twee prachtige paranimfen! Suzanne, dankjewel voor het samen suffe series op de bank kijken, maar ook voor het altijd aanwezige luisterend oor. Jij denkt zulke mooie dingen, ik ben altijd weer benieuwd waar ons volgende gesprek over gaat. Len, het is jammer dat ik die quote over vriendschap nooit meer heb kunnen terugvinden, want dan had ik nu woorden gehad. Dus dan zeg ik het maar zo: ik ben heel blij dat jij in mijn leven bent; al denken we vaak hetzelfde, toch voeg je steeds weer iets nieuws toe.

Maarten, thank you for inspiring me to rez Amygdala and to create Siobhan and Skaoi. We go well together in both worlds; being with you is an adventure that I enjoy to no end. /love

En ten slotte, Flip, Papa en Mama. Flip, lief zusje, we beleefden avonturen toen we klein waren en nu nog steeds. Waar we ook zijn, onderweg in de auto, samen op de bank, wandelend door een stad of museum, ik ben altijd blij als ik je naast me heb. Papa en Mama, ik denk dat jullie mij iets heel waardevols hebben meegeven. Een nieuwsgierigheid die geen grenzen kent. Al die reizen, al die dingen die jullie ons hebben laten zien, al die gesprekken over wiskunde en vliegtuigmotoren (papa) en feminisme en politiek (mama) hebben een fundamentele rol gespeeld in mijn ontwikkeling als mens en als wetenschapper. Dank jullie wel!

KLI Dissertation Series

The "Kurt Lewin Institute Dissertation Series" started in 1997. Since 2009 the following dissertations have been published:

2009-1: Marijke Leliveld: *Ethics in Economic Decision-Making*

2009-2: Monique Pollmann: *Accuracy and Bias in Person Perception*

2009-3: Krispijn Faddegon: *Regulatory Focus in Group Contexts*

2009-4: Lieven Brebels: *Mirror, mirror on the wall… Procedural fairness as an evaluative and regulatory looking-glass self*

2009-5: Daphne Wiersema: *Taking it personally: Self-esteem and the protection of self-related attitudes*

2009-6: Judith D.M. Grob: *Dial E for Emotion: Context and Consequences of Emotion Regulation*

2009-7: Katherine Stroebe: *Is this about me? Responding to subtle discrimination - beyond an individual versus group perspective*

2009-8: Menno Vos: *Identity patterns in diverse work groups: Improving social integration outcomes through relational identities*

2009-9: Lennart Renkema: *Facing Death Together: Understanding The Consequences of Mortality Threats*

2009-10: Michael Vliek: *Group-based social comparison processes: An intragroup level of analysis*

2009-11: Karlijn Massar: *Unconscious rivals: The automatic evaluation of rivals in jealousy-evoking situations*

2009-12: Bart Terwel: *Origins and consequences of public trust: Towards an understanding of public acceptance of carbon dioxide capture and storage*

2009-13: Emma ter Mors: *Dealing with information about complex issues: The role of source perceptions*

2009-14: Martijn Veltkamp: *On the Instigation of Implicit Motivation: How Deprivation and Positive Affect Cause Motivated Behavior*

2009-15: Marret K. Noordewier: *Consistency and the unexpected*

2009-16: Sytske van der Velde: *Imitation of Emotion: How meaning affects the link between imitation and liking*

2009-17: Jacomijn Hofstra: *Attaching Cultures: The role of attachment styles in explaining majority members' acculturation attitudes*

2009-18: Jacqueline Tanghe: *Affect in Groups: Convergence, Conditions and Consequences*

2009-19: Anne Marike Lokhorst: *Using Commitment to Improve Environmental Quality*

2009-20: Jonathan van 't Riet: *Framing Health Communication Messages*

2009-21: Suzanne Pietersma: *Persuasive Health Communication: A Self-Perspective*

2009-22: Remco Wijn: *A functional perspective on the justice judgment process and its consequences*

2009-23: Niels van de Ven: *The bright side of a deadly sin: The psychology of envy*

2009-24: Anthon Klapwijk: *The Power of Interpersonal Generosity*

2010-1: Maarten Wubben: *Social Functions of Emotions in Social Dilemmas*

2010-2: Joyce Rupert: *Diversity faultlines and team learning*

2010-3: Daniel Lakens: *Abstract Concepts in Grounded Cognition*

2010-4: Luuk Albers: *Double You? Function and Form of Implicit and Explicit Self-Esteem*

2010-5: Matthijs Baas: *The Psychology of Creativity: Moods, Minds, and Motives*

2010-6: Elanor Kamans: *When the Weak Hit back: Studies on the Role of Power in Intergroup Conflict*

2010-7: Skyler Hawk: *Changing Channels: Flexibility in Empathic Emotion Processes*

2010-8: Nailah Ayub: *National Diversity and Conflict: The Role of Social Attitudes and Beliefs*

2010-9: Job van der Schalk: *Echoing Emotions: Reactions to Emotional Displays in Intergroup Context*

2010-10: Nevra Cem: *Organizational citizenship behavior and counterproductive work behavior: Cross-cultural comparisons between Turkey and the Netherlands*

2010-11: Ron Broeders: *On Situated and Embodied Knowledge Regarding Moral Issues*

2010-12: Margriet Braun: *Dealing with a deviant group member*

2010-13: Dennis Bleeker: *Representing or defecting? The pursuit of individual upward mobility in low status groups*

2010-14: Petra Hopman: *Group Members Reflecting on Intergroup Relations*

2010-15: Janneke Oostrom: *New Technology in Personnel Selection: The Validity and Acceptability of Multimedia Tests*

2010-16: Annefloor Klep: *The Sharing of Affect: Pathways, Processes, and Performance*

2010-17: Geertje Schuitema: *Priceless policies. Factors influencing the acceptability of transport pricing policies*

2010-18: Femke van Horen: *Breaking the mould on copycats: What makes product imitation strategies successful?*

2010-19: Niek van Ulzen: *Exploring affective perception and social action*

2010-20: Simon Dalley: *Women's body dissatisfaction and restrictive eating behaviour: A tyranny of a thin-ideal or a fear of fat?*

2010-21: Paul Preenen: *Challenge at Work: A matter of give and take*

2010-22: Katarzyna Ewa Kubacka: *The Rules of Attraction: Trust, Anxiety and Gratitude*

2010-23: Loes Kessels: *May I have your attention please? A neuroscientific study into message attention for health information*

2011-1: Elze Ufkes: *Neighbor-to-neighbor conflicts in multicultural neighborhoods*

2011-2: Kim van Erp: *When worlds collide. The role of justice, conflict and personality for expatriate couples' adjustment*

2011-3: Yana Avramova: *How the mind moods*

2011-4: Jan Willem Bolderdijk: *Buying people: The persuasive power of money*

2011-5: Nina Regenberg: *Sensible Moves*

2011-6: Sonja Schinkel: *Applicant reactions to selection events: Interactive effects of fairness, feedback and attributions*

2011-7: Suzanne Oosterwijk: *Moving the Mind: Embodied Emotion Concepts and their Consequences*