Moving the mind: embodied emotion concepts and their consequences

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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

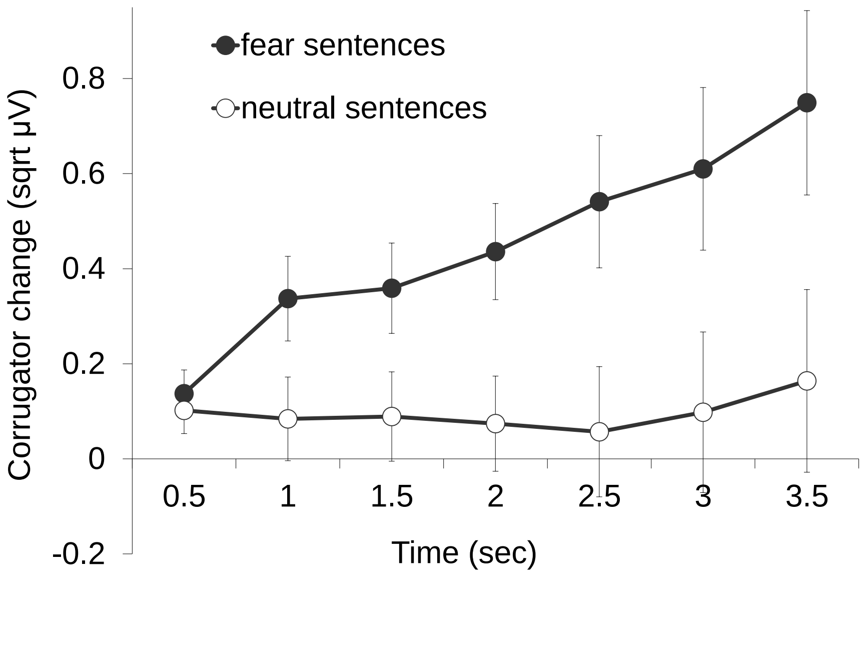
An ANOVA performed on the sentence ratings showed that fear sentences (M = 405, SD = 121) were significantly more associated with fear than neutral sentences (M = 29, SD = 29), $F(1, 88) = 406.96$, $p < .001$, $\eta_p^2 = .82$. Analyses of the picture ratings showed that fear pictures were judged as 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, $t(41) = 2.60$, $p = .013$.

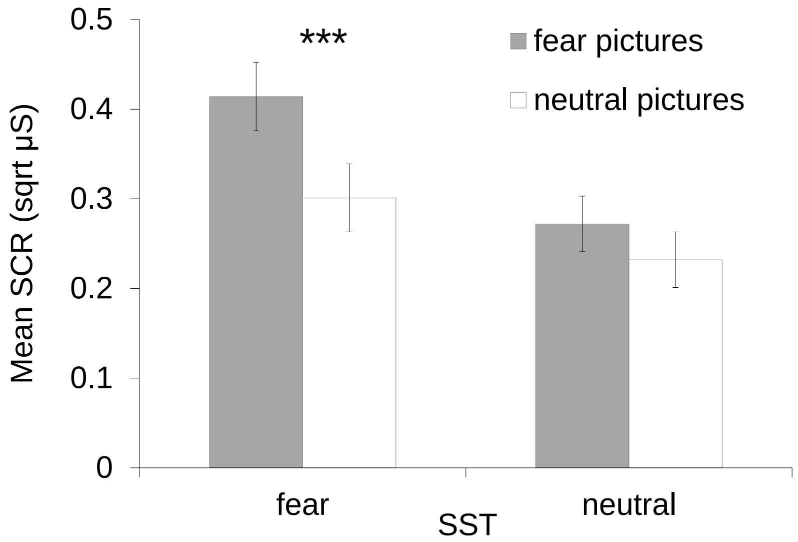
Figure 2. Mean change scores for corrugator supercilii indicate a difference in corrugator activity over time comparing fear and neutral sentences. Vertical bars represent standard errors.



Picture Viewing Task[2]

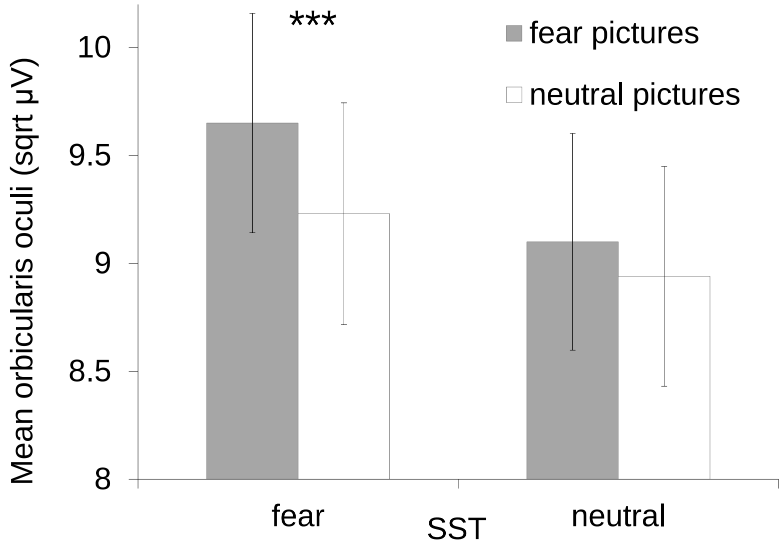
Electrodermal activity. In line with our expectations, skin conductance activity while viewing pictures was modulated by the former activation of fear knowledge. As illustrated in Figure 3, the difference in mean SCR towards fearful and neutral pictures was larger after unscrambling fear sentences compared 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, $F(1, 81) = 3.22$, $p < .076$, $\eta_p^2 = .04$.

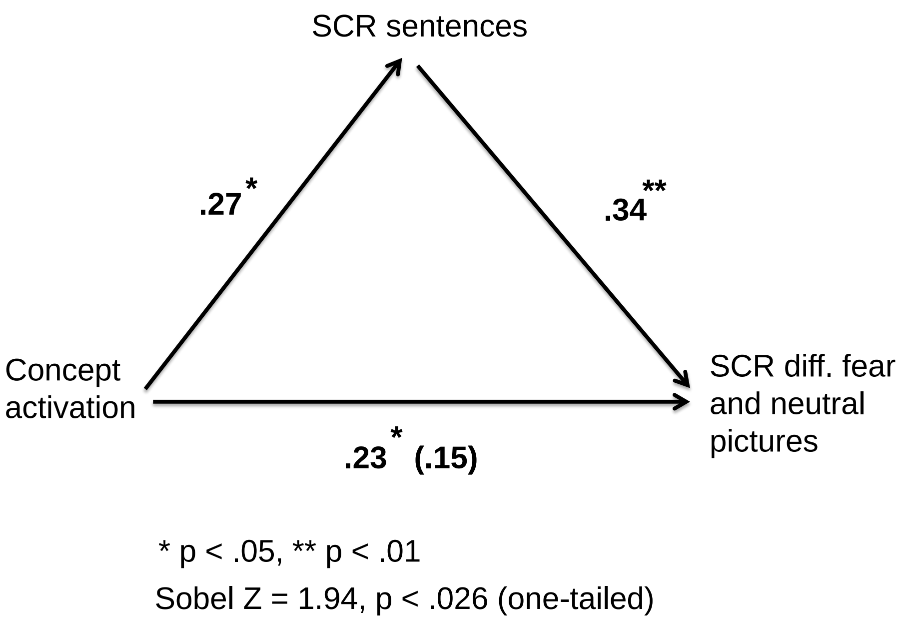
Figure 4. Mean change scores for orbicularis oculi (right) indicate a significantly larger startle response while viewing fearful compared to neutral pictures (startle modulation) only in the fear condition. Vertical bars represent standard errors.
*** p < .01



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.