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Research Article

Emotional Conception

How Embodied Emotion Concepts Guide Perception and Facial Action

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ABSTRACT—*This study assessed embodied simulation via electromyography (EMG) as participants first encoded emotionally ambiguous faces with emotion concepts (i.e., "angry," "happy") and later passively viewed the faces without the concepts. Memory for the faces was also measured. At initial encoding, participants displayed more smiling-related EMG activity in response to faces paired with "happy" than in response to faces paired with "angry." Later, in the absence of concepts, participants remembered happiness-encoded faces as happier than anger-encoded faces. Further, during passive reexposure to the ambiguous faces, participants' EMG indicated spontaneous emotion-specific mimicry, which in turn predicted memory bias. No specific EMG activity was observed when participants encoded or viewed faces with non-emotion-related valenced concepts, or when participants encoded or viewed Chinese ideographs. From an embodiment perspective, emotion simulation is a measure of what is currently perceived. Thus, these findings provide evidence of genuine concept-driven changes in emotion perception. More generally, the findings highlight embodiment's role in the representation and processing of emotional information.*

The notion that emotional and motivational concepts influence perception is embedded in psychological lore. Nowhere are the implications of such concept-driven processing more acute—or more controversial—than in the perception of emotion stimuli. Among the most common and significant emotion stimuli are facial expressions. Emotional expressions are widely acknowledged as essential in communicating internal feelings and behavioral intentions (Ekman & Oster, 1979). Yet, in practice, such expressions are typically blends whose interpretation requires some top-down information from the perceiver (Aviezer et al., 2008; Russell, 1997; Scherer & Tannenbaum, 1986; Wallbott, 1988).[1] The research reported here explored the perceptual and bodily consequences of applying emotion concepts to emotional expressions. This exploration is grounded in a theoretical framework in which perceptual, conceptual, and bodily responses are intimately linked through the embodied nature of mental representation. We show that viewing an ambiguous expression (e.g., a blend of anger and happiness) in the context of processing a specific emotion concept (e.g., "anger") influences not only the encoding of the expression, but also the way the expression is later perceived. This influence is evidenced by spontaneous facial mimicry that, according to the embodied-cognition perspective, is an integral part of emotion perception. Conversely, the effect of categorical encoding on spontaneous bodily responses highlights the embodied nature of emotion concepts.

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EMOTION CONCEPTS IN THE PERCEPTION OF FACIAL EXPRESSION

In earlier research, we obtained initial evidence for the role of categorization in the encoding of emotional expressions (Halberstadt & Niedenthal, 2001). In one study, participants saw computer-presented images of blended facial expressions, pretested to be equally consistent with angry and happy emotions (in a different study, the expressions were equally consistent

[1]The possibility that concepts transform facial perception has fascinated researchers and the public alike at least since the 1920s, when the filmmaker Lev Kuleshov demonstrated that what audiences "see" in an actor's face depends on the larger interpretive context (Mobbs et al., 2006; Wallbott, 1988).

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with angry and sad emotions). The morphed expressions were accompanied by a disambiguating label, either "angry" or "happy." Later, participants viewed short movies in which the target's face changed gradually from extreme anger to extreme happiness and were asked to freeze each movie at the precise image seen at encoding. As predicted, faces paired with angry labels were remembered as more angry than faces paired with happy labels, particularly when participants were required to explain at encoding why the targets were feeling the emotions. Subsequent research (Halberstadt, 2005) showed that memory for the concepts themselves was unrelated to the magnitude of their biasing effects, suggesting that participants did not merely reconstruct their "memory" for emotional expressions at the time of the face memory test. Instead, it appears that participants visually encoded the expressions as angry or happy in the context of the corresponding emotion concepts and remembered these visual images later.

However, although it appears that the concepts biased later recognition of the emotional expressions, there is little evidence for a more provocative interpretation of this intriguing phenomenon—that the concepts biased actual *perception* of the expressions. Support for this stronger interpretation requires evidence as to what participants actually see when they view an ambiguous face following exposure to a biasing emotion concept. Of course, distinguishing perceptual from postperceptual mechanisms, such as reporting biases, has long been a challenge for researchers, although recent performance-based perceptual measures have been promising (e.g., Bukach, Gauthier, & Tarr, 2006; Tanaka & Curran, 2001; for a review, see Goldstone, Gerganov, Landy, & Roberts, 2008). In the case of emotion perception, what is needed is an on-line, nonverbal indication whether, for example, happiness-encoded morphed faces are indeed perceived as happy after encoding. Such evidence can be provided by physiological measures that tap into spontaneous bodily responses to expressions, such as facial electromyography (EMG). More important, looking at bodily responses provides a way to examine the novel theoretical idea that emotion perception and emotion conception are related via the common, embodied nature of their representation.

EMBODIED EMOTION CONCEPTS

A novel way of understanding how concepts interact with perception is provided by recent theoretical and empirical work on *embodied cognition* (Barsalou, 1999, 2008; Niedenthal, 2007; Smith & Semin, 2004). In this account, concepts are fundamentally grounded in sensorimotor and interoceptive experience, having representations that are modal, rather than abstract. Concepts are also situated, with a particular context determining what aspects of modal representation will be used. As a result, the application of a concept in perception, thinking, or memory involves a partial, context-dependent reinstantiation of the relevant original experiences with the stimulus, rather than access to a generic amodal redescription of such experiences (Barsalou, 1999, 2008; Smith & Semin, 2004). Thus, in this view, emotion concepts are modality-specific embodied simulations of emotional states and reactions (Niedenthal, 2008; Niedenthal, Barsalou, Winkielman, Krauth-Gruber, & Ric, 2005).

The embodied-cognition account assumes that both the use of an emotion concept and the perception of particular emotional expressions inherently involve simulation of the corresponding emotion. Thus, the account makes interesting predictions in the experimental paradigm employed in our earlier study (Halberstadt & Niedenthal, 2001), and also provides a novel tool for testing them. First, the embodiment account predicts concept-driven simulation of emotion during encoding. Previous studies suggest that thinking about an emotion concept is associated with bodily simulation of the corresponding emotion (e.g., Niedenthal, Winkielman, Mondillon, & Vermeulen, 2009). Conversely, studies also suggest that bodily simulation is involved in the processing of emotional expression (e.g., Niedenthal, 2007; Niedenthal, Brauer, Halberstadt, & Innes-Ker, 2001; Oberman, Winkielman, & Ramachandran, 2007; Pitcher, Garrido, Walsh, & Duchaine, 2008; Wallbott, 1991). Thus, while viewing—and attempting to disambiguate—an emotionally ambiguous face, participants should simulate the emotional expression associated with the emotion concept that accompanies the face.

Second, and perhaps more interesting, the embodiment account predicts that the emotion simulated during encoding will also be simulated when the same face is encountered in the *absence* of the concept. It is now well established that individuals spontaneously respond facially to others' emotional expressions, typically in a mimicry-like fashion—smiling in response to smiles and frowning in response to frowns (Dimberg, 1982; Dimberg, Thunberg, & Elmehed, 2000).[2] Thus, this concept-dependent facial responding (absent memory for the concept) can serve as a proxy for how the previously viewed ambiguous face is actually perceived. Accordingly, mimicry upon reexposure to the face would simultaneously provide evidence of genuine concept-driven change in emotion perception and, more generally, evidence of the embodied nature of emotional processing.

THE PRESENT STUDY

The present study was designed to test for embodied representation of emotion (as reflected in bodily simulations) during encoding and perception of ambiguous emotional expressions. In an extrapolation of our previous (Halberstadt & Niedenthal, 2001) paradigm, participants were first exposed to faces ex-

[2]Facial responses to other people's expressions can also reflect processes other than mimicry, such as an emotional response (Dimberg, Thunberg, & Grunedal, 2002; Moody, McIntosh, Mann, & Weisser, 2007; van Honk & Schutter, 2007). Our data and theoretical account are compatible with both interpretations.

pressing blends of anger and happiness, each paired with either an emotion concept (i.e., “angry” or “happy”) or an equally valenced concept not related to emotion (e.g., “reliable,” “messy”). To provide stimulus control, and to assess the extent to which any reactions were due to the presentation of the concepts themselves, we also exposed participants to Chinese ideographs paired with the same concepts. On a later recognition test, participants were asked to identify the faces they had seen at encoding, as in our earlier study (Halberstadt & Niedenthal, 2001). In addition, as a separate task, participants were asked to view the original faces and ideographs passively, without further instructions.

Spontaneous simulation of emotion was assessed at encoding and during passive exposure via facial EMG over the zygomaticus major and corrugator supercilii muscles (the “smiling” and “frowning” muscles, respectively). We predicted that participants would simulate the expressions associated with the emotion concepts used to encode the faces. Furthermore, if emotion concepts fundamentally influence the perception of faces with which they are encoded, then participants would be expected to “imitate” the relevant emotions when reexposed to the original faces, and this effect would be independent of explicit memory for the emotion concepts. Finally, we predicted that these effects hold when concepts can support processing of the current emotional percept (i.e., “happy,” “angry”), but not when concepts (equally valenced) do not bear on the emotional percept (i.e., “reliable,” “messy”) or when emotional simulation is irrelevant for the perception and interpretation of the stimulus (e.g., when participants encode Chinese ideographs).

METHOD

Participants

Participants were 27 undergraduate and graduate students at the University of Denver. They were recruited through advertisements and paid $10 per hour.

Stimuli and Apparatus

Faces presented at encoding were 18 morphed images of professional actors (10 female and 8 male) expressing blends of happiness and anger. The faces represented the mathematical midpoint of 100-frame movies, each of which gradually blended pretested happy and angry expressions of a single individual. All individuals were dressed in black turtlenecks and photographed on a black background from the shoulders up in full-front perspective. The blends were created with Morph 2.5 (Gryphon Software Corp., San Diego, CA; see Halberstadt & Niedenthal, 2001, for full details of the morphing process). Additionally, 18 Chinese ideographs were used as control stimuli. Examples of both types of stimuli appear in Figure 1.

Fig. 1. Examples of ambiguous faces and ideographs used in the study. The faces represent the 50% midpoint between anger and happiness.

During encoding, each stimulus within a set (18 faces or 18 ideographs) was randomly paired with one of eight adjectives taken from Anderson’s (1968) personality-trait norms. Some stimuli were paired with emotion-related concepts (six with “happy” and six with “angry”). Some were paired with non-emotion-related valenced concepts (two with the positive concepts “wise” and “reliable,” two with the negative concepts “cynical” and “messy”). Emotion-related and non-emotion-related concepts were matched on likeableness and meaningfulness (Anderson, 1968). The remaining two stimuli in each set were paired with neutral concepts (“quiet,” “hesitant”) and used for filler trials. No effects were associated with these neutral filler items, so no analyses including them are reported here.

EMG recording and processing conformed to psychophysiological standards and followed the methods of earlier studies (see Winkielman & Cacioppo, 2001, for more details). Two adjacent Ag/AgCl electrodes, with impedances reduced to less than 10 kΩ, were placed over the regions of the left zygomaticus major (cheek) muscle and corrugator supercilii (brow) muscle. EMG was recorded from two additional regions, orbicularis oculi (eye corner) and medial frontalis (forehead), to control for blinking and nonspecific facial responses (no main effects or interactions were observed for these control regions, so they are not discussed further). EMG signals were acquired with Neuroscan (Charlotte, NC) equipment, filtered with a 10-Hz to 500-Hz band pass, and sampled at 2048 Hz. After acquisition, raw EMG signals were submitted to standard data preprocessing steps (Fridlund & Cacioppo, 1986). First, the signals were integrated, rectified, and screened for movement artifacts. Second, the data were logarithmically transformed, to reduce the impact of extreme values. Third, the data were standardized within participants and within individual muscle sites, to reduce the impact of differential reactivity across individuals and to allow meaningful comparison between muscle sites.

Procedure

Participants reported individually to the laboratory for an experiment on “brain reactions to computer images.” There were four phases to the experiment: (a) stimulus encoding; (b) and (c) recognition and viewing, in counterbalanced order; and (d) concept recall.

Encoding

After providing informed consent, participants viewed the 18 morphed faces and 18 ideographs for 30 s each, in a random order. The stimuli were presented with E-Prime software (Psychology Software Tools, Pittsburgh, PA). As in our earlier study (Halberstadt & Niedenthal, 2001), on each trial participants were instructed to try to silently explain (in their head) "why this person could be ___," or "why this ideograph could mean ___," with the blank filled in by one of the stimulus concepts (i.e., "happy," "angry," "wise," "reliable," "quiet," "hesitant," "cynical," or "messy"). EMG was recorded during the first 20 s of encoding.

Recognition and Viewing

Following a 10-min unrelated filler task (viewing random dot patterns), participants performed either a recognition task or a viewing task, the order of which was counterbalanced. In the recognition task, participants were presented with each of the 18 movies from which the stimulus faces were generated. Participants were instructed to view each movie using a sliding scale positioned below it, and to set the movie to the exact image seen at encoding. Movies were always set initially to their midpoint (see Halberstadt & Niedenthal, 2001, for details). In the viewing task, participants were presented again with the 36 faces and ideographs, in a new random order. Stimuli were presented for 4 s each, with a 5-s interstimulus interval, without any concepts; EMG was recorded throughout the task.

Concept Recall

Finally, participants were asked to recall the concept that had been paired with each face and ideograph during encoding. The 36 faces and ideographs appeared individually, in a new random order, for 1 s each. On each trial, participants responded by pressing a key corresponding to one of the eight concepts.

RESULTS

In our data analysis, we first examined whether conceptual encoding influenced perception as measured by participants' identification of encoded faces (thereby replicating and extending effects from Halberstadt & Niedenthal, 2001). Then, in order to understand the role of embodied simulation in the phenomenon, we examined EMG activity during encoding and subsequent exposure.

Recognition Memory for Faces

Participants' recognition data (i.e., the frames at which the emotion movies were stopped, representing participants' visual memory for the faces seen at encoding) were analyzed in a 2 (valence: positive vs. negative) × 2 (concept type: emotion-related vs. non-emotion-related) analysis of variance (ANOVA). A main effect of valence indicated that faces encoded with positive concepts were remembered as more happy than those encoded with negative concepts, $F(1, 26) = 7.22$, $p < .05$. However, a significant interaction, depicted in Figure 2, revealed that the effect was entirely due to the influence of emotion-related concepts. Faces encoded with the "happy" concept were remembered as more happy than faces encoded with the "angry" concept, $F(1, 26) = 4.98$, $p < .05$. Furthermore, "happy" faces were also remembered as more happy (i.e., the remembered frame was closer to the "happy" end of the emotion movie), and "angry" faces were remembered as more angry (i.e., closer to the "angry" end of the emotion movie), than the faces shown at encoding (always Frame 50), single-sample $ts(26) = 3.66$ and -1.48, $ps = .01$ and $.08$ (one-tailed). For faces paired with non-emotion-related positive and negative concepts, there was no effect of encoding valence, and the remembered frame did not differ from Frame 50. In short, as predicted, the categorical influence on perception was specific to emotion concepts that were applicable to the perceptual content.

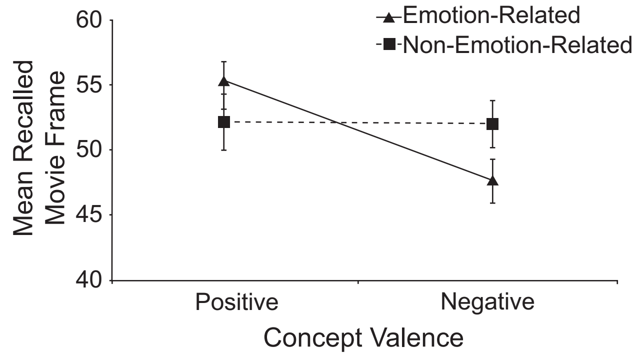

Fig. 2. Mean movie frame identified as a face seen at encoding, as a function of the valence and emotion relatedness of the concept paired with the face. Responses could range from Frame 1 (100% angry) to Frame 100 (100% happy). Frame 50 represents the initially encoded stimulus and thus perfect accuracy. Error bars represent standard errors of the mean.

EMG Responses During Conceptual Encoding

In all EMG analyses, we calculated the mean level of muscle activity during each second after each stimulus presentation and baseline-corrected these scores by subtracting the value from the 2-s prestimulus period (Winkielman & Cacioppo, 2001).[3] Preliminary analyses of activity at encoding revealed no meaningful interactions involving time, indicating that muscle activity was relatively stable across the encoding period. Therefore, EMG responses were averaged over the 20-s recording period and analyzed in 2 (muscle) × 2 (valence) repeated

[3]Because recordings from the prestimulus period included orientation to a fixation point, it is not surprising that some of the observed differences from baseline were negative.

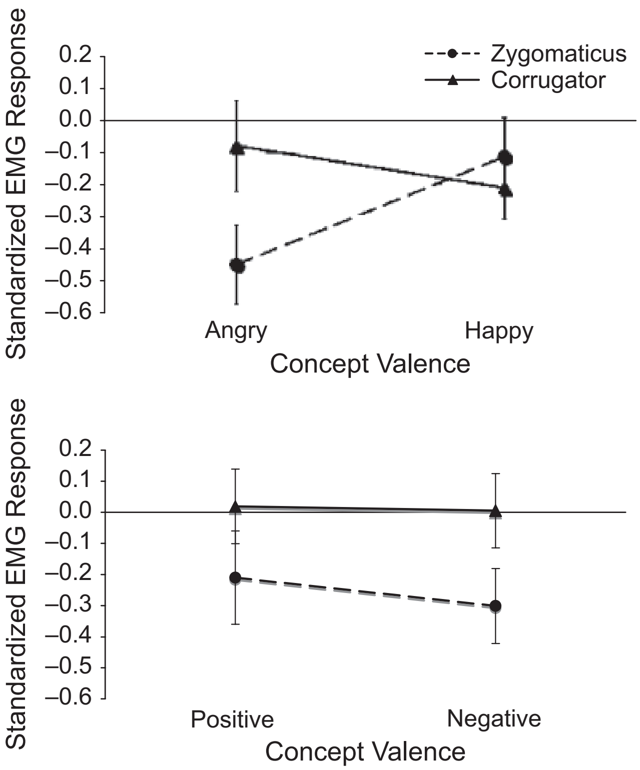

Fig. 3. Mean standardized baseline-corrected electromyographic (EMG) responses to ambiguous faces during encoding, separately for the zygomaticus major and corrugator supercilii. The top graph shows results when faces were encoded using emotion-related concepts, and the bottom graph shows results when faces were encoded using non-emotion-related concepts. Error bars represent standard errors of the mean.

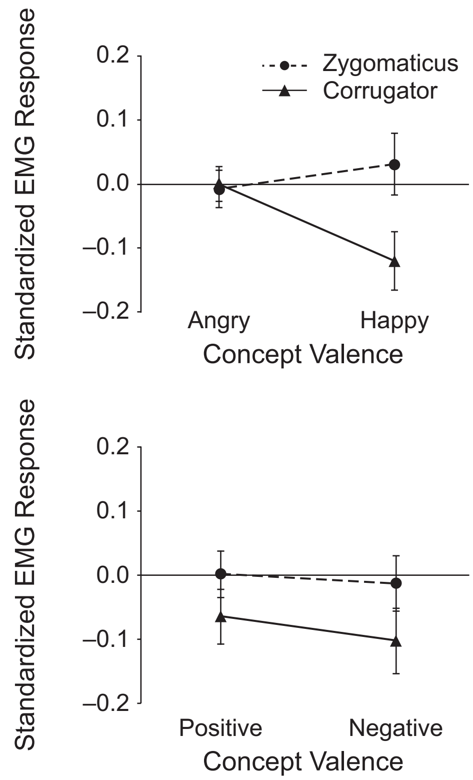

Fig. 4. Mean standardized baseline-corrected electromyographic (EMG) responses to passively viewed ambiguous faces, separately for the zygomaticus major and corrugator supercilii. The top graph shows results for faces previously encoded using emotion-related concepts, and the bottom graph shows results for faces previously encoded using non-emotion-related concepts. Error bars represent standard errors of the mean.

measures within-subjects ANOVAs, conducted separately for emotional and nonemotional concept types. These analyses were first conducted for faces and then for ideographs.

When faces were encoded in terms of emotional concepts, there was a significant Muscle × Valence interaction, $F(1, 21) = 11.65$, $p < .005$ (see Fig. 3, top panel). Simple-effects tests indicated that zygomaticus activity was significantly stronger, and corrugator activity marginally weaker, when the encoding concept was "happy," rather than "angry," $ts(21) = 2.40$ and 1.40, $ps < .01$ and .10 (one-tailed). When faces were encoded in terms of valenced but non-emotion-related concepts, the Muscle × Valence interaction was nonsignificant, $F < 1$ (see Fig. 3, bottom panel). The same analysis of EMG activity during ideograph encoding revealed only an uninteresting main effect of muscle, $F(1, 21) = 6.31$, $p < .05$, reflecting overall greater corrugator than zygomaticus activity (.04 vs. −.30). No other effects reached significance.

EMG Responses During Passive Reexposure

EMG during reexposure to the faces was averaged within each of the 4 s of viewing time and submitted to 2 (muscle) × 2 (valence) × 4 (second) repeated measures ANOVAs, conducted separately for each combination of concept and stimulus type. Once again, when concepts were emotional in nature, the Muscle × Valence interaction was significant, $F(1, 21) = 4.88$, $p < .05$ (see Fig. 4, top panel). Overall, zygomaticus activity was nonsignificantly stronger, and corrugator activity was weaker, $t(21) = 2.46$, $p < .05$, during viewing of happiness-encoded, compared with anger-encoded, faces. However, a three-way interaction with second, $F(3, 63) = 7.12$, $p = .001$, indicated that the Muscle × Valence interaction grew stronger over time, reaching significance only in the 3rd and 4th seconds, $Fs(1, 21) = 9.26$ and 5.67, $ps < .01$ and .05. (The differences between "happy"-face and "angry"-face activation for the zygomaticus and corrugator muscles, respectively, are as follows: .00 and −.02 in the 1st second, .01 and −.05 in the 2nd second, .12 and −.20 in the 3rd second, and .04 and −.22 in the 4th second.) There were no significant effects when participants viewed faces that had been encoded with non-emotion-related concepts (see Fig. 4, bottom panel).[4]

The same analysis on the ideograph data revealed only one effect, a Muscle × Valence interaction, $F(1, 21) = 8.18$, $p < .005$;

[4]Though our central prediction focused on the interaction, it is of some interest that spontaneous EMG responses to "happy" faces were more differentiated than those to "angry" faces. This could reflect complexities involved in mimicking, or emotionally responding to, other people's anger expressions (Dimberg et al., 2002; Moody et al., 2007; van Honk & Schutter, 2007).

zygomaticus activity was stronger, and corrugator activity weaker, during viewing of ideographs that had been encoded with positive concepts, relative to those that had been encoded with negative concepts. This effect was not qualified by concept type (emotional vs. nonemotional) or time.

Relationship Between Postencoding EMG and Recognition

The preceding analyses show that the concepts with which the target faces were encoded influenced both memory for their emotional expressions and participants' spontaneous facial mimicry when reexposed to the faces. We propose that these two effects occurred for the same reason: the embodied nature of the conceptual representation at encoding, which was partially reinstantiated in the presence of the face, and which reflected the participants' perception of it during recognition. To verify this relationship between the two dependent variables, we used muscle activation in the passive viewing phase of the study to predict memory bias, collapsed across theoretically related muscle-concept combinations to enhance the power of the test. Specifically, zygomaticus activation in the case of happiness-encoded faces and corrugator activation in the case of anger-encoded faces were treated as equivalent. In these emotion-congruent combinations, muscle activation should predict memory bias. Similarly, zygomaticus activation in the case of anger-encoded faces and corrugator activation in the case of happiness-encoded faces were treated as equivalent. In these emotion-incongruent combinations, muscle activation should not predict memory bias. Muscle activation, congruency, and their interaction were used to statistically predict face memory (reverse-scored when predicted by corrugator activity).

This analysis revealed that the interaction was significant, as expected: Muscle activation significantly predicted memory bias for the faces in the congruent combinations, $r = .44$, $p < .005$, but not in the incongruent combinations, $r = .22$, n.s. The same analyses conducted on muscle activity and nonemotional positive and negative concepts yielded no significant effects (rs = .03 and .10, ps > .5).

Concept Memory

Memory for the concepts paired with the stimuli at encoding was analyzed in Concept Type × Valence ANOVAs conducted separately for faces and ideographs. For faces, the analysis revealed a main effect of valence, $F(1, 21) = 4.99$, $p < .05$; positively valenced concepts were remembered better than negatively valenced concepts (73% vs. 63%). For ideographs, the analysis revealed a main effect of concept type, $F(1, 21) = 10.40$, $p < .005$; emotion-related concepts were remembered better than non-emotion-related concepts (80% vs. 57%). There was no Concept Type × Valence interaction in either analysis, as would be required for concept memory to account for either the memory or the EMG effects.

To examine further the possible mediating role of label memory in the reported effects, we correlated memory for each type of concept (emotion-related and non-emotion-related, positive and negative) with both recognition memory for and EMG activity during reexposure to the faces that had been paired with these concepts. Concept memory did not predict face memory or muscle activity in any of the four concept conditions.

DISCUSSION

Social stimuli are inherently ambiguous, and emotional stimuli are particularly so. The theoretical importance of emotional expressions in effective communication notwithstanding, people often feel and express mixtures of emotional states (Russell, 1997; Scherer & Tannenbaum, 1986). Thus, perceivers must rely at least partially on top-down, conceptual input to disambiguate this important social information (Wallbott, 1988). Previous research found that concepts applied to ambiguous faces indeed influenced how they were encoded and later remembered (Halberstadt, 2003; Halberstadt & Niedenthal, 2001). The findings led Halberstadt (2003) to call emotion perception a "paradox," in that efforts to interpret other individuals' facial expressions can lead, ironically, to distortions of the very emotions perceivers are trying to disambiguate.

But how does this change in emotion perception happen? The current research investigated the remarkable possibility that the concepts available at encoding influence not just how faces are interpreted, but also how they are perceived. Concept-driven change in perception has been a controversial and long-researched claim in psychology (Schyns, Goldstone, & Thibaut, 1998). However, good evidence for such influence has been elusive, largely because of the difficulty in establishing differences in perception itself, rather than in its cognitive sequelae. For example, consider the classic claims that participants were "locked" into their prior interpretation of an ambiguous figure (Leeper, 1935), or that Princeton undergraduates "saw" more infractions committed by Dartmouth football players than did Dartmouth undergraduates watching the same game (Hastdorf & Cantril, 1954). These claims were based on participants' self-reports of the content of their perception, rather than on their perception per se. Evidence for emotion-biased perception has been particularly difficult to acquire, despite its unique importance in understanding social interaction, and despite the fact that the foundational program of research on concepts and percepts, the "new look in perception," made radical (if inadequately tested) claims about this very topic (Bruner & Postman, 1949).

The current study relied on a new and increasingly well-supported account of conceptual representation—embodied cognition—to make novel predictions about facial behavior in the context of emotion concepts and to gain more direct access to perceivers' percepts. According to the embodiment account, conceptual processing, whether top-down or bottom-up, involves partial simulation of the neural activity present when the concept was originally learned. This account predicts that participants should simulate, at least to some degree, bodily components of anger and happiness when using these concepts to interpret target faces. Conversely, the account also predicts that participants' own angry and happy expressions should be indicative of the perception of the corresponding emotional expressions in the target faces.

The current data support both predictions. Participants using "happy" to interpret an ambiguous emotional expression expressed more happiness on their own face, compared with participants using "angry" to interpret the same expression. Furthermore, the concepts used at encoding had later consequences. First, they biased later perceptual memory for the expressions (a result that replicates Halberstadt & Niedenthal's, 2001, findings). Second, they influenced bodily responding to the ambiguous expressions when those expressions were passively encountered in the absence of the concepts, making participants respond as if the faces were now perceived as happy or angry. Moreover, the second effect (spontaneous facial response) predicted the first (memory bias). In other words, depending on the concept used to encode it, the same face elicited either angry or happy expressions, which in the embodiment view are inherent components of the perception of these emotions.

Equally important are the conditions in which changes in bodily responding did *not* occur. Participants did not systematically change their own facial expressions when using valenced, but non-emotion-related concepts to initially encode faces, or when viewing faces previously encoded in terms of those concepts, even though the concepts were of equivalent valence to "anger" and "happiness." Nor did participants change their own expressions when encoding or viewing ideographs, even when emotion concepts were used to interpret them. Rather, participants expressed anger and happiness specifically when using emotion concepts to interpret emotional faces. This finding is best understood from an embodiment perspective. If concepts are indeed embodied, they should be situated and simulated in highly domain-specific ways: Only an angry face is represented and simulated as the corresponding facial expression; a "cynical" face, or an ideograph with an angry meaning, does not imply the same collection of behaviors (though it may imply different, also predictable, behaviors). Thus, the simulation of anger and happiness during processing of faces paired with emotion concepts and, equally, the failure to simulate these emotions with other stimulus-concept combinations both suggest that emotion representation was embodied.

Even if one accepts the validity of an embodiment approach, however, the current data might be interpreted in other ways. The most a priori plausible of these alternative accounts is the possibility that perceivers imitated emotions when viewing faces not because they perceived the faces as expressing those emotions, but because they reactivated the concepts associated with the faces at encoding. Indeed, because perception, conception, and action are intimately connected in theories of embodiment, it can be difficult to distinguish them in practice. Nevertheless, the current data constitute strong evidence against the conceptual-reactivation account, in that participants' ability to explicitly remember the concepts used at encoding bore no relationship to either their memory for the faces or the extent to which they spontaneously mimicked the faces during reexposure. Of course, it is conceivable that another, perhaps implicit, test of concept memory might be more sensitive to conceptual reactivation in the current paradigm, but there is no evidence in our data of such reactivation.

Such ambiguities notwithstanding, the current data tell a consistent and provocative story about concepts, emotion perception, and facial action. Perceivers faced with the fundamental social task of decoding emotional expressions simulated the concepts available to interpret those expressions. The domain-specificity of these simulations makes sense from an embodiment perspective that links perception and facial action. With this link established, and no evidence for conceptual reactivation, the most reasonable explanation of subsequent concept-congruent imitation of the ambiguous expressions is that those expressions were actually seen as angry and happy. The data thereby simultaneously provide support for embodiment as a coherent account of emotion representation and for the usefulness of the embodiment approach in gaining access to previously elusive perceptual phenomena.

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