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Emotion Words Shape Emotion Percepts

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People believe they see emotion written on the faces of other people. In an instant, simple facial actions are transformed into information about another's emotional state. The present research examined whether a perceiver unknowingly contributes to emotion perception with emotion word knowledge. We present 2 studies that together support a role for emotion concepts in the formation of visual percepts of emotion. As predicted, we found that perceptual priming of emotional faces (e.g., a scowling face) was disrupted when the accessibility of a relevant emotion word (e.g., *anger*) was temporarily reduced, demonstrating that the exact same face was encoded differently when a word was accessible versus when it was not. The implications of these findings for a linguistically relative view of emotion perception are discussed.

Keywords: emotion perception, perceptual priming, linguistic relativity, words, conceptual knowledge

Although linguistic relativity theory (Whorf, 1956/1998) has a long and controversial history, there is accumulating evidence that words shape perception in a variety of domains, including color (e.g., Roberson, Pak, & Hanley, 2008), time (Casasanto & Boroditsky, 2008), and motion (Meteyard, Bahrami, & Vigliocco, 2007), as well as in the visual search for abstract objects (Lupyan & Spivey, 2010). There is also emerging evidence that emotion words act as a context during emotion perception (e.g., Halberstadt, Winkielman, Niedenthal, & Dalle, 2009; Lindquist, Barrett, Bliss-Moreau, & Russell, 2006; Roberson, Damjanovic, & Pilling, 2007; for reviews, see Barrett, Lindquist, & Gendron, 2007; Barrett, Mesquita, & Gendron, 2011). In the present research, we extended this work in a novel direction by showing that the conceptual knowledge associated with emotion words influences the initial encoding of emotion percepts.

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Existing Evidence That Emotion Words Shape Emotion Perception

In the typical emotion perception experiment, a perceiver is presented with a face posing emotion as well as several emotion words, and the task is to choose the word that best matches the face. Participants have high accuracy when they are asked to perceive emotion in a face when selecting an emotion word from a set of provided alternatives (meaning that participants choose the word intended by the experimenter; for a recent review, see Matsumoto, Keltner, Shiota, Frank, & O'Sullivan, 2008). A number of experiments in the emotion literature demonstrate, however, that as emotion words become more remote from a perception task, emotion perception progressively suffers. When perceivers are asked to freely label faces that are posed in emotional configurations, accuracy drops significantly (cf. Russell, 1994; e.g., Boucher & Carlson, 1980; Widen, Christy, Hewett, & Russell, in press),[1] suggesting provided words "aid the observer in resolving ambiguities" inherent in even caricatured facial portrayals of emotion (Boucher & Carlson, 1980, p. 274). When participants are not asked to choose an emotion word but to simply judge whether or not two faces portray the same emotion (perceptual matching), accuracy drops even further (e.g., Lindquist et al., 2006). Perceptual matching can be further impaired by satiating the meaning of the relevant emotion word (i.e., rendering their meaning temporarily inaccessible), even though emotion words are not explicitly necessary for performing the task (Lindquist et al., 2006). This

[1] Although accuracy rates do drop significantly when words are removed from emotion perception tasks, performance does remain above chance in many experiments. This is not inconsistent with the view that language supports the formation of discrete emotion percepts, however, because language could still play an implicit role in those experiments.

impairment in emotion perception is not due to other explanations such as fatigue or working memory load. Together, these data show that emotion words clearly play a role in emotion perception tasks, such that removing emotion words from the experiment, even when they are not necessary to perform the perceptual task, impairs perception accuracy.

Such findings provide initial support for a language-as-context account of emotion perception in which emotion word meaning is hypothesized to help reduce the uncertainty that is inherent in facial actions. Similar to most accounts of person perception, in which a constant stream of actions is transformed into meaningful "behaviors" as a perceiver infers a mental state cause for the actions (Gilbert, 1998; Kozak, Marsh, & Wegner, 2006), words appear to resolve smiles into happiness, scowls into anger, and pouts into sadness – emotions, as mental states, are presumed to cause the actions (i.e., thereby transforming facial actions into emotional expressions) for reviews, see Barrett et al., 2007, 2011; Gendron, Mesquita, & Barrett, in press).

Other, perhaps less direct, evidence for a language-as-context account of emotion perception exists. Children can easily match a face to a word but have difficulty matching faces from the same emotion category (e.g., they are better at pairing a scowling face with the word *angry* than with another scowling face; Russell & Widen, 2002), and their performance on this type of task improves in parallel as they learn linguistic emotion categories (Widen & Russell, 2008, 2010). Emotion words can also bias perceptual memory for emotion (Halberstadt et al., 2009), such that memory for a posed emotional face can be driven by emotion words in a completely perceiver-driven (or what the cognitive literature would call "top-down") fashion (i.e., with no perceptual information in the face that is consistent with the category label; Fernández-Dols, Carrera, Barchard, & Gacitua, 2008). Without emotion words, people do not even perceive emotion in a categorical fashion (Fugate, Gouzoules, & Barrett, 2010; Roberson et al., 2007); it is as if perceivers can detect small changes in facial actions, but do not know which changes are psychologically meaningful in the absence of words. An important finding is that categorical perception can be induced when participants learn to pair facial behaviors with arbitrary verbal labels (Fugate et al., 2010), demonstrating that language can impose categories that the perceptual system does not spontaneously recognize.

Also consistent with the language-as-context account, several imaging studies in the past 5 years have demonstrated that visual representations of discrete emotion do not occur simply as a consequence of visual information coming from a stimulus (such as a face) (e.g., Fox, Moon, Iaria, & Barton, 2009; Thielscher & Pessoa, 2007). When perceivers report seeing a given emotion in a face (e.g., anger), visual association regions (e.g., fusiform gyrus [FFA], superior temporal sulcus [STS]) and an extended network of "affective" brain regions (e.g., anterior cingulate cortex, insula) are engaged, even when the face is neutral in content (Thielscher & Pessoa, 2007). Most recently, it was discovered that category knowledge shapes neural representations of faces posing emotion (Fox et al., 2009). Typically, there is decreasing neural response in visual association regions (FFA, STS) with multiple presentations of emotional faces of the same category (e.g., with multiple scowling faces). Fox et al. demonstrated that regardless of the facial actions posed, neural responses will decrease as long as faces are categorized as the same (e.g., scowling faces categorized as "fear" produce a reduction in neural response after a perceiver has seen multiple examples of a fear expression); alternatively, when scowling faces are categorized as "anger" after viewing fear expressions, neural response rebounds in these regions. These studies suggest that the perceptual representations in these regions are not solely determined by the structural information from the face (i.e., bottom-up information) but instead reflect perceiver-driven information as well (i.e., what category of face the perceiver reports). The above two findings are consistent with the hypothesis that conceptual knowledge is shaping perception, but they do not conclusively demonstrate that it is language, per se, that is driving these effects.

Taken together, the studies reviewed in this section make the case that perceivers judge and remember faces portraying emotion in a way that is shaped by emotion language. Furthermore, language appears to contribute to perceptual representations of emotion. It remains unclear, however, whether emotion words are having their effect during percept formation or at some postperceptual decision stage. For example, in our prior work (Lindquist et al., 2006) in which we reduced the accessibility of emotion word meaning by satiating emotion words, which in turn reduced the speed and accuracy for perceptual matching of emotional faces, it is possible that the reduced accessibility only disrupted an implicit labeling process that proceeds after the percepts are already formed. In this article, we tested the hypothesis that emotion words serve as a form of internal perceiver-driven context that contributes to the formation of an emotional percept, even when the task does not explicitly involve emotion words (Study 1) and when the judgment that perceivers produced is irrelevant to emotion (Study 2) (ruling out an implicit labeling effect).

The Present Experiments

In the present research, we extended the language-as-context account to hypothesize that emotion words shape the perceptual encoding of emotion portrayed on another person's face, such that high-level visual representations are impacted by emotion word accessibility. Specifically, we tested the idea that emotion word meaning influences how perceivers *construct* perceptual representations of scowling faces as "angry" or pouting faces as "sad," such that without accessibility of emotion words, perceptual encoding of discrete emotion in a face is changed (even as posed facial actions remain exactly the same). These experiments tested a key aspect of our psychological construction account of emotion perception (the conceptual act model; Barrett, 2006a, 2006b; Barrett et al., 2007). A key idea in the conceptual act model is that people experience each other as emotional when they conceptualize and make meaning out of affective information in the face, voice, etc. Without some top-down context (including the category knowledge about emotion possessed by the perceiver), facial actions remain ambiguous in terms of discrete emotional meaning. In this approach, emotion concepts represent a key ingredient in emotion perception.

To test our construction hypothesis, we employed a phenomenon called *repetition priming* (for a review, see Grill-Spector, 2008). Repetition priming occurs when participants are faster to respond to a stimulus after having been presented with that stimulus previously. Usually, this speeded response reflects having encoded the same perceptual information on a prior encounter with that stimulus and is associated with repetition suppression (i.e., a decreased blood-oxygen-level-dependent response across presentations measured with functional MRI) in association regions of the ventral visual stream (i.e., inferior temporal/fusiform regions; Wig, Buckner, & Schacter, 2009). If the representation of the same stimulus differs across presentations in these cases, then repetition priming will be disrupted. In some cases, repetition priming can reflect semantic priming (e.g., when participants are asked to produce a semantic judgment of the stimuli; e.g., Wig, Grafton, Demos, & Kelley, 2005) or response priming (e.g., when a participant is making the same response to a stimulus over and over; Horner & Henson, 2008; Wig et al., 2009). In our experiments, we ensured that priming (i.e., decreases in reaction time) reflected the degree to which the same physical stimulus was encoded more than once by having participants make a perceptual judgment about the faces (e.g., "Which face have you seen before?" in Study 1 and "How far apart are the eyes?" in Study 2), thereby avoiding semantic priming. We also had participants render a judgment about the final presentation of a target face only, but not for earlier presentations (i.e., not when the face served as a prime), thereby avoiding response priming. In Study 2, we also included two control conditions to ensure that we were indeed isolating (and then disrupting) a perceptual effect (rather than a semantic effect).

To examine whether words contribute to the perceptual encoding of faces portraying emotion, we decreased the accessibility of emotion word meaning on a trial-by-trial basis using a procedure called *semantic satiation* (e.g., Lindquist et al., 2006; Tian & Huber, 2010; for a review, see Black, 2004). Research has found that repeating a word 30 times leads to a temporary decrease in the accessibility of the word's meaning. This manipulation interferes with judgments of category membership (Balota & Black, 1997; Smith, 1984), semantic relatedness (Smith & Klein, 1990), naming famous faces (Lewis & Ellis, 2000), matching visual objects to labels (Shimokido, 2007), and perceptually matching visual exemplars of a category (Lindquist et al., 2006). Furthermore, when a word is semantically satiated beforehand, it no longer elicits the N400 event-related potential (ERP) component that is sensitive to semantic incongruence (Kounios, Kotz, & Holcomb, 2000). Recent evidence suggests that satiation serves to disconnect the semantic meaning of the term from the phonological form of the word (Tian & Huber, 2010).

On some trials in our experiments, participants repeated an emotion word 30 times to temporarily satiate its meaning. On other trials, participants completed a control manipulation (they repeated an emotion word three times in Study 1; they repeated a control word 30 times in Study 2). Within 500 ms of word repetition, while the word's meaning was still satiated, participants were presented with a posed emotional face to encode. Participants were then presented with the target face again 600 (Study 1) to 800 (Study 2) ms after word repetition (when the effect of satiation had sufficient time to dissipate), after which we measured whether there was a subsequent reduction in repetition priming (i.e., slower reaction times when the participant made a perceptual judgment about the face).[2] We predicted that repetition priming would be intact on control trials because emotion words would be accessible during encoding of the initial face and the subsequent target face. As a result of the consistent language accessibility across presentations, we predicted that the two percepts would be the same, leading to repetition priming. We predicted that repetition priming would not be intact on emotion satiation trials because encoding of the initial face would occur in a context free from the relevant emotion word, but encoding of the same face, when presented again as the target would take place when the word's meaning was more accessible. As a result of the different language accessibility contexts across the two presentations of the same face, we predicted that the two percepts would differ from one another, thus diminishing repetition priming. This would constitute support for our hypothesis that emotion words support the construction of emotional percepts because such a reduction in perceptual priming would mean that the perceptual representation of a face portraying emotion is changed depending on whether the relevant word meaning is accessible (i.e., the percept formed during the presentation when the word was inaccessible would be different from the one formed when the word's meaning was more accessible). More broadly, these data would suggest that the perceptual representation of another person's emotions is not solely dependent on bottom-up visual input from a face alone, but also reflects what the perceiver knows (and can access) about emotion. That is, it would provide evidence that percepts of emotion contain a conceptual element. Such findings would also be consistent with a predictive coding account of repetition priming (Summerfield, Trittschuh, Monti, Mesulam, & Egner, 2008), where fulfilled *perceptual* expectations drive the neural repetition suppression effect (i.e., reductions in the blood-oxygen-level-dependent response to repeated presentation of a stimulus reflect the expectation of that stimulus occurring again). If our hypothesis is correct, then our data would suggest that repetition suppression is shaped by top-down *conceptual* expectations.

Study 1

As an initial test of our construction hypothesis, we conducted a first experiment as proof of concept. Our repetition priming paradigm closely followed that of Ratcliff and McKoon (1996). Specifically, participants first completed a study phase that familiarized them to the set of stimulus faces so as to produce a more robust priming effect (i.e., priming increases with repeated presentations of a stimulus and plateaus after six to eight stimulus presentations; Li, Miller, & Desimone, 1993). We then attempted to break repetition priming in the main task block by semantically satiating emotion words on a trial-by-trial basis. Our semantic satiation procedure was consistent with that of Lindquist and colleagues (2006) in which participants either repeated an emotion word 30 times (satiation) or three times (control).

Method

Participants. Participants were 60 Boston College students (33 women and 27 men). Participants were remunerated with either 1 credit toward a departmental requirement or $10. All participants completed informed consent on entering the laboratory and prior to beginning the experiment.

Stimuli. Stimuli were created from facial portrayals from 12 identities (seven female, five male) of fear, anger, sadness, disgust, and neutral facial actions (Ekman & Friesen, 1976). These stimuli

[2] This was a particularly clean judgment in Study 2 in which participants did not need to have encountered a prior stimulus on the trial to render a judgment.

were morphed to represent 40% and 80% signal strength portrayals. These stimuli were created with Morphman 2000 software (STOIK, Moscow, Russia) by warping a facial portrayal of emotion to a neutral portrayal (by the same identity) and varying the amount of physical contribution that each endpoint (emotional or neutral) had to a given morphed frame.

Procedure. Participants were seated 60 cm from the computer screen and provided with instructions. An experimenter remained in the testing room to ensure compliance. Participants first studied a set of 48 faces either weakly or intensely depicting anger, sadness, fear, or disgust (see Figure 1a). Each face was presented for 2 s, followed by a 200-ms intertrial interval. Participants then completed the experimental task, which entailed a modified semantic satiation procedure followed by a repetition priming procedure within each experimental trial (see Figure 1b for an example of an experimental trial). On test trials, a face portraying emotion was always repeated once as a prime and once as a target, resulting in the potential for repetition priming on every trial. At the beginning of each trial, participants completed a standard semantic satiation manipulation by repeating an emotion word (e.g., *anger*) either 30 times (to reduce its accessibility) or three times (traditionally used as a control in semantic satiation experiments). On all trials, participants repeated an emotion word that was relevant to the emotional faces being judged (called the satiation comparison in earlier studies; Lindquist et al., 2006). After word repetition, participants saw a fixation cross (500 ms) followed by study face (50 ms; e.g., either a weak or intense facial depiction of anger, whichever they saw in the study period), which was masked with a scrambled face image (400 ms). Next, participants immediately saw both weak and intense versions (40% and 80%) of the same face, portraying the same emotion, and indicated which stimulus they had seen before. Latency to render this response served as our main dependent variable of interest.

Results

Data preparation. Data were filtered such that trials associated with outlying reaction times (defined as below 300 ms and anything 3 standard deviations above the mean, or 4,003 ms) were removed; 5.14% of total trials. An analysis of variance (ANOVA) performed on percentage accuracy revealed no main effect for word repetition, $F(1, 59) = 0.563$, $p = .456$, $\eta = .009$, such that participants did not differ in accuracy depending on whether it was a satiation or control trial. Because there was no difference in accuracy across the satiation and control conditions, inaccurate trials (an additional 37% of the total trials) were removed from analysis.

Analyses. As predicted, participants showed reduced repetition priming after a relevant emotion word was satiated, compared with the control condition in which an emotion word was repeated three times, $F(1, 59) = 8.166$, $p = .006$, $\eta^2 = .112$. Participants were significantly slower to judge which face had been initially encoded after the relevant emotion word was satiated versus control (see Figure 2).

Discussion

Performance in a repetition priming task for emotional faces was impeded when the relevant emotion word meaning was inaccessible during encoding. These data indicate that perceptual priming was diminished when the meaning of the relevant emotion word was temporarily inaccessible at the encoding of a portrayal of emotion. This was the case, even though emotion words were not

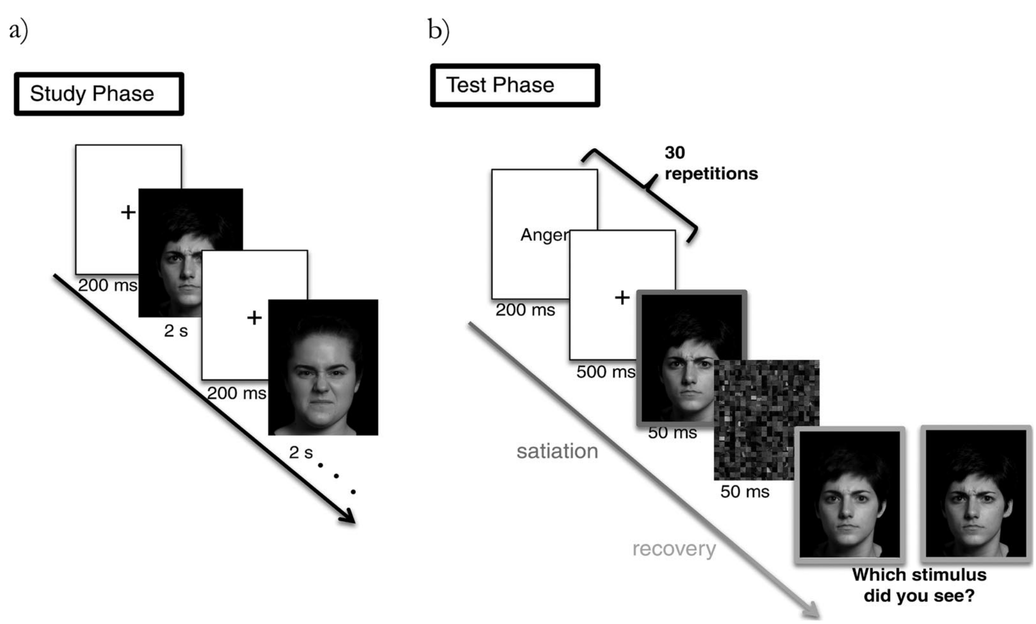

Figure 1. Example of a typical trial in Study 1. First, a study phase took place in which 48 images were displayed (a), following which there was a test phase (b), where on each trial a word was repeated either three or 30 times, a prime was presented, which was followed by a forced-choice task. Participants were asked to indicate which of the two faces (if either) was presented earlier in the trial.

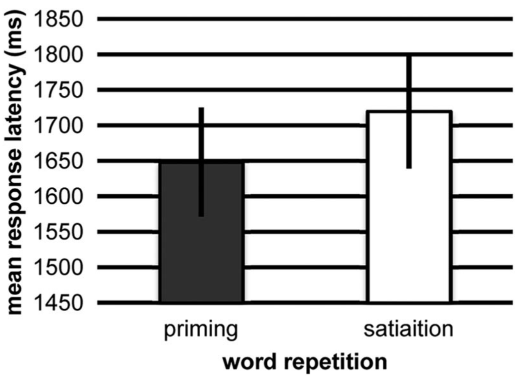

Figure 2. Results from Study 1. Mean response latency (±*SE*) plotted for the emotion word satiation and emotion word priming conditions.

explicitly required for participants to perform the perception task. This finding constituted the first evidence consistent with the construction hypothesis: Satiating an emotion word appeared to change basic perceptual encoding of emotional faces, implying that conceptual knowledge for emotion was active during the creation of an emotional percept. The fact that the task did not explicitly require conceptual knowledge implies that this knowledge is routinely active during emotion perception.

Study 2

Study 2 replicated and extended the findings from Study 1 to provide stronger support for the construction hypothesis. As in Study 1, we designed our experiment to establish a precise, unambiguous perceptual priming effect (which we then attempted to disrupt with emotion word satiation). In this study, however, participants rendered a perceptual judgment about a single target face rather than a pair of faces. Participants viewed a face after word repetition; we refer to this as the prime face. Participants then viewed a second face; we refer to this as the target face. Participants rendered a perceptual judgment about the target face (about the distance between the eyes). We systematically varied the relationship between the prime and target faces across trials (based on Sasaki & Nakajima, 2000) to establish repetition priming for emotional faces, which we then attempted to disrupt with emotion word satiation. In the baseline condition, the prime face and target face were different; this served as the comparison against which repetition priming effects could be computed. In the full repetition priming condition, the prime and target faces were identical, so that any decrease in response time compared with the baseline condition would be evidence of perceptual priming (that we could then attempt to disrupt by satiating emotion words). We also included two additional types of control trials: emotion repetition trials in which primes and targets were portraying the same emotion but were different in identity (a control to rule out *semantic* priming), and identity repetition trials in which prime and target faces were identical in identity but not in portrayed emotion (a control to rule out that participants are not implicitly judging prime faces to produce *response* priming to identity consistent target faces).[3]

In Study 2, we also attempted to improve on the existing semantic satiation method. The prior satiation literature used a word priming procedure (i.e., three word repetitions) to serve as the control against which satiation was compared. We decoupled word priming and control conditions by introducing trials in which participants repeated a completely irrelevant abstract word (e.g., *future*) 30 times (a satiation control condition) and in which they repeated an abstract word that was irrelevant to emotion (e.g., *space*) 27 times before repeating the relevant emotion word three times (an emotion word prime condition). These conditions were matched for length (i.e., all involved repeating a word 30 times), allowing us to rule out fatigue as an alternative explanation of our findings. We hypothesized that, compared with the baseline condition, participants would show perceptual priming in the full repetition condition when participants repeated an irrelevant abstract word 30 times, but that this repetition priming would be diminished when an emotion word was satiated. That is, we predicted that people would make the perceptual judgment faster in the full repetition condition than in the baseline condition, but only after repeating an irrelevant abstract word; we predicted that the response time savings would be reduced when participants repeated an emotion word 30 times, providing evidence that perceptual priming had been disrupted. We did not expect repetition priming in the other conditions. These findings would be consistent with our construction hypothesis because they would provide evidence that perceptual priming, specifically, and not semantic or response priming was impacted by emotion word satiation.

Method

Participants. Participants were 48 Boston College students (23 women and 25 men). Participants were remunerated with either 1 credit toward a departmental requirement or $10. All participants completed informed consent on entering the laboratory prior to beginning the experiment.

Stimuli. The stimuli were faces posing stereotyped facial actions for sadness, disgust, fear, or anger (stimuli were taken from Ekman & Friesen, 1976, Pictures of Facial Affect; IASLab Face Set[4]; Tottenham, Borscheid, Ellertsen, Marcus, & Nelson, 2002, NimStim set of Facial Expressions). Seventy-two identities (36 male, 36 female) were used to create the stimuli. Stimuli from the NimStim and Ekman face sets were placed on a black background, contrast and brightness adjusted in Adobe Photoshop CS2 to create a uniform set of facial stimuli. Stimuli were presented in black in white at 400 × 514 pixels at central fixation.

Procedure. Participants were seated 60 cm from the computer screen and provided with instructions. An experimenter remained in the testing room to ensure compliance. Participants then completed the experimental task, which entailed a modified semantic satiation procedure followed by a repetition priming procedure within each experimental trial (see Figure 3 for an example of an experimental trial). During the semantic satiation

[3] Response priming is a speeded reaction time simply due to rendering the same judgment about a stimulus repeatedly. Because the response in Study 2 was tied to identity, this type of priming would be evidenced in identity consistent as well as fully consistent face repetition trials.

[4] Development of the Interdisciplinary Affective Science Laboratory (IASLab) Face Set was supported by the National Institutes of Health Director's Pioneer Award (DP1OD003312) to Lisa Feldman Barrett. More information is available on-line at www.affective-science.org

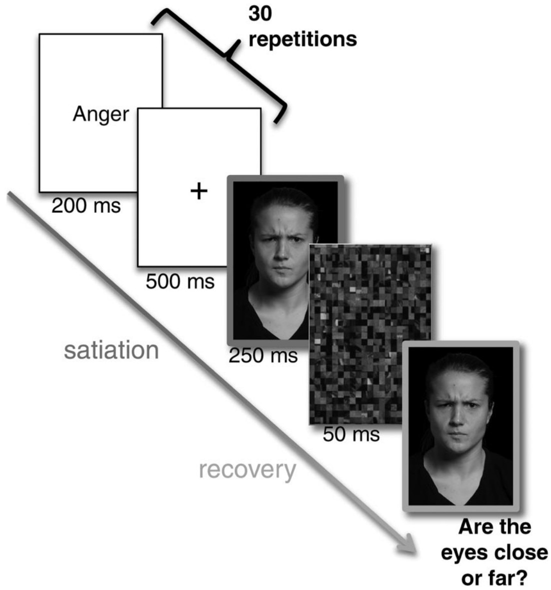

Figure 3. Example of a typical trial in Study 2. On a given trial, participants first repeated words 30 times. This produced satiation of the word repeated. Participants were next presented with a prime face that was always a facial depiction of emotion. This image was visually masked by a scrambled face. At this point, the brief satiation effects began to recover. Participants were then presented with a target face, which either matched or mismatched the prime face in emotion and identity. Participants were then asked to render a perceptual judgment about the target face: Are the eyes closer together or farther apart? Response latency was recorded.

procedure, participants repeated words in one of three conditions: (1) *emotion word satiation* in which a relevant emotion word was repeated 30 times (emotion satiation); (2) *emotion word priming* in which an irrelevant word was repeated 27 times, followed immediately by an emotion word repeated three times (the combination of irrelevant and emotion words was randomized across trials); or (3) *control word satiation* in which an irrelevant word was repeated 30 times. Each word appeared on screen for 500 ms with a 200-ms blank screen following each presentation. Participants were instructed to repeat the word out loud each time it flashed on screen.

Following word satiation, a face prime was flashed on screen for 250 ms. For emotion word satiation and priming trials, the prime face always depicted the same emotion (e.g., the word *anger* was repeated and then participants viewed a scowling face). Immediately following the prime face, participants viewed a scrambled-face mask for 400 ms, followed by the target face.[5] The target face was in one of four conditions relative to the prime face that preceded it in the trial: (1) *full*: the exact same identity posing the exact same emotion (to elicit perceptual priming); (2) *emotion* consistent: the same emotion posed by a different identity than the face prime (as a control to rule out semantic priming); (3) *identity* consistent: a different emotion posed by the same identity as the face prime (as a control to rule out response priming); and (4) *baseline*: a completely different face (different emotion and different identity) than the face prime (as the true control condition where no repetition priming will occur). Participants made a perceptual judgment about the target face (i.e., judged whether the target person's eyes were "close" or "far" apart). The target face remained on screen until the participants responded by pressing the *1* or *9* key (counterbalanced across block and participant). Response latency was recorded. Participants completed four practice trials prior to the experimental trials. There were 96 experimental trials in total. The experimental trials were split in two blocks of 48, with the second block exactly the same as the first but in a different randomized order. There was a brief break between the two experimental blocks during which participants were provided with water. After completing the experimental trials, participants were debriefed, compensated, and thanked for their participation.

Results

Data preparation. Trials with a reaction time below 300 ms or above 3,000 ms were removed (4.3% of trials removed). Next, because we could not use response accuracy to remove "incorrect" trials (because there was no "accuracy" criterion for "close" vs. "far" perceptual judgments of eye distance), we used a stringent criterion for selecting trials; trials with reaction times 2 standard deviations above the mean of the reaction time distribution (i.e., trials with response latency greater than 2467.55 ms) were excluded on the basis that participants were spending too long deliberating their response (an additional 9.03% of the total number of trials were removed). The remaining data were normally distributed.

We next computed our index of repetition priming for each condition. A behavioral repetition priming index was computed by subtracting each condition mean from the mean reaction time for the baseline control condition: trials on which a control word was satiated and the target face was novel (i.e., irrelevant word satiation condition in which prime and target faces were different in emotion and identity). For each participant, condition means were subtracted from this baseline control because no repetition priming should have occurred on these trials (i.e., neither face or identity aspects of the face were repeated across presentations). This type of index is typical for studies assessing repetition priming because it allows for assessment of priming within an individual (i.e., it takes into account that individual's baseline latency to render a response to a novel stimulus).

Analyses. We conducted the full-factorial 3 (word repetition: emotion word satiation, control word satiation, emotion word priming) × 3 (face repetition: full, emotion, identity) repeated measures ANOVA on the repetition priming indices (i.e., reaction time difference scores) and found a significant interaction, $F(2, 94) = 3.437$, $p = .01$, $\eta^2 = .029$ (see Table 1 for descriptive statistics). To probe the meaning of the interaction, we tested the construction hypothesis directly with a 2 (word repetition: emotion word satiation, control word satiation) × 3 (face repetition: full, emotion, identity) repeated measures ANOVA. As predicted, we observed a robust perceptual priming effect, as evidenced by a significant main effect of face repetition, $F(2, 94) = 6.605$, $p =$

[5] The target stimulus was masked to disrupt continued processing. This was necessary to tightly control the length of processing across satiation conditions and to avoid illusory conjunctions between the prime and target stimulus. This may have only limited utility, however, given the suggestion that backward masking affects reentrant processing but not feedforward projections (Fahrenfort, Scholte, & Lamme, 2007).

Table 1
Repetition Priming Scores

	Face repetition					
	Full face		Emotion		Identity	
Word repetition	*M*	*SD*	*M*	*SD*	*M*	*SD*
Emotion satiation	39.99	211.10	5.00	209.83	50.22	205.00
Control satiation	118.86	215.57	3.34	228.35	4.91	232.77
Word priming	51.07	195.14	38.86	189.18	24.68	190.96

Note. Repetition priming scores are presented in milliseconds.

.002, η^2 = .052 (see Figure 4). Follow-up, one-sample *t* tests revealed that following control word satiation, participants were significantly faster to make a perceptual judgment about a face (i.e., showed perceptual priming) if the exact same face was repeated within a trial, $t(47) = 3.820$, $p = .001$. This priming effect was not observed (i.e., priming scores did not differ from zero) when the same emotion (e.g., anger) was posed by different identities (i.e., emotion consistent face priming), nor was it observed when the identity but not the emotion portrayal was repeated (i.e., identity consistent face priming), $t(47) = 0.101$, $p = .46$, and $t(47) = 0.146$, $p = .443$, respectively. These findings demonstrate that the repetition priming we observed in the full repetition condition reflected *perceptual* priming. Null priming effects in the emotion consistent and identity consistent face priming conditions rule out alternative explanations of our priming effects as semantic or response driven, respectively.

As predicted, we were able to disrupt perceptual priming with emotion word satiation (mean changes in reaction time are presented in Figure 3). A significant interaction between word repetition and face repetition, $F(2, 94) = 5.179$, $p = .007$, $\eta^2 = .035$, followed by a paired *t* test in the full repetition condition indicated that satiating an emotion word reduced perceptual priming.[6] Compared with control word satiation, participants were slower to make a perceptual judgment when the relevant emotion word's meaning was satiated, $t(47) = -2.671$, $p = .01$, but more important, perceptual priming was no longer in evidence following emotion word satiation, $t(47) = 0.313$, $p = .20$. The fact that perceptual priming was completely wiped out when the prime face was encoded as the emotion word's meaning was inaccessible, but the target face was encoded as the emotion word's meaning was accessible, indicates that the exact same face was perceptually encoded differently depending on whether emotion concepts were accessible.

We were also able to rule out the possibility that satiating an emotion word influenced the *semantic* priming of emotional faces. If emotion word satiation impacted the processing of the semantic meaning of the target (rather than influencing the perceptual encoding of the prime face), we would expect slowed reaction times on any trial in which the target face matched the emotion word as exemplars of the same emotion category. Consistent with our predictions, however, participants were not slower to respond to faces in the emotion consistent trial type (i.e., when the emotion matched between the prime and target face, but not identity) compared with when a control word was repeated, $t(47) = 0.075$, $p = .47$ (one-tailed).

Finally, no priming effects were in evidence for any trial type when participants repeated an irrelevant word 27 times, followed by an emotion word three times (i.e., emotion word priming trials; marginal $M = 38.21$, $SD = 191.76$, $p > .05$), regardless of the face priming condition, $F(2, 94) = 0.469$, $p = .627$, $\eta^2 = .01$. Furthermore, we did not find any evidence that emotion word priming enhanced or disrupted perceptual priming for a face. Specifically, participants' reaction times following emotion word priming were consistently slow across all face conditions. These findings suggest that reaction times were driven by some other feature of the experimental design when a control word was repeated 27 times following by an emotion word 3 times. One possible explanation is that reaction times in this condition reflect a switching cost. Unbeknownst to participants, on these trials, the to-be-repeated word switched only three repetitions before the onset of the prime face. Because this was an unexpected change of word, it may have produced a switching cost that generally slowed reaction time on these trials. Given that this condition was not integral to the construction hypothesis, we did not analyze the data from this condition further.

Discussion

Consistent with Study 1, the results from Study 2 provided continued support for the construction hypothesis. First, we successfully elicited a precise perceptual priming effect that was specifically reduced by manipulating the accessibility of an emotion word at the time of encoding. That is, when a face portraying emotion was initially encoded while the relevant emotion word's meaning was temporarily inaccessible, that face no longer served as a perceptual prime for itself when it was then encoded again with the emotion word accessible. These data indicate that the percept formed in the two presentations was different, even though the sensory input from the face was exactly the same on both occasions. Put simply, emotion word accessibility changed the visual percept that participants formed. These data provide clear evidence that emotion concepts participate in the construction of an emotional percept, even when emotion judgments are not re-

[6] In the second set of analyses, no main effect of word repetition emerged in the overall 2 (word repetition: emotion word satiation, control word satiation) × 3 (face repetition: full, emotion, identity) repeated measures ANOVA, $F(1, 47) = 0.330$, $p = .569$, $\eta^2 = .002$. This is consistent with our prediction that the effect of word repetition would be dependent on the face priming condition.

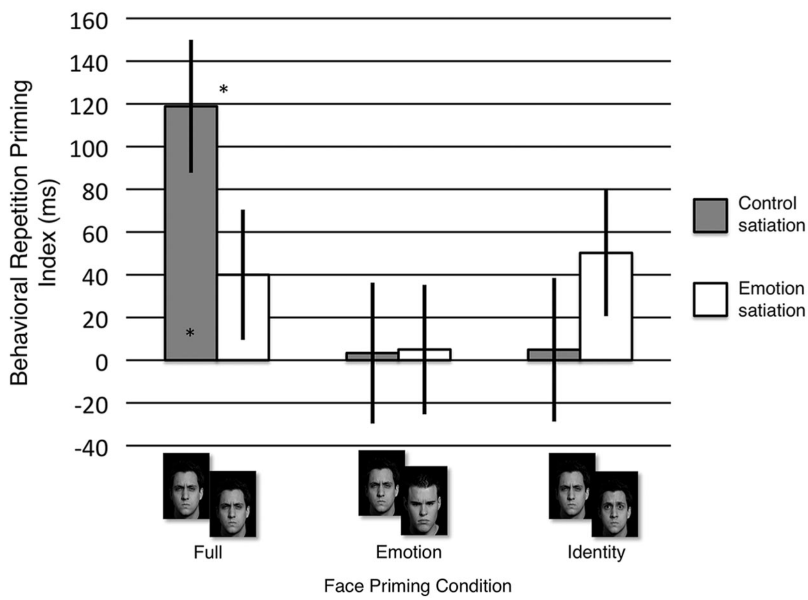

Figure 4. Computed repetition priming scores ($\pm SE$) in Study 2 for the three face priming conditions—(1) full (emotion and identity consistent across prime and target), (2) emotion (emotion, but not identity, consistent across prime and target), and (3) identity (identity, but not emotion, consistent across prime and target). In each face priming condition, words were repeated in one of two conditions: (1) control satiation and (2) emotion satiation. An asterisk indicates a significant effect at the $p < .05$ level (two-tailed).

quired for the task and participants were not operating under the goal to "identify" the emotional content in the faces that they saw. Our findings cannot be explained by appealing to response priming, semantic priming, or fatigue as explanations.

Although some prior data may be tempting to interpret as evidence that language shapes perceptual representations (e.g., language induced biases in which morphed face participants identified as previously seen; Halberstadt et al., 2009), those effects are based on explicit memory (i.e., participants were asked to recall perceptual information encoded earlier). Thus, those findings may be accounted for by the constructive nature of memory. The initial perceptual representation may not have been shaped by language, but the process of reconstructing the perceptual representation might have been. In the present work, Study 1 is open to a similar memory-based interpretation (i.e., language may impact the reconstruction of a percept from memory) because participants were required to make an explicit judgment about whether they had seen a given stimulus before. Study 2 did not rely on explicit memory, however, providing support for our interpretation that language has an impact at encoding.

General Discussion

Implications for Emotion Perception

The present findings clearly establish, along with other recent findings (e.g., Lindquist et al., 2006; Roberson et al., 2007), that emotion words provide an important (although often unrecognized) context in emotion perception. The current studies take the language-as-context hypothesis further, however, in providing the first evidence that conceptual processing (i.e., the ability to access the semantic meaning of emotion words) alters percept formation during emotion perception that is occurring implicitly and automatically. In the repetition priming tasks used here, participants were not required to explicitly categorize or otherwise know anything about the emotion conveyed by the face stimulus to render a perceptual judgment about the face. Nonetheless, reducing the accessibility of emotion words still had a measurable impact on the perceptual representation of emotion in faces.

The present findings are consistent with a psychological construction approach to emotion (Barrett, 2006a, 2006b; Barrett et al., 2007; Lindquist & Barrett, 2008), which proposes that instances of emotional experience and emotion perception are constructed from the interplay of more basic ingredients that are not themselves specific to emotion. Our findings are broadly consistent with this theoretical approach because they demonstrate that conceptual knowledge (anchored by words) participates in constructing the perceptual representation of another person's emotion, even when the sensory input provided by the stimulus should be sufficient (i.e., the posed emotional expressions were clear portrayals of a single discrete emotion, unlike morphed stimuli sometimes used in other language–perception work, e.g., Halberstadt et al., 2009).

Our psychological construction model was crafted to solve the emotion paradox described in Barrett (2006b). Specifically, objective measures of facial actions during an emotional episode (e.g., facial electromyographic measurements) indicate that the people rarely scowl when angry, pout when sad, and so forth (for recent reviews, see Barrett, 2006a; Cacioppo, Berntson, Larsen, Poehlmann, & Ito, 2000; Mauss & Robinson, 2009; Russell, Bachorowski, & Fernández-Dols, 2003). Yet, people routinely have the experience of seeing emotion written in the faces of other people. The present research can help resolve this paradox because our data suggest that conceptual knowledge about emotion, anchored with emotion words, plays a key role in generating an emotion perception to begin with. It may be that concept activation also impacts perceptual representations in the absence of discrete information from another person's face (e.g., Thielscher & Pessoa, 2007).

The present findings also help explain why regions in the human brain implicated in language-based functions (e.g., the ventrolateral prefrontal cortex and anterior temporal lobe [ATL]) consistently show an increase in activation during emotion perception tasks (see Lindquist, Wager, Kober, Bliss-Moreau, & Barrett, in press, for meta-analytic findings from the neuroimaging literature). Furthermore, our findings also help elucidate why individuals with semantic deficits (due to progressive neurodegeneration in the ATL) have deficits in emotion perception (e.g., Calabria, Cotelli, Adenzato, Zanetti, & Miniussi, 2009).

The present findings are also consistent with the broader literature on perception, in which conceptual processing routinely has a significant impact on normal perceptual events. Vision is not a completely stimulus-driven affair. For example, the context in which an object appears will shape the "predictions" that a perceiver makes about the object—the same visual object may be represented as a hairdryer or a screw gun, depending on the concepts that the context evokes (Fenske, Aminoff, Gronau, & Bar, 2006). Furthermore, perceiver-based goals (e.g., to find a "house" or an "animal") can lead to modulation of high-level visual regions by specific sites in frontal cortex (Gazzaley et al., 2007; Morishima et al., 2009; Summerfield et al., 2006). Perceiver-driven modulation of the visual stream can even happen in the absence of the visual input of a stimulus (Johnson, Mitchell, Raye, D'Esposito, & Johnson, 2007; Mechelli, Price, Friston, & Ishai, 2004; Yi, Turke-Browne, Chun, & Johnson, 2008) and appears to have strong topographical overlap with stimulus-driven activations (Stokes, Thompson, Cusack, & Duncan, 2009; but see Sung & Ogawa, 2008). For example, brain activations associated visual imagery of the letters *O* and *X* were compared with those produced by actually viewing these letters, and there was strong overlap in the patterns of activation in the lateral occipital complex. Taken together, the findings discussed in this paragraph suggest that emotion perception is not necessarily unique, given that conceptual knowledge functions as a top-down influence in many forms of perception.

There is also ample evidence that other forms of context shape the perception of emotion (for recent reviews, see Barrett et al., 2011; Gendron et al., in press). For example, body postures (e.g., Meeren, van Heijnsbergen, & de Gelder, 2005), vocalizations (e.g., de Gelder & Vroomen, 2000), situational descriptions (e.g., Carroll & Russell, 1996), and even other people (e.g., Masuda et al., 2008) can influence the emotion perceived in a face. One possibility is that language is just another type of context to add to the list—an internal context in the mind of the perceiver. Another possibility is that conceptual knowledge drives some of these other context effects. External context (i.e., a situational description) more strongly shapes judgments of emotion when that context clearly points to a single category of emotion (i.e., when participants will apply a single emotion label to the context; Fernández-Dols, Wallbott, & Sanchez, 1991). Those findings suggest that the activation of a concept may mediate other situational context effects.

Mechanisms of the Language–Perception Link

One clear direction for future research is to examine the mechanisms by which language contributes to perception. A first step will be to understand the neural underpinnings of the semantic satiation effect. It is possible to formulate working hypotheses based on the existing literature. For example, semantic satiation disrupts the N400 ERP component (Kounios et al., 2000), which is linked to the anterior temporal lobe (ATL) in intracranial field potential (McCarthy, Nobre, Bentin, & Spencer, 1995), functional MRI, and ERP (Rossell, Price, & Nobre, 2003) studies. Based on those findings, one could hypothesize that the ATL is responsible for the language-based perceptual effects that we observed in our experiments.[7] Yet, recent work also demonstrated that disrupting activity in the left inferior frontal gyrus (with transcranial magnetic stimulation) led to reaction time increases in a discrete emotion labeling task (forced-choice mind in the eyes task; Keuken et al., 2011). Based on those findings, it is also possible to hypothesize that semantic functions supported by the left inferior frontal gyrus (LIFG) play a role in emotion perception.[8] Given that the findings in Keuken et al. (2011) were limited to a task in which participants were asked to apply a label, however, and that the LIFG is often discussed as a region involved in response selection (e.g., Rodd, Johnsrude, & Davis, 2010), this region might be thought of as supporting explicit judgments of emotion.

In addition to identifying the sources of language-based modulation of perception, it will be important to examine when and how perceptual representations are shaped by language accessibility. For example, it is possible that "gist"-level predictions (e.g., Bar, 2007) about faces portraying emotion generated by the orbital frontal cortex (and feeding back to high-level visual regions) may by shaped by language (for a similar view, see Lupyan & Spivey, 2008). Furthermore, although the reductions in perceptual priming

[7] Indeed, there is a literature suggesting that the ATL is a heteromodal association area involved in representing concepts (e.g., Lambon Ralph, Pobric, & Jefferies, 2009). ATL has been implicated in the semantic representation of words (for a recent meta-analysis, see Visser, Jefferies, & Lambon Ralph, 2010) and the right ATL with social concepts specifically (Zahn et al., 2007). Furthermore, the ATL is brought online in mental state attribution tasks (Ross & Olson, 2010). Yet, other literature suggests that the ATL is involved in more specific functions such as representing person-specific knowledge (right ATL; e.g., Ross, McCoy, Wolk, Coslett, & Olson, 2010) or knowledge of unique entities (e.g., landmarks) more generally (left ATL; e.g., Tranel, 2010). Future work will be necessary to determine whether the ATL is important for the effects observed here and, if so, what type of representation is involved.

[8] The LIFG finding was originally interpreted within a mirror neuron framework by Keuken and colleagues. Mirror neurons are thought to be neurons that fire both to the execution and perception of action, allowing for understanding of others' actions using the same neural architecture that produces action. Yet, a mirror neuron interpretation of LIFG function is a matter of much debate (e.g., Lingnau, Gesierich, & Caramazza, 2009). Furthermore, there is ample evidence that the LIFG is engaged in semantic tasks (e.g., Gitelman, Nobre, Sonty, Parrish, & Mesulam, 2005), making it also likely that it is a semantic function of this region that is involved in emotion perception.

observed in Study 2 indicate that high-level visual representations are shaped by language, it is possible that language can influence more basic aspects of perception formation given the massive bidirectional projections between the ventral visual stream and posterior visual regions (for a review of connectivity, see Kveraga, Ghuman, & Bar, 2007).

Finally, the present findings speak to the move in the language embodiment literature (e.g., Barsalou, 2008) to break down the distinction between perception and conceptualization as separate faculties of the mind. Neuroimaging findings in this literature suggest that the same regions involved in actually experiencing sensory stimuli or performing actions are also involved in representing concepts. Behavioral studies compellingly demonstrate that activating conceptual knowledge can shape perceptual and motor task performance (for recent review of these literatures, see Barsalou, 2008; Martin, 2007). In an embodied view of emotion knowledge, when participants utter an emotion word (e.g., *anger*), they automatically generate the word's meaning by partially reactivating neural representations of specific instances of that category (Barsalou, 1999, 2003).[9] When the concept of anger is activated, this may also involve representations of what an angry person looks like. From that standpoint, the role of language in emotion perception may simply be a reflection of how words are normally represented in the mind of the perceiver, and thus may be as routine as language itself.

[9] Recent evidence suggests that the processing of emotion words (e.g., the word *anger*) leads to an embodied motor representation (Foroni & Semin, 2009; Halberstadt et al., 2009; Niedenthal, Winkielman, Mondillon, & Vermeulen, 2009; for a review, see Glenberg, Webster, Mouilso, Havas, & Lindeman, 2009), and disrupting neural activity in somatosensory cortex (with transcranial magnetic stimulation) can disrupt the ability to label the discrete emotion in another's face (Pitcher, Garrido, Walsh, & Duchaine, 2008).

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