When a Word is Worth a Thousand Pictures: Language Shapes Perceptual Memory for Emotion

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Abstract

Across three studies we show that emotion words support the acquisition of conceptual knowledge for emotional facial actions that then biases subsequent perceptual memory for later emotional facial actions. In all studies, participants first associated emotional facial actions with a word during a learning phase or completed a control task. In a target phase, participants studied slightly different category exemplars. During a final test phase, participants identified which face the individual had been making during the target phase (i.e., the learned face, the target face, or a morphed combination). Studies 1 and 2 demonstrate that pairing never-before-seen "alien" facial actions with nonsense words during the learning phase biases perceptual memory for facial actions subsequently viewed during the target phase. Study 3 replicates these findings with the familiar emotion categories *fear* and *anger*. Across all three studies, participants were more likely to choose the face that had been linked with a word during the learning phase than the face actually studied in the target phase. These findings suggest that pairing facial actions with words can shape later perceptual memory for emotional facial actions.

Keywords: perceptual memory, facial actions, facial expressions, emotion perception, language, conceptual knowledge

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Growing evidence suggests that the ability to perceive a discrete emotion ("fear," "anger," "disgust," etc.) in someone else's facial actions is a constructive process that relies as much on your pre-existing knowledge about emotional facial actions as what is actually present on the person's face (see Doyle & Lindquist, 2017; Lindquist, Satpute & Gendron, 2015 for a review). The scowls, frowns, grimaces, and growls you see over time presumably develop into conceptual knowledge of what the category *anger* looks like, helping you to make meaning of new instances of facial actions as instances of anger.

Evidence suggests that language may be especially important to the acquisition and use of such conceptual knowledge (Barsalou et al. 2005; Lupyan & Clark, 2015; Lindquist et al. 2015; 2016 a, b; Xu, 2016). First, emotion words may help people link perceptual representations of emotional facial actions in memory, even when those perceptual representations are not identical, thus helping people to form conceptual knowledge for emotion expressions (for evidence with novel categories in infants, see Plunkett et al. 2008). Second, words help people to access and use that conceptual knowledge during online visual perception (Lupyan & Thompson-Schill, 2012), helping to create on-going perceptions of sensory information from the environment. Similarly, words are hypothesized to influence how emotion is perceived in faces (for reviews see Barrett et al. 2007; Doyle & Lindquist, 2017; Lindquist et al. 2015a, b; 2016; Lindquist & Gendron, 2013). Thus, we hypothesized that emotion language biases perceptual memory for facial actions, causing people to remember target facial actions as appearing more similar to past perceptions of category exemplars than they actually were. We tested this hypothesis in the present studies.

The Present Studies

We conducted three experiments to test whether conceptual knowledge that is supported by language biases memory for subsequently viewed emotional facial actions. Research has examined how memory for emotion (e.g., Foa, Gilboa-Schechtman, Amir, & Freshman, 2000; Gilboa-Schechtman, Erhard-Weiss, & Jeczemien, 2002; D'Argembeau, Van der Linden, Comblain, & Etienne, 2003; Stiernströmer, Wolgast, & Johansson, 2016; Silvia, Allan, Beauchamp, Maschauer, & Workman, 2006) and for facial identity (e.g., D'Argembeau & Van der Linden, 2007; Jackson, Wu, Linden, & Raymond, 2009, Kottoor, 1989; Leigland, Schulz, & Janowsky, 2004; Mather & Carstensen, 2003; Ridout, Astell, Reid, Glen, & O'Carroll, 2003; Johansson, Mecklinger, & Treese, 2004; Sergerie, Lepage, & Armony, 2005) is influenced by the facial actions present on the face at encoding. However, little research to our knowledge has examined how language might shape the encoding and retrieval of those facial actions in memory in the first place.

We modeled our studies after Santos (2008), who found that pairing object category exemplars (e.g., novel mechanical devices) with words helped participants to acquire novel conceptual knowledge for those categories and biased perceptual memory for subsequent category exemplars. These findings are consistent with a small body of literature demonstrating that language shapes perceptual memory. For example, language facilitates performance on redintegration memory tasks, where portions of a visual stimulus serve as cues for retrieval of the whole. Participants are better able to correctly match partial shapes to their wholes after labeling shapes with words (Santa, 1975). Even meaningless labels (e.g., "latuk") facilitated performance on the redintegration task, suggesting that labels facilitate retrieval of a visual perceptual representation even when the label itself has no pre-existing link to the shape (Santa, 1975). In the domain of face perception, classic "verbal overshadowing" findings suggest that describing a facial identity using words biases perceptual memory of that face towards the verbal description and away from the actual perceptual information present on the face (Schooler & Engstler-Schooler, 1990).

At least one existing study suggests that language shapes perceptual memories for facial actions. Individuals who described why a posed facial action consisting of 50% angry and 50% happy facial actions was "angry" later remembered the face as being more intensely angry (i.e., greater than 50%) than those faces that were not described as "angry" (Halberstadt & Neidenthal, 2001). These findings are consistent with the idea that labeling the face caused participants to draw on conceptual knowledge for the category *anger,* thus biasing how the perceptual information on the face was encoded in memory. However, this study did not model where participants' conceptual knowledge for *anger* comes from in the first place. The present findings thus build upon and extend the initial work to examine how conceptual knowledge may be acquired, used during perception, and how it biases subsequent memory for facial actions associated with emotions. We test these hypotheses using never-before-seen alien "emotion" categories (Studies 1 and 2). We then replicate these findings with familiar emotion categories (Study 3). [1]

Study 1: Language shapes perceptual memory for novel facial actions

Study 1 experimentally tested the role of language in biasing perceptual memory for facial actions for novel emotion categories. We assessed whether participants could create new conceptual knowledge from facial actions that are not typically associated with English-language emotion categories by pairing them with words and whether this would in turn bias participants' perceptual memory for subsequently seen "target" facial actions. Participants completed

[1] Stimuli and data are available at osf.io/bjqu6

learning, *target*, and *test* phases in which they were exposed to novel alien facial actions. Participants were assigned to a between-subjects condition prior to completing the *learning* phase: one group learned to pair novel facial actions with nonsense words, whereas the other group performed a control task. Next, all participants completed a *target* phase in which they studied slightly different exemplars of the novel facial actions. Finally, after a buffer phase, we tested participants' perceptual memory for target faces in a *test* phase. Consistent with our hypothesis that pairing novel facial actions with words biases perceptual memory for subsequently viewed facial actions, we predicted that participants in the verbal condition would be most likely to recall having seen the learned face during the test phase.

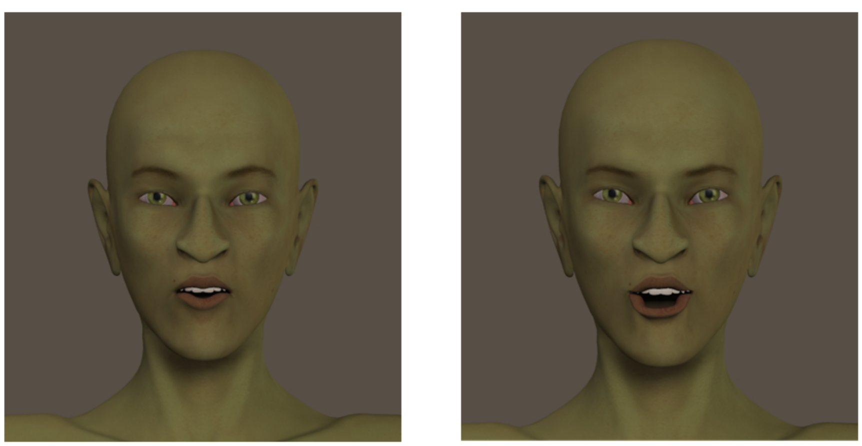
Method

Participants

Participants were 103 undergraduate students (50 women, M_{age} = 19.16, SD = 1.20). Data from three participants were removed because they failed to enter a response on two or more trials in the test phase, meaning that they responded to less than 75% of trials (final N = 100). Results were identical whether these three participants were included in the final sample or not. We excluded them to be conservative.

Stimuli

Drawing inspiration from Lupyan et al. (2007), we created a set of novel "alien" facial stimuli using the Poser Pro 2012 3D character art and animation software (http://poser.smithmicro.com/poser.html). In order to further decouple the stimuli from perceivers' existing emotion concept knowledge, we elongated the faces, colored them in shades of green and yellow, and told participants that they were members of a "fictional alien species." The stimuli were validated on Amazon Mechanical Turk to ensure that perceivers did not consistently rate the faces as depicting specific English-language emotion categories. Pilot testing revealed that the stimuli used in Study 1 (hereafter "Emotion 1" and "Emotion 2"; see Figure 1 for examples) were not freely labeled as depicting an instance of any single emotion category with consistent frequency to assume that they represent a single English-language emotion category. Although participants were able to label the stimuli with all manner of words when asked to do so, there was not consistent agreement amongst raters in terms of which emotion category words were freely produced. For example, Emotion 1 was labeled as an instance of 18 distinct emotional and mental states, and Emotion 2 was labeled as 19 distinct emotional and mental states. The stimuli were thus ambiguous in terms of their emotional meaning and can be considered novel facial actions that are not consistently associated with specific English-language emotion categories. Furthermore, paired samples t-tests revealed that each face was perceived as equally positive and negative, $t(173) = 1.498$, $p = .14$ (Emotion 1), and $t(149) = .521$, $p = .60$ (Emotion 2).



Emotion 1 Emotion 2

Figure 1. Examples of novel emotion stimuli used in Studies 1 and 2. Emotion 1 was labeled as an instance of 18 different emotional and mental states (*N* = 160) (e.g., 18.75% of participants used labels such as “surprised” or “shocked,” 15.63% used labels such as “curious” or “interested,” 11.88% used labels such as “happiness,” “laughter,” “amusement,” “excitement,” or “joy,” 11.25% used labels such as “confused,” “befuddled,” or “dumbfounded,” and so on). Emotion 2 was labeled as 19 different emotional and mental states (*N* = 166) (e.g., 34.34% of participants used labels such as “happiness,” “laughter,” “amusement,” “excitement,” or “joy,” 21.08% used labels such as “surprised,” “appalled,” or “shocked,” 10.24% used labels such as “anger,” “fury,” or “mad and so on).

Procedure

Participants were positioned approximately 20 inches from a monitor with a screen resolution of 1440 x 900 pixels. The images presented were 275 x 297 pixels. Thus, the images subtended approximately 8.7° x 10.4° of visual angle.

Learning Phase. As Figure 2 illustrates, participants completed 128 trials where they viewed novel “alien” facial muscle configurations that formed a facial action perceived as expressing emotion. On each trial, the face was one of eight digital identities created in Poser Pro 2012.

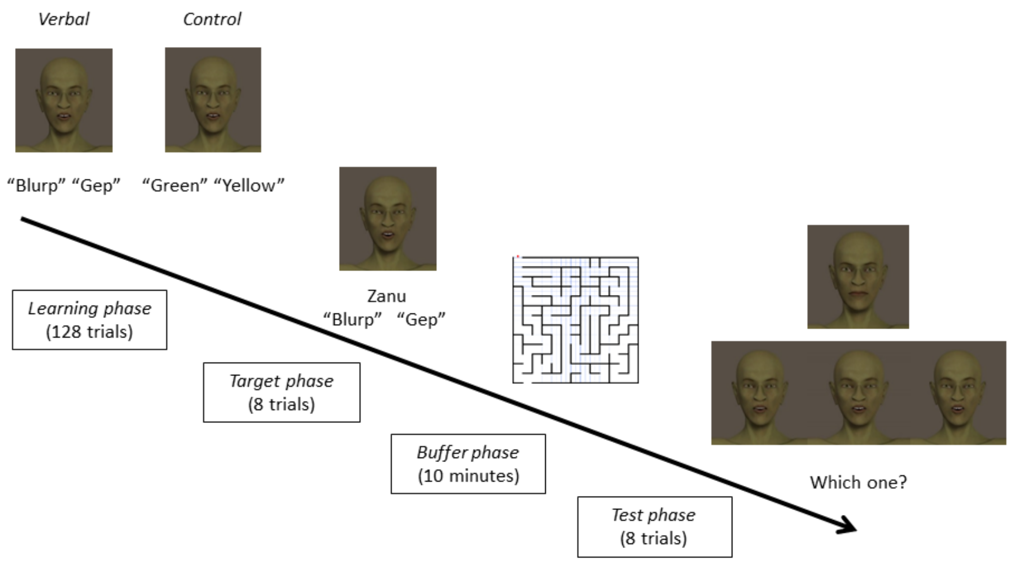


Figure 2. Overview of Study 1. In Study 1, participants learned to associate "alien" facial actions with nonsense words. They then saw slightly different versions of the same novel facial actions during the target phase. In a buffer phase, participants completed a series of paper-and-pencil mazes. During the test phase, participants were asked to recall which facial action they saw during the target phase: the learned face, the target face, or a morph of the two.

Participants in the *verbal condition* categorized the faces using the nonsense labels "blurp" and "gep,"[2] via a button press and repeated the answer out loud to ensure they were engaging in the task. Participants received feedback on whether their response was accurate or inaccurate. Each identity was presented a total of 16 times, each time shown with the same facial expression for one of the two novel emotions used in the study. In the *control condition,* participants were asked to make a categorical judgment about the novel faces, judging whether

[2] Because certain nonsense consonant-vowel structures are typically associated with particular perceptual characteristics (Lupyan & Cassanto, 2015), the nonsense labels were counterbalanced such that some participants learned that "Emotion 1" was called "blurp" and others learned that it was called "gep" (and vice versa with "Emotion 2").

the alien's skin was more green or yellow in color. Accuracy rates for the categorical judgments in both the control condition (M = 99.30%, SD = 1.08%) and verbal condition were high (M = 97.64%, SD = 4.88%).

Target phase. As Figure 2 illustrates, in the target phase participants viewed the same identities from the learning phase, but the faces depicted slightly different facial actions. To ensure that participants did not explicitly encode differences between the learned and target faces, target facial actions were only subtly different from the faces seen during the learning phase. We used Poser to reduce the degree of activation in each facial action in our novel "emotions" by 20-50%, depending on the degree of activation of that particular facial action in the initial face. This achieved the goal of creating two exemplars that looked subtly different from one another (e.g., if "Emotion 1" had lowered eyelids and a dropped jaw, the version seen in the target phase had 20% less lowered eyelids and 50% less lowered jaw). On each trial, a novel facial action appeared for 3s along with a name (e.g., "Zanu"). Participants were told that their goal in the target phase was to learn the identities of the individuals they had seen previously. In reality, the purpose of this phase was to expose perceivers to the target faces while activating the conceptual knowledge established for the two "alien emotion words" during the learning phase. Our interest was to see if that conceptual knowledge would then bias perceptual memory for the target faces.

Following the presentation of the name, participants in the verbal condition were also asked to categorize the face as an instance of "blurp" or "gep" as they had done in the learning phase. Categorizing the new faces using emotion labels provided the opportunity to reactivate the novel conceptual knowledge that participants had previously acquired and associated with the word. Because control participants had not yet been exposed to the nonsense emotion labels, they simply viewed the labels on screen after they learned the aliens' names in the target phase. Being exposed to the nonsense labels is an appropriate control task because the purpose of this phase is simply to bring the "alien emotion word" online in the presence of a slightly different emotional face. For controls, there was no conceptual knowledge associated with the nonsense "alien emotion words" but they were nonetheless exposed to the labels to control for the fact that participants in the verbal condition saw the labels in the study phase. Each identity was seen once; participants thus completed a total of eight trials.

Buffer phase. Participants performed a buffer task for 10 minutes, where they completed a packet of mazes. The buffer phase was included to ensure that perceptual memories of the faces were not merely stored in working memory between the phases, or that our findings were evidence of perceptual priming.

Test phase. We assessed participants' perceptual memory for the face seen in the target phase by asking them to identify which face they studied when they learned the individual's name. On each trial, participants first saw one of the identities with a neutral face to cue them to the identity in question. Next, depictions of three emotional facial actions were displayed below it: the target face, the original learned face, and a 50%-50% morph of the two faces. Participants were asked to make a single response indicating which of the three faces they were most certain the alien was making when they learned its name. Faces were randomized such that the target face was equally likely to be in position one, two, or three on a given trial. There was one test trial for each identity, for a total of eight trials.

Data analysis. To investigate which face participants were more likely to choose during the test phase, we first computed the percentage of trials in which participants chose the learned face, the morph face, or the target face. This procedure allowed us to make easy-to-interpret between-group comparisons of the percentage of trials in which participants chose the learned face, as well as to make within-group comparisons of the overall content of participants' choices. However, because our dependent variable is ordinal, we also followed this analysis with a non-parametric test that is appropriate for ordinal data. Specifically, we conducted a Wilcoxon Rank Sum Test that accounts for the fact that our data are clustered (Rosner, Glynn, & Lee, 2006; Jiang, 2017). This procedure enabled us to compare the shape of the distributions of participants' responses across conditions to determine whether participants in the verbal condition were more likely to choose the learned face as compared to the target face or morph, as we predicted.

Results and Discussion

Consistent with our predictions that pairing novel facial actions with words would bias perceptual memory of later facial actions, participants in the verbal condition chose the learned face on a significantly greater percentage of trials as compared to participants in the control condition, $t(98) = 2.92$, $p = .004$, $d = 0.59$, 95% CI [3.16%, 16.59%] (see Figure 3).

We also investigated whether participants chose the learned, morph, or target face more often than would be expected by chance (chance responding would be 33% because there were 3 faces to choose from in each trial of the test phase). Within the verbal condition, participants were around chance to choose the learned face (on 35.14% of trials) and the target face (on 33.49% of trials) (*p*s > .1). Furthermore, participants in the verbal condition chose the morph face significantly less often (on 28.54% of trials) than would be expected by chance, $t(52) = -2.33$, $p = .02$, $d = -0.65$, 95% CI [-8.31%, -.62%]. Participants in the control condition, who did *not* pair the novel faces with words, chose the learned face significantly less often (on 25.27% of trials) than would be expected by chance, $t(46) = -3.28$, $p = .002$, $d = -0.97$, 95% CI [-12.48%, -3.00%], and they chose the target face significantly more often (on 39.36% of trials) than would be expected by chance, $t(46) = 2.20$, $p = .03$, $d = .65$, 95% CI [.53%, 12.19%]. Control participants were around chance to choose the morph face (on 33.24% of trials) ($p > .1$).

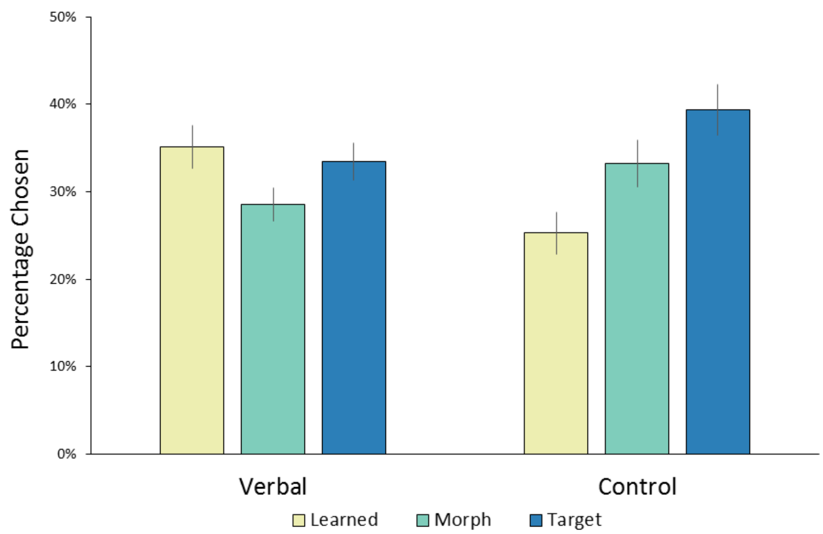


Figure 3. Descriptive Analyses from Study 1. Means and 95% confidence intervals reveal that participants in the verbal condition were significantly more likely than those in the control condition to choose the learned face during the test phase, $t(98) = 2.92$, $p = .004$, $d = 0.59$, 95% CI [3.16%, 16.59%].

As predicted, the Wilcoxon Rank Sum Test for clustered data revealed a significant difference in rank scores between the verbal and control conditions ($Z = 2.45$, $p = 0.014$). Consistent with our hypotheses, the distributions revealed that participants in the verbal condition chose the learned face more often than controls (see Figure 4).

Taken together, these findings suggest that pairing faces with words during an initial learning phase biased participants' perceptual memory for the faces they studied during the target phase. In contrast, participants in the control condition were more accurate to choose the target face and to avoid choosing the learned face.

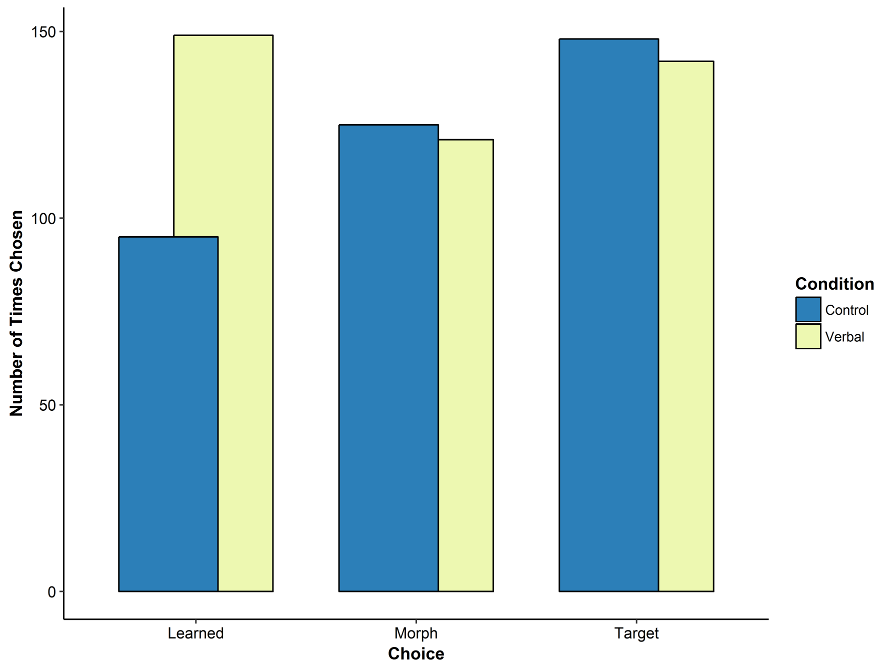


Figure 4. Non-parametric Analyses from Study 1. The Wilcoxon Rank Sum Test for clustered data revealed that the distributions of participants' choices differed between groups, with participants in the verbal condition choosing the learned face more than participants in the control condition.

Study 2: Replication with a graded measure of perceptual memory

Study 1 explicitly tested the importance of language in biasing perceptual memory for facial actions associated with emotion. Study 2 conceptually replicated and extended these findings by assessing whether participants' subjective perceptual memories for the novel emotion categories exist on a gradient. Using an identical paradigm, we again asked participants to complete learning*, target,* and *test* phases. As in Study 1, the *test* phase asked participants to choose the face they most confidently recalled seeing in the target phase and we predicted that participants in the verbal condition would be significantly more likely than controls to choose the learned face. However, in Study 2, we also asked participants to make their next-best guess to allow us to perform a set of follow-up analyses that assess a gradient in participants' perceptual memories for facial actions. We predicted that participants would be most likely to recall the learned face in the verbal condition, followed by the morph (which contained 50% of the learned content), followed by the actual target face. We predicted that participants in the control condition would be less likely to show this gradient in perceptual memory.

Method

Participants

Participants were 111 undergraduate students (63 women, M_{age} = 19.16, SD = 1.81). Data from seven participants were removed because their learning phase data were not properly saved, so we could not verify that they had completed at least 75% of the trials. Data from an additional 10 participants were removed because they failed to enter a response on at least two trials in the test phase, meaning that they responded to less than 75% of trials (final N = 94). Importantly, results were identical whether these 17 participants were included in the final sample or not. We thus excluded them to be conservative as we did in Study 1.

Procedure

Participants were positioned approximately 20 inches from a monitor with a screen resolution of 1440 x 900 pixels. The images presented were 275 x 297 pixels. Thus, the images subtended approximately 8.7° x 10.4° of visual angle.

The procedure for Study 2 was similar to that of Study 1, except that we used a modified test phase. To assess a gradient in participants' perceptual memories for the face viewed in the target phase, participants ranked the exemplars based on their confidence that each facial action was seen during the target phase. Participants pressed the number below each face to rank them in order (e.g., "1" for the learned face, "2" for the morphed face, or "3" for the target face).

After 3s the screen refreshed, and participants were asked to select the face they were the *next* most confident they saw during the target phase (i.e., their "second choice"). We deduced participants' "third choice" based on their first and second choices. There was one test trial for each identity, for a total of eight trials (two responses per trial). As in Study 1, accuracy rates for the categorical judgments in the learning phase for both the control condition (M = 98.96%, SD = 1.41) and verbal condition were high (M = 96.04%, SD = 10.41).

Data analysis. We used three methods to assess the extent to which language biased perceptual memory of the target faces. Since participants' first choice is an indication of their most confident perceptual memory, we again determined the percentage of trials on which participants chose the learned face first as compared to choosing the morph face first or the target face first. In addition, we conducted non-parametric tests to determine whether the shape of the choice distributions differed between groups. As in Study 1, these methods served as our primary index of participants' perceptual memory for the faces presented in the target phase.

As a follow-up to our primary analyses, we also computed a *bias score* to serve as a complementary index of the graded nature of participants' memory for the faces presented in the target phase. We based our bias score on Santos (2008), who demonstrated that pairing words with exemplars from object categories (i.e., novel mechanical devices) shifted or "biased" the gradient of participants' memory towards the initial exemplars and away from a set of target exemplars. The bias score thus took advantage of the fact that participants' subjective perceptual memory could exist on a gradient ranging from the most bias (the face seen during learning), to some bias (the morphed face, which consisted of 50% of the learned content) to the least bias (the actually seen target face). Thus, the bias score allowed us to determine if on average, participants' perceptual memory for a target face is most likely to share features in common with the learned face, second most likely to share features with the morphed face and least likely to share features with the target face.

To compute the bias score, the learned face was assigned a weight of 2, the target face was assigned a weight of 0, and the morphed face was assigned a weight of 1 (because it was a 50-50% blend of the two). Weights were then multiplied by the ranked order of participants' responses. For instance, if a participant ranked the learned face "1", and the morph face "2" and the target face "3", then the bias score would be (2 x 2) + (1 x 1) + (0 x 0) = 5, indicating the largest degree of bias. If a participant ranked the target face "1", and the morph face "2" and the learned face "3", the bias score would be (0 x 2) + (1 x 1) + (2 x 0) = 1, indicating no bias. This bias score was computed for participants' responses on each of the eight test trials, and the mean bias score was calculated for each participant across trials. Participants' mean bias score in the relative distribution of possible bias scores (1-5) thus reflected their degree of bias. Mean bias scores were compared in an independent samples *t*-test. We predicted that if emotion words are important in acquiring entirely novel emotion categories that then bias perceptual memory, then perceivers in the verbal condition would show higher bias scores than those in the control condition.

Results and Discussion

Consistent with our hypotheses and replicating Study 1, participants in the verbal condition were significantly more likely than those in the control condition to choose the learned face first on a higher percentage of trials ($t(92) = 2.25$, $p = .03$, $d = 0.46$, 95% CI [1.00%, 15.93%]) (see Figure 5).[3]

[3] This test is not significant at the Bonferroni adjusted threshold of .017.

When comparing the percentage of trials on which participants chose the learned face first within the two conditions, participants in the verbal condition were equally likely to choose the learned face first (on 32.91% of trials) when compared to the morph face (on 27.04% of trials) or the target face (on 36.48% of trials), (*p*s > .10). Participants in the verbal condition were only significantly more likely to choose the target face first when compared to the morph face ($t(48) = -2.65$, $p = .01$, $d = 0.61$, 95% CI [-16.60%, -2.28%]).[4] However, as in Study 1, participants in the control condition tended to show the least amount of bias in their perceptual memories. Controls were more likely to accurately choose the target face (on 42.78% of trials) first when deciding which face they had seen during the target phase, as compared to the learned face (24.44% of trials), $t(44) = -3.39$, $p = .001$, $d = 0.91$, 95% CI [-29.24%, -7.42%], or the morph face (28.89% of trials), $t(44) = -2.68$, $p = .01$, $d = 0.71$, 95% CI [-24.35%, -3.44%][5] (see Figure 5). Participants in the control condition were equally likely to choose the learned vs. morph face first ($p > .10$).

[4] This test remains significant at the Bonferroni adjusted threshold of .017.
[5] These tests remain significant at the Bonferroni adjusted threshold of .017.

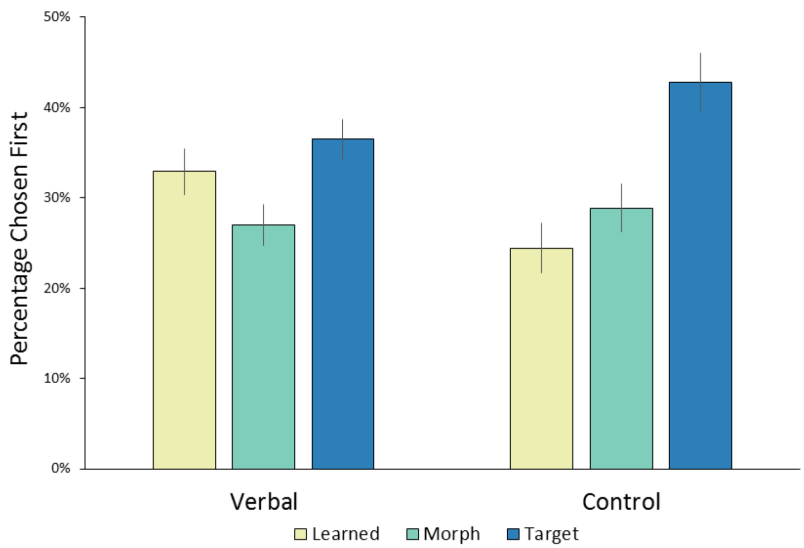


Figure 5. Descriptive Analyses from Study 2. Means and 95% confidence intervals reveal that, as in Study 1, participants in the verbal condition were significantly more likely than those in the control condition to choose the learned face first, $t(92) = 2.25$, $p = .03$, $d = 0.46$, 95% CI [1.00%, 15.93%].

As in Study 1, we also conducted non-parametric analyses to account for the fact that participants' first choice, our dependent variable, was ordinal in nature. Consistent with our hypotheses and replicating Study 1, the distributions of participants' first choices differed between groups ($Z = 2.09$, $p = 0.037$). Participants in the verbal condition chose the learned face first more often than did controls (see Figure 6).

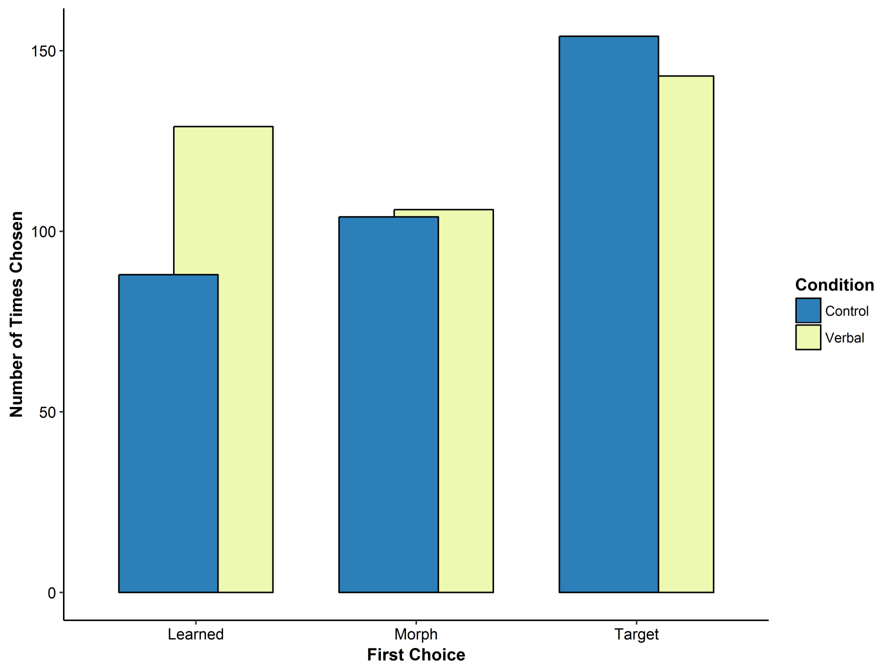


Figure 6. Non-parametric Analyses from Study 2. The Wilcoxon Rank Sum Test for clustered data revealed that, as in Study 1, the distributions of participants' choices differed between groups.

Consistent with these findings, our bias score analyses revealed that bias values for the verbal condition were significantly greater than bias values for the control condition $t(92) = 2.73$, $p = .01$, $d = 0.56$, 95% CI [0.10, 0.64] (see Figure 7). That is, participants in the verbal condition were more likely to choose the learned or morph face first and the target face last, whereas participants in the control condition were more likely to choose the target face first and the learned or morph face last. These findings again suggest that pairing faces with words during the learning phase caused a bias in participants' perceptual memory for novel facial actions.

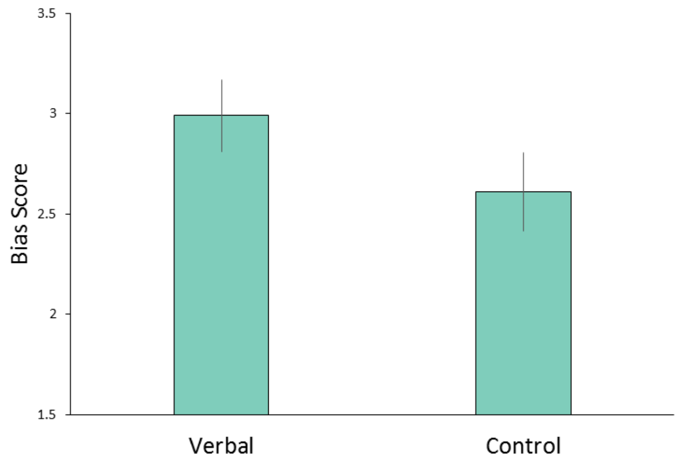


Figure 7. Bias scores from Study 2. Means and 95% confidence intervals reveal that verbal trials had significantly more bias than control trials. These findings suggest that nonsense words used as emotion labels in the learning phase helped participants acquire novel perceptual categories that biased perception of subsequent faces.

Study 3: Replication with familiar facial actions

In Studies 1 and 2, participants were not familiar with the meaning of the nonsense emotion labels prior to the start of the experiment and possessed no pre-existing conceptual knowledge for those novel emotion categories. Yet in daily life, participants usually have pre-existing conceptual knowledge for an emotion category such as *anger*. In Study 3, we thus tested whether associating the words “fear” and “anger” with new exemplars of fearful and angry facial actions caused participants to update their existing conceptual knowledge for the emotion categories *fear* and *anger.* We predicted this would in turn bias participants’ perceptual memories for later seen fearful and angry facial actions. These findings would thus replicate and extend our findings from Studies 1-2 to suggest that the acquisition of conceptual knowledge is an on-going process that has the potential to shape perceptual memory for subsequently seen emotional facial actions across time.

In Study 3, participants again completed *learning*, *target*, and *test* phases, but this time they saw instances of fearful and angry facial actions. One group learned to pair fearful and angry facial actions with the words “fear” and “anger,” respectively, whereas the other group performed a control task in which they did not pair facial actions with emotion words.

Method

Participants

Participants were 91 undergraduate students (44 women, M_{age} = 19.30, *SD* = 2.82). Data from eight participants were removed because they failed to complete at least 75% of the trials in either the learning or target phase. Data from two additional participants were removed because they failed to enter a response on two trials in the test phase, which meant that we had 75% or less of these participants’ data (final *N* = 81).

Procedure

Participants were positioned approximately 20 inches from a monitor with a screen resolution of 1440 x 900 pixels. The images presented were 250 x 310 pixels. Thus, the images subtended approximately 7.9° x 10.8° of visual angle.

We made three major changes to the procedure for Study 3. First, we used Poser 7 3D character art and animation software to create stereotypical and non-stereotypical facial actions associated with the categories *fear* and *anger*. Stereotypical faces were developed based on the caricatures of English emotional facial actions depicted in Ekman & Friesen (1976). For instance, fearful facial actions depicted wide eyes, raised eyebrows and open mouths, whereas angry facial actions depicted furrowed eyebrows and clenched teeth. To ensure that participants did not explicitly encode differences between the learned and target faces, target facial actions were again subtly different from the faces seen during the learning phase. We achieved subtle differences by making faces in the target phase less stereotypical versions of the facial actions associated with each category. Participants thus viewed non-stereotypical versions of the facial actions for each emotion category in the learning phase and more stereotypical facial expressions for each category in the target phase. We reasoned that demonstrating that perceptual memory can be shifted away from more stereotypical exemplars and toward non-stereotypical exemplars when exemplars are paired with language would provide even stronger support for our hypothesis that language alters perceptual memory of emotional facial actions.

A second change involved our verbal v. control manipulation. In the *verbal condition*, participants learned to categorize non-stereotypical instances of *fear* and *anger* using the English labels "fear," and "anger." In the *control condition,* participants made a perceptual judgment about the features of the emotional facial actions by judging how close together v. far apart the eyes of the face were (as per Gendron et al. 2012). Unlike the previous control task, in which participants could be looking anywhere on the face to render a judgment about the color of the alien's skin, this modified control task required participants to view the central features of faces that are diagnostic for rendering emotion judgments (Adolphs, Gosselin, Buchanan, Tranel, Schyns, & Damasio, 2005). Thus, we could rule out the possibility that findings in Studies 1-2 were driven by the fact that participants in the control condition were not encoding the emotionally relevant information because they were not looking at the areas of the face that are typically viewed during emotion perception. As in Studies 1-2, this control task did not explicitly invoke emotion category words.

Finally, because control participants already knew the meaning of the labels "fear" and "anger" before the start of the task, both participants in the verbal condition and control condition were exposed to these labels during the target phase and judged whether the facial actions depicted "fear" or "anger." As in Studies 1-2, this process served to re-activate newly acquired conceptual knowledge for participants in the verbal condition but controlled for the fact that participants in the verbal condition were seeing words during the target phase. Otherwise, the procedure and data analyses for Study 3 were the same as that of Study 2 (see Figure 8).

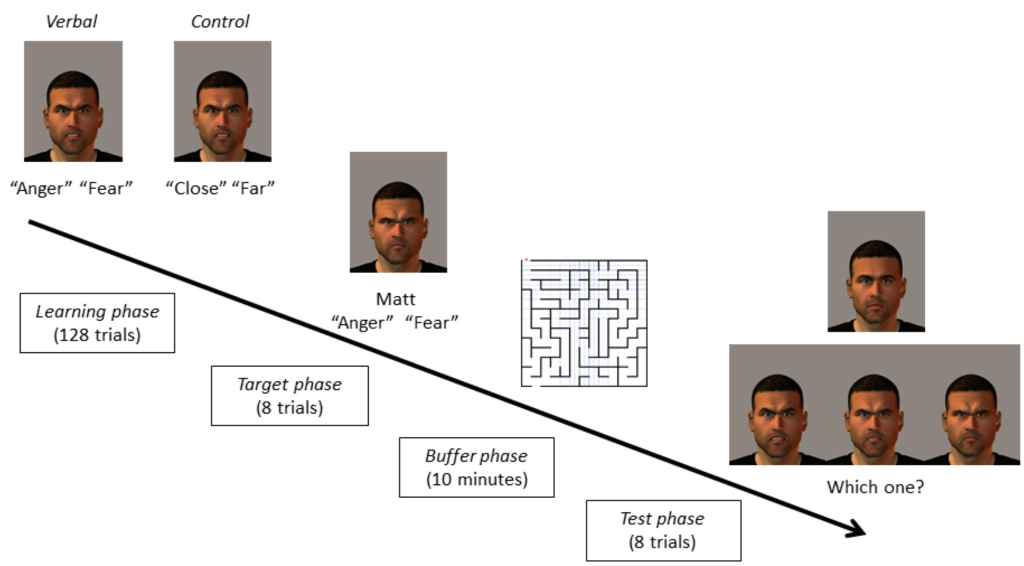


Figure 8. Overview of Study 3. Participants completed learning, target and test phases similar to Study 2. However, in Study 3, participants learned to associate facial expressions of familiar emotion categories with emotion words, or performed a control task in which they judged whether the eyes were close together or far apart.

Results and Discussion

For our primary analysis of participants' perceptual memories for the facial actions viewed in the target phase, we again investigated which face participants were more likely to choose first during the test phase.[6] Consistent with our hypotheses and prior findings, participants in the verbal condition were marginally more likely than those in the control condition to choose the learned face first on a greater percentage of trials, $t(80) = 1.81$, $p = .075$, $d = 0.40$, 95% CI [-0.86%, 17.73%] (see Figure 9).

Within the verbal condition, participants were more likely to choose the learned face first (on 50.00% of trials) when deciding which face they had seen during the target phase, as compared to the actual target face (17.56% of trials), $t(41) = 5.29$, $p < .001$, $d = 1.48$, 95% CI [20.06%, 44.82%]. Participants in the verbal condition were also more likely to choose the learned face compared to the morph face first (29.46% of trials) $t(41) = 3.74$, $p = .001$, $d = 0.99$, 95% CI [9.46%, 31.61%]. Finally, participants in the verbal condition were more likely to choose the morph face first compared to the target face, $t(41) = 2.64$, $p = .01$, $d = 0.65$, 95% CI [2.80%, 21.01%].

In the control condition, participants were also more likely to choose the learned face first (on 41.56% of trials) when deciding which face they had seen during the target phase, as compared to the actual target face (23.44% of trials), $t(39) = 3.83$, $p < .001$, $d = 0.69$, 95% CI [8.55%, 27.70%]. Whereas participants in the verbal condition were more likely to choose the learned vs. morph face first, participants in the control condition were equally likely to choose the learned vs. morph face first ($p > .05$). This finding suggests that pairing facial actions with emotion words in the verbal condition better facilitated the updating of conceptual knowledge for

[6] We again considered Bonferroni adjusted alpha levels of .017 because we conducted three tests per condition (i.e., .05/3). All three of the hypothesis tests for the verbal condition remained significant after considering this more conservative threshold.

emotion categories, which influenced perceptual memory for those faces. Without pairing the facial actions with emotion words, participants in the control condition were equally biased to choose the learned and morph faces first. Finally, participants in the control condition were also more likely to choose the morph face (33.13% of trials) compared to the target face first, $t(39) = 2.10$, $p = .042$, $d = 0.21$, 95% CI [0.35%, 19.03%].

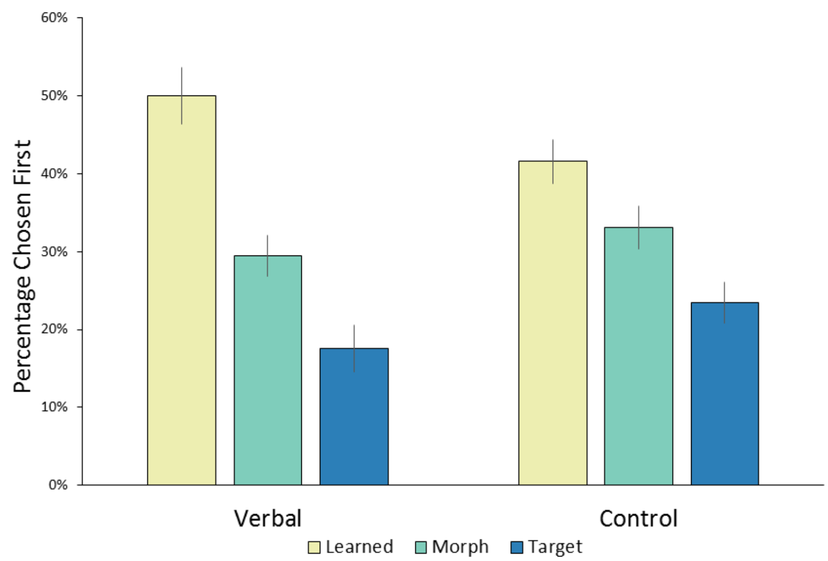


Figure 9. Descriptive Analyses from Study 3. Means and 95% confidence intervals reveal that participants in the verbal condition were marginally more likely than those in the control condition to choose the learned face first, $t(80) = 1.81$, $p = .075$, $d = 0.40$, 95% CI [-0.86%, 17.73%].

Non-parametric analyses revealed that distributions of participants' first choices again differed between groups ($Z = 2.11$, $p = 0.035$). Replicating Studies 1-2, participants in the verbal condition chose the learned face first more often than did controls (see Figure 6).

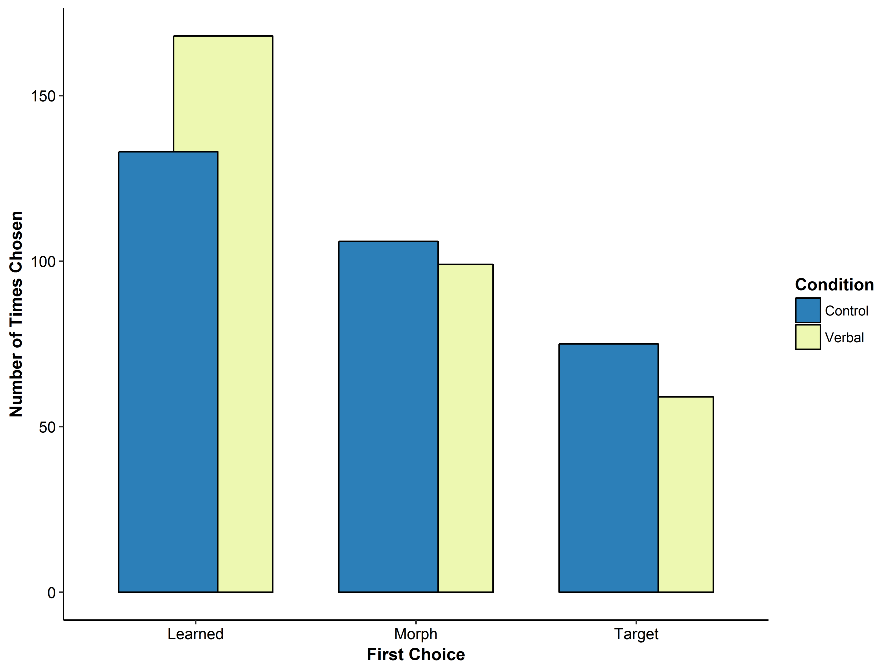


Figure 10. Non-parametric Analyses from Study 3. The Wilcoxon Rank Sum Test for clustered data revealed that, as in Studies 1-2, the distributions of participants' choices differed between groups.

In follow-up analyses, we again computed a bias score to assess a gradient in participants' perceptual memory of the facial actions. As in Study 2, pairing facial actions with emotion words in the learning phase was relatively more likely to bias perceptual memory for subsequently perceived facial actions. Bias values for the verbal condition were significantly greater than bias values for the control condition $t(80) = 2.40$, $p = .02$, $d = 0.53$ 95% CI [0.07, 0.70] (see Figure 11).

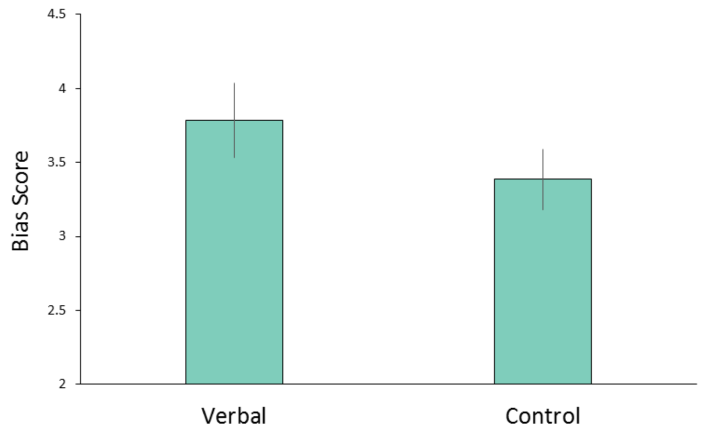


Figure 11. Bias scores from Study 3. As in Study 2, means and 95% confidence intervals reveal that verbal trials had significantly more bias than control trials, indicating that emotion words employed during the initial learning phase helped participants acquire new perceptual representations that biased perception of subsequent faces towards the perceptual information presented in the learning phase.

General Discussion

In three studies, we demonstrate the role of language in biasing perceptual memory for facial actions associated with emotions. Using a combination of learning and perceptual memory tasks, we demonstrated that pairing facial actions with words biased perceptual memory for subsequently perceived facial actions. For instance, when a novel “alien” emotional expression was paired with a nonsense word, participants were more likely to recall seeing a subsequent exemplar of that category as being more similar to the initially learned face. These findings suggest that the phonological form of an unknown word can help people cohere together never-before-seen facial expressions as meaningful categories. These categories serve as the conceptual knowledge that in turn biases later memory of similar exemplars of “alien” facial actions. Furthermore, language helped participants update existing conceptual knowledge of familiar emotion categories (e.g., *anger*), suggesting that the role of language in shaping perceptual memory for emotion is not limited to novel emotion concepts.

These findings are consistent with constructionist accounts of emotion, which suggest that emotion words help support the concept knowledge that allows people to understand others' affective facial displays as instances of specific emotion categories (Barrett, 2017; Lindquist et al. 2015; 2016a, b). Words are thought to be particularly useful in the acquisition and use of concept knowledge (Barsalou et al. 2005; Lupyan & Clark, 2015; Xu, 2016) and there is suggestive evidence that this might be especially the case in abstract categories such as emotions (see Lindquist et al 2015a, b; 2016; Lindquist & Gendron, 2013 for discussions).

Although our findings are unlikely to be unique to emotion categories—indeed, words appear to drive acquisition and perception of other non-emotional categories (e.g., Lupyan et al. 2007)—they can explain why the acquisition of emotion words in early childhood correlates with the ability to perceive emotions categorically on faces (see Widen, 2013) and why facilitating (Nook et al. 2015) or disrupting access to emotion words (Gendron et al. 2012; Lindquist et al. 2006; 2014) in adult perceivers alters the online perception of emotional facial expressions. Our findings might also explain why people from different cultures do not necessarily associate the same facial actions with the same emotion category words (i.e., there are cultural differences in the facial actions associated with "anger" or "surprise;" Jack et al. 2016). People likely learn to associate the facial actions that are most frequent, or most useful, to their culture with the phonological form of the word for that category. Thus, even when there is cross-cultural equivalence in terms of the emotion categories encoded in language (i.e., many cultures possess a word for "anger"), these words need not correspond to a universal set of facial actions.

On the other hand, our findings can describe why including words in experimental tasks *can* induce relatively greater cross-cultural agreement about which facial actions are associated with which emotion categories. If words guide the formation or use of conceptual knowledge, and conceptual knowledge shapes encoding or retrieval of subsequently seen facial actions, then researchers can unintentionally alter the nature of their participants' conceptual knowledge any time facial stimuli are paired with words and repeated in an experiment (as in most forced-choice categorization studies). For instance, studies trying to assess the universality of emotion perception often perform intensive "manipulation checks" that might unintentionally serve as a learning phase like that used in the present studies. Such "manipulation checks" can help participants to form associations between certain facial actions and certain words in the context of that experiment (see Sauter et al. 2015). In test phases, participants then see caricatured photographs of posed facial actions and 2-6 labels from the "manipulation check" phase (e.g., Ekman et al. 1987). Indeed, cross-cultural studies that regularly employ these methods are more likely to find evidence of so-called "universal" facial emotion recognition than experiments that use free response options in which participants are not taught any labels in advance (see Gendron et al. 2015 for a discussion).

Limitations and Future Directions

To our knowledge, our findings are some of the first to explicitly test the extent to which pairing images of facial actions with words helps participants acquire novel conceptual knowledge for emotion that biases subsequent perceptual memory. They are thus not without limitations. A first limitation is that we cannot identify whether the acquisition of conceptual knowledge impacted the encoding of the faces seen during the target phase, the retrieval of those faces during the test phase, or both. Prior research suggests that both mechanisms are possible.

For instance, bias could have occurred at encoding insofar as the presence of words in emotion perception tasks causes participants to perceive faces more categorically (Fugate et al. 2010; Nook et al. 2015; Roberson et al. 2007), warping the perception of the “bottom-up” sensory information towards the category representation stored in memory. Halberstadt (2005) found that labeling a 50%-50% morph of anger and happiness as “anger” during encoding caused perceivers to furrow their own eyebrows (i.e., a facial action consistent with anger). The extent to which perceivers had furrowed their brows during encoding then predicted the extent to which they later recalled seeing the face as more intensely angry. These findings imply that bias occurred at encoding and is in part a product of facial mimicry. On the other hand, evidence from verbal overshadowing studies of facial identity suggests that the biasing effect of verbal information might occur during retrieval of perceptual representations, since reducing the delay between initial perception of the face, verbal description, and recall reduced verbal overshadowing (Schooler & Engstler-Schooler, 1990). In the present studies we did not include a condition in which participants were asked to identify the test faces immediately after encoding so we cannot adjudicate between these possibilities. However, future studies could do so to determine whether updating conceptual knowledge or acquiring new conceptual knowledge influences encoding, retrieval, or both equally.

Second, although we tried to institute control tasks that were well matched with our experimental manipulations, they nonetheless leave open alternate interpretations. In Studies 1-2, we used a control task that required participants to judge how yellow v. green the “alien” stimuli were. Here we were able to match participants’ judgments to the objective amount of color used to create each stimulus in order to compute participants’ accuracy. However, it remains a possibility that in making a judgment about the color of the skin, participants could have ignored the emotional aspects of the face. We attempted to rectify this issue in Study 3 by instituting a task designed to ensure that participants were paying attention to the portions of the face that are important to emotion-based judgments. Following Gendron et al. (2012), we asked participants to make a subjective judgment about how close v. far apart the eyes of the face were. These judgments did not have an accuracy criterion, however, which meant that we could not be sure that participants were performing the task as specified. Although both of these alternate interpretations are possible when the studies are considered in isolation, when in combination, our findings suggest that these alternate interpretations are not likely to be of major concern. Our findings demonstrated a biasing effect when faces were paired with words in an initial learning phase across Studies 1-3, regardless of the control condition used. Ideally, future research would replicate and extend these findings using a completely different learning manipulation to provide converging evidence.

Third, the pattern of our findings differed slightly depending on whether participants were acquiring completely novel category knowledge and viewing completely novel facial actions or whether they were adding conceptual knowledge to existing categories (i.e., *fear* and *anger*) and viewing familiar facial actions (i.e., fearful and angry facial actions). In all studies, participants were more likely to choose the learned face when in the verbal compared to the control condition. However, when assessing the pattern of choices within conditions, participants in the verbal condition in Studies 1-2 were equally likely to choose the learned and the target faces and participants in the control condition were more likely to accurately choose the target face without bias. In Study 3, participants within the control condition were still more likely to choose the learned face than the target face, even though they were less likely to choose the learned face than participants in the verbal condition as we predicted. These differences in the patterns of participants' choices might be related to the type of stimuli used. In Studies 1-2, participants were viewing completely novel facial actions that they had never seen before. One possibility is that with greater learning opportunities, participants would have developed more robust conceptual knowledge for the novel emotions and we would have observed an even stronger bias towards the learned face within the verbal conditions and away from the learned face in the control condition. Another possibility is that asking participants to elaborate more on the emotions being experienced by the alien and inferring that those emotions had some purpose might have strengthened our effects in Studies 1-2. For instance, Halberstadt and Niedenthal (2001) observed the greatest bias in perceptual memory when participants were asked to elaborate on *why* the morphed face observed was "angry." Thus, it would be interesting in future studies to investigate whether the perceptual memory bias becomes stronger when the words are associated with situated meaning during the learning phase (i.e., "gep" is an emotional facial action that the alien makes when it is communicating that it wants to go in search of food).

In contrast, pairing words with novel exemplars in Study 3 might have had an even stronger effect in biasing participants' perceptual memory for later seen faces because they were adding the learned faces to pre-existing conceptual knowledge for the categories *fear* and *anger*. That is, there might be an even greater reliance on conceptual information stored in memory when perceiving and encoding facial actions associated with emotion categories that are familiar and/or routinely used. Future research should examine the extent to which novel v. familiar category learning and perceptual memory differs in the domain of emotion.

A final limitation regards alternate explanations of our findings. It remains a possibility that labeling merely intensifies the primacy effect that is known to bias memory in general. However, this possibility would not be inconsistent with the idea that language is preferentially helping individuals to encode the facial expressions in their environment that subsequently bias perceptual memory for other exemplars from that category. Nonetheless, the idea that language merely influences the primacy effect is inconsistent with at least one study (Hagen, Meacham, & Mesibov, 1970) that found that overt labeling dampens the primacy effect in short term memory compared to when items are not labeled. To weigh in on this question, future studies might investigate the extent to which updating exemplars stored in memory is a product of primacy or whether it is influenced by other factors such as a participants' goals (i.e., when goals to accurately understand emotional facial expressions are high v. low). It would also be interesting to know whether it occurs only in specific contexts (i.e., during development; when acclimating to a new culture) or whether it is an on-going process (i.e., individuals are always updating their cache of concept knowledge for emotion categories). If category learning is an on-going process, as suggested by our Study 3, then aside from initial learning of facial expressions during childhood, there would really be no "primacy" effect per se; rather, perceptual representations would always be most influenced by whatever the most recent or relevant exemplars for that emotion category were.

Conclusion

In conclusion, several studies demonstrated that emotion words support the acquisition of new conceptual knowledge that then biased subsequent perceptual memory for emotional facial actions. Our findings add to growing evidence that language plays a role in emotion, and emotion perception in particular (Barrett et al. 2007; Herbert, Sfärlea, & Blumenthal, 2013; Lindquist, MacCormack & Shablack, 2015; Lindquist, Satpute, & Gendron, 2015; Lindquist, Gendron, & Satpute, 2016; Lindquist & Gendron, 2013).

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Author Note

Data and ideas appearing in the present manuscript are not under consideration at any other journal, but they have been included in the following conference presentations:

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Doyle, C.M., & Lindquist, K.A. (April, 2014). Language supports perceptual symbols for emotion. Poster presented at the Society for Affective Science, Washington, D.C.

Doyle, C.M., & Lindquist, K.A. (February, 2014). Language supports perceptual symbols for emotion. Poster presented at the Emotion Pre-conference of the Society for Personality and Social Psychology, Austin, TX.

Lakdawala, S., Mellor, A., Lindquist, K.A., Barsalou, L., & Barrett, L.F. (February, 2008). Simulation bias: A test of embodied emotion knowledge. Poster presented at the Emotion Pre-conference at the annual meeting of the Society for Personality and Social Psychology, Albuquerque, NM.

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