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Learning new words' emotional meanings in the contexts of faces and sentences

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Language is a powerful vehicle for expressing emotions, although the process by which words acquire their emotional meaning remains poorly understood. This study investigates how words acquire emotional meanings using two types of associative contexts: faces and sentences. To this end, participants were exposed to pseudowords repeatedly paired either with faces or with sentences expressing the emotions of disgust, sadness, or neutrality. We examined participants' acquisition of meanings by testing them in both within-modality (e.g., learning pseudowords with faces and testing them with a new set of faces with the target expressions) and cross-modality generalization tasks (e.g. learning pseudowords with faces and testing them with sentences). Results in the generalization tests showed that the participants in the Face Group acquired disgust and neutral meanings better than participants in the Sentence Group. In turn, participants in the Sentence Group acquired the meaning of sadness better than their counterparts in the Face Group, but this advantage was only manifested in the cross-modality test with faces. We conclude that both contexts are effective for acquiring the emotional meaning of words, although acquisition with faces is more versatile or generalizable.*

An important semantic dimension of words is their emotional valence. Some words refer to pleasant or positive concepts (party, intelligence),

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whereas others refer to unpleasant or negative concepts (pandemic, cancer). Moreover, these words can work as powerful emotional stimuli themselves, inducing neural activities similar to those induced by emotional facial expressions or emotional pictures (Citron, 2012; Schacht & Sommer, 2009). But how do words acquire their emotional connotations? One possibility is that associative learning plays a role, as these words could repeatedly co-occur with specific emotional stimuli in daily experience. For instance, the disgusting connotation of some words (vomit, cockroach) could be induced by their associations with the corresponding perceptual stimuli, as well as with proprioceptive reactions or with facial expressions of disgust. The present study investigates the acquisition of emotional connotations for new words using two different associative contexts: faces and sentences. Despite the potential relevance of these two associative mechanisms, to our knowledge, no comparison has ever been conducted to explore which of the two mechanisms induces words' emotional meaning more efficiently.

Facial expressions are effective communication channels (Brosch et al., 2008; Darwin, 1872) and an essential component for expressing emotions (Ekman, 1992a, 1993; Russell et al., 2003). There is experimental evidence that emotional words and facial expressions are strongly associated in one's semantic memory, interfering with each other in Stroop tasks (Baggott et al., 2011; Beall & Herbert, 2008; Kar et al., 2018; Stenberg et al., 1998). Even in late bilinguals, processing emotional words in the second language triggers motor potentials in specific face muscles (Baumeister et al., 2017) and induces word-face conflicts in Stroop tasks (Fan et al., 2016, 2018). However, the emotionality of second-language words is considerably reduced compared to that of first-language words, because the processing of meaning is more direct and automatic in the first language than in the second language (Kroll & Stewart, 1994; Opitz & Degner, 2012; Pavlenko, 2012). In addition, studies on how children acquire emotion concepts have found that they initially recognize emotions through the facial expressions of their caregivers (Denham, 1998; Izard, 1971) and later acquire linguistic labels for concrete emotions as their language proficiency improves (Markham & Adams, 1992; Vicari et al., 2000). For adults, emotions could also be recognized both through other people's facial expressions and by being associated with words referring to emotional states and events (Kissler et al., 2009; Niedenthal et al., 2002; Padmala et al., 2011).

Previous associative learning studies have shown that associating neutral facial expressions with emotional facial expressions modifies the affective evaluation of the former in both healthy participants (Walther, 2002) and dementia patients (Blessing et al., 2013). However, whether such an effect exists in the acquisition of emotional valence for new words remains

unclear. Since facial expressions are one of the first accessible sources of emotion acquisition for humans, and they are strongly associated with emotional words in adults' memory, we expected that face-new word associations will play an important role in the acquisition of words' emotionality.

Another possible scenario for acquiring new word meaning is in the context of other words or sentences. This is quite common for adults when they learn low-frequency words in their own language or new words in a second language (Chaffin et al., 2001; Landauer & Dumais, 1997; Lindsay & Gaskell, 2010). In the laboratory, experiments pairing new words with linguistic contexts succeeded in inducing lexical representations. For instance, in a study by Frishkoff and colleagues (2010), participants received novel words embedded in informative sentences. In a second session, the trained new words compared to untrained new words showed ERP signatures similar to those for familiar words and modulated the N400 in a semantic priming paradigm.

Moreover, numerous laboratory studies have suggested that emotional words can modify the emotional valence of neutral words. For instance, neutral words can acquire emotional connotations through pairing with emotional words even in the absence of contingency awareness (de Houwer et al., 1994, 1997). Such an effect has been found even when nonsense trigram syllables were paired with emotional words (A. W. Staats & Staats, 1959; C. K. Staats & Staats, 1957). Note, however, that in real life, when we look an unfamiliar word up in the dictionary, the meaning of the word is usually explained with more detailed information than just a single word. It thus seems more realistic to use sentences describing certain emotion-inducing scenarios for emotion acquisition than to use single words. But only a few studies have adopted such a design. An interesting exception was the study reported by Junghofer and colleagues (2017), in which sentences describing either a neutral occupation of a person or a criminal activity were paired with neutral faces. After training, neutral faces were considered less pleasant and induced more extensive brain activity when associated with criminal rather than neutral behaviours. In the current research, as far as we know, we use for the first time sentences as a learning context to induce emotionality in new words.

Previous studies investigating contextual emotion acquisition have focused on the difference between emotional and neutral valences. Behavioural research suggests that pseudowords associated with negative pictures are better remembered than those associated with neutral pictures (Eden et al., 2014). Evidence from EEG studies suggests that pseudowords with acquired emotional and neutral connotations differ in an early time

window and in the P300, indicating that contextual learning using pictures is suitable to establish emotional associations in words (Fritsch & Kuchinke, 2013). The present study intends to go further by examining the acquisition of specific emotional connotations, beyond general differences in affective valence. With this aim, in this study two types of negative stimuli, disgust and sadness, as well as neutral stimuli were paired with pseudowords to induce the acquisition of emotional meanings. We chose the two negative emotions for several reasons. Firstly, we were primarily interested in the study of disgust, one of the six primary emotions (Ekman, 1992b), which has been relatively neglected in the field of emotional language. Secondly, rather than establishing a gross contrast with a positive emotion like happiness, we wanted to contrast it with another negatively valenced emotion. Moreover, happiness, the only primary positive emotion, is more effectively induced by pictures, real-life experiences, or videos than by single sentences (Ferrer et al., 2015; Yan & Dillard, 2010). Thirdly, we chose sadness as a contrasting emotion for disgust because they have several distinctive features: disgust is mainly triggered by external physical stimuli (Rozin & Haidt, 2013), whereas sadness is a more internal and psychosocial emotion (Mikulincer & Florian, 1997); moreover, the two emotions differ in facial expressions. We are aware that other negative emotions such as fear or anger are also very distinctive and easy to identify in face recognition tasks (Adolphs et al., 1999; Mattavelli et al., 2014). However, like disgust, they are generally reactions to threatening stimuli (Spielberger & Reheiser, 2010), while sadness differs from disgust as it is the response to the loss of valuable stimuli or goals (Lench et al., 2011). The neutral emotion condition was included as a control baseline.

Disgust is induced by specific types of aversive stimuli (Rozin et al., 1994). Unique facial expressions and physiological responses can be induced by the emotion of disgust. For facial expressions, nose wrinkle, gape, tongue extrusion, and raised upper lips were reported to be associated with disgust (Rozin et al., 1994). Psychophysiological responses including nausea, reduced heart rate, amplified skin conductance (Stark et al., 2005), and decreased respiratory rate (Ritz et al., 2005) are induced when contacting disgusting stimuli. Stimuli inducing disgust usually come with the threat of contamination or disease and feeling disgust encourages withdrawal behaviours (Woody & Teachman, 2006). Therefore, disgust protects us from noxious substances that may harm us or reduce our wellbeing (Rozin & Fallon, 1987). Previous studies also suggested that viewing disgust facial expressions would activate the insula, which is the main neural structure involved in disgust processing (Jabbi et al., 2008; Wicker et al., 2003).

Sadness, on the other hand, results mainly from loss (Carver, 2004; Lench et al., 2011; Levine & Pizarro, 2004) and failure (Lench et al., 2011). Sadness can be induced by social and non-social situations of loss (Keltner & Kring, 1998) and relevant facial expressions are associated with reduced sympathetic (lower skin conductance level, lengthened cardiac pre-ejection period) and increased parasympathetic (higher respiratory sinus arrhythmia) activities (Marsh et al., 2008). Sadness, while sharing a negative valence with disgust, is more endogenously oriented (Lench et al., 2016) and is often characterized by a facial expression that lowers the corners of the mouth and raises the inner portion of the brows (Ekman et al., 2002).

According to previous studies, the facial expressions of disgust elicit stronger activation of the defensive motivational system and the orientation response than the those of sadness (Gantiva et al., 2019). Therefore, it is expected that the associative context of faces will be more advantageous for the acquisition of disgusting connotations than sad connotations for new words. In addition, it is thought that faces will be more effective than sentences for acquiring disgust-related meanings, as faces are simpler and more straightforward. On the other hand, sentences can demonstrate advantages for the acquisition of sadness over disgust, as sentences are able to describe scenarios that are more specific, which are compatible with the endogenous nature of sadness (Lench et al., 2016).

This study aims to explore the acquisition of words' emotional meanings using faces and sentences as two different associative contexts. To this end, participants were divided into two different groups to acquire disgusting, sad, and neutral emotional connotations for pseudowords through either faces (Face Group) or sentences describing emotion-related scenarios (Sentence Group). The experimental design included a Learning Phase and an Evaluation Phase. In the Learning Phase, pseudowords repeatedly associated with either faces or sentences were presented to participants in three blocks. After each block, there was a block learning test to instantly probe participants' learning of the associations between the pseudowords and the particular faces or sentences presented in the learning block. When the Learning Phase was finished, participants proceeded to the Evaluation Phase, comprising a pseudoword matching test, a within-modality generalization test, and a cross-modality generalization test. The Evaluation Phase was designed to assess whether the learned pseudowords acquired emotional connotations after their repetitive associations with emotional stimuli.

EXPERIMENT 1

METHOD

Participants. Eighty-four native Spanish-speaking and physically and mentally healthy college students from the University of La Laguna (Spain) participated in the experiment in return for course credits. All participants were right-handed with normal or corrected to normal vision. Half of the participants were randomly assigned to the Face Group, learning the associations between pseudowords and faces, while the remaining participants were assigned to the Sentence Group to learn the associations between pseudowords and sentences. Two participants in the Face Group and one participant in the Sentence Group were excluded from the analyses for their excessive errors in the Learning Phase (accuracy < 60%).

Materials. Thirty pseudowords of 5-7 letters were composed with the first two letters being "al", "ro", and "le", respectively. Forty-five faces were selected for the Face Group (15 disgusting, 15 sad, and 15 neutral). The faces were selected from the KDEF (Lundqvist et al., 1998) stimuli set. The experimental face stimuli portrayed 15 individuals (eight females: KDEF no. 01, 02, 05, 07, 09, 11, 13, and 14; and seven males: KDEF no. 10, 11, 12, 13, 17, 22, and 23), each showing one of the three expressions (disgust, sadness, and neutral). Non-facial areas (e.g., hair) were removed by applying an ellipsoidal mask. The arousal data of the faces were obtained from the KDEF documents (*Karolinska Directed Emotional Faces (KDEF) documents — Department of Experimental Clinical and Health Psychology — Ghent University*, n.d.) (see Table 1). There was a significant effect of emotion, $F(1, 44) = 22.596$, $p < .001$, $\eta^2 = .518$. Post-hoc tests showed that disgust and sadness faces were significantly more arousing than neutral faces ($p < .001$), and there was no significant difference of arousal between disgust and sadness faces ($p = .520$). The faces were presented against a black background. Each face stimulus was 11.5 cm high by 8.5 cm wide, equalling a visual angle of 9.40° (vertical) × 6.95° (horizontal) at 70-cm viewing distance.

Table 1. Means and Standard Deviations of arousal of the faces used in the experiment.

	AROUSAL
EMOTION	
disgust	3.57 (0.5)
sadness	3.41 (0.4)
neutral	2.64 (0.3)
overall	3.21 (0.6)

For the Sentence Group, 54 emotional sentences were composed to describe disgusting, sad, and neutral scenarios. Thirty-nine students of the same college population who did not participate in the final experiment rated the emotions expressed by the sentences through online questionnaires. Participants were asked to select the emotional label (neutral, sadness, happiness, disgust, or anger) that best fit the emotion connoted by the sentences, and to rate how confident they felt about their choices on a 5-point scale (1-a little sure, 5-completely sure). Another group of 32 college students rated the arousal of the sentences in a different questionnaire, over a 5-point scale (1-very peaceful, 5-very exciting). Only sentences with 70% or more choices of the intended emotion were retained (see Table 2). The average categorization rates of the retained disgusting, sad, and neutral sentences were 88.89% (SD = 9.91%), 89.74% (SD = 8.78%), and 89.74% (SD = 9.84%), respectively. In total, 45 emotional sentences were used for the experiment (15 disgusting, 15 sad, and 15 neutral). Critically, there was no significant difference among the sentences of the three emotional categories in intended emotion choice rates, $F(1, 44) = .027$, $p = .973$, $\eta^2 = .001$, or confidence scores, $F(1, 44) = .102$, $p = .903$, $\eta^2 = .005$. For arousal, there was a significant effect of emotion, $F(1, 44) = 119.327$, $p < .001$, $\eta^2 = .850$. Post-hoc tests showed that disgusting sentences and sad sentences were significantly more arousing than neutral sentences ($p < .001$) and there was no significant difference of arousal between disgusting and sad sentences ($p = .916$). The mean arousal scores for disgusting, sad, and neutral sentences were 4.32 (SD = .393), 4.25 (SD = .671), and 1.84 (SD = .380), respectively. The sentences were presented against a black background in Times New Roman font, size 30.

Table 2. Means and Standard Deviations of the categorization rates (percentage), choice confidence scores, and arousal of the sentences used in the experiment.

	CATEGORIZATION RATES	CHOICE CONFIDENCE SCORES	AROUSAL
EMOTION	%		
disgust	88.89 (10)	4.64 (0.2)	4.32 (0.4)
sadness	89.74 (9)	4.62 (0.3)	4.25 (0.7)
neutral	89.74 (10)	4.40 (0.2)	1.84 (0.4)
overall	89.46 (9)	4.55 (0.3)	3.47 (1.3)

In total, 30 pseudowords, 45 faces, and 45 sentences were used in the experiment. Ten pseudowords were assigned to each emotion category (disgust, sadness, neutral) to pair with 10 faces/sentences of the corresponding emotion, which were presented to participants in the Learning Phase. The 15 remaining faces/sentences were used for the generalization tests in the Evaluation Phase (5 in each emotion category). All 30 pseudowords appeared in all the generalization tests with the correct response counterbalanced across participants as well as the assignment of pseudowords to emotions.

Design and Procedure. The experiment used a mixed 2 x 3 factorial design, with learning procedure (faces and sentences) as between-participant factor and emotion (disgust, sadness, and neutral) as within-participant factor. The Learning Phase consisted of three blocks, each followed by a testing block. The Learning Phase was followed by an Evaluation Phase, as illustrated in Figure 1 and Table 3.

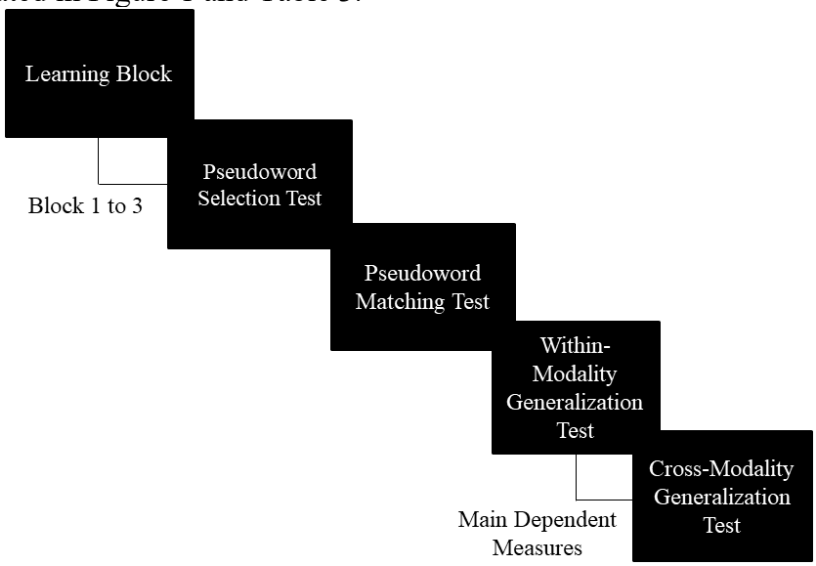


Figure 1. Experimental procedures for both groups.

Table 3. Outline of the experimental design.

Two learning groups: faces and sentences The Face Group was presented with pseudowords paired with faces. The Sentence Group was presented with pseudowords paired with sentences.
Three emotions: disgust, sadness, and neutral In both groups the stimuli paired with pseudowords (either faces or sentences) involved disgusting, sad, or neutral emotional connotations.
Main dependent measures: • Within-modality generalization tests o The Face Group was presented with new faces to test how the emotional connotations of pseudowords generalize to unlearned faces. o The Sentence Group was presented with new sentences to test how the emotional connotations of pseudowords generalize to unlearned sentences. • Cross-modality generalization tests o The Face Group was presented with sentences to test how the emotional connotations of pseudowords generalize to emotional sentences. o The Sentence Group was presented with faces to test how the emotional connotations of pseudowords generalize to facial expressions.

Participants in both groups started the experiment by reading the task instructions. They were asked to memorize the association between the face/sentence and the pseudoword and then to complete the following tests. The instructions did not mention anything about emotion and only the learning and testing blocks were explained. After reading the instructions, participants completed a practice block of 6 learning trials and 3 testing trials. The pseudowords and faces/sentences used in the practice block were not presented during the experiment. Instructions for the Evaluation Phase were given after completing the Learning Phase. Participants' accuracies and response times for the evaluation tests were recorded.

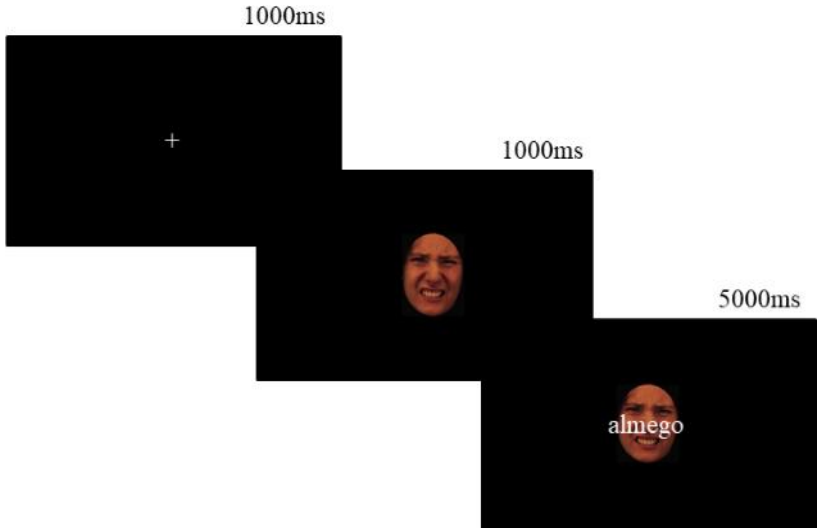
Learning in the Face Group. The Learning Phase was divided into three blocks. There were four face-pseudoword pairs of each emotion in the first block and three in the second and third blocks. Each pair was repeated six times within each block resulting in 72, 54, and 54 trials in the first, the second, and the third block, respectively. Pseudowords starting with "al", "ro", and "le" were respectively assigned to one of the three emotion pairs.

The assignment was counterbalanced across participants. Each trial began with a fixation cross presented for 1000 ms in Times New Roman font, size 30 followed by the face presented for 1000 ms. Then, the pseudoword was presented in Times New Roman font, size 50 in the middle of the screen over the face for 5000 ms (see Figure 2 A). After each learning block, the participant's learning of the associations was evaluated in a pseudoword selection test. Each trial in this test began with a fixation cross presented in Times New Roman font, size 30 for 1000 ms, followed by one of the faces previously seen presented for 1000 ms (see Figure 2 B). Then, two pseudowords from the preceding learning block were presented at the lower-left corner of the screen in Times New Roman font, size 18. The participant was required to select which one had been associated with the face on the screen by pressing "1" on the keyboard for the pseudoword on the left and "2" for the pseudoword on the right (not the keypad) with their left hand. The time limit for response was 5000 ms.

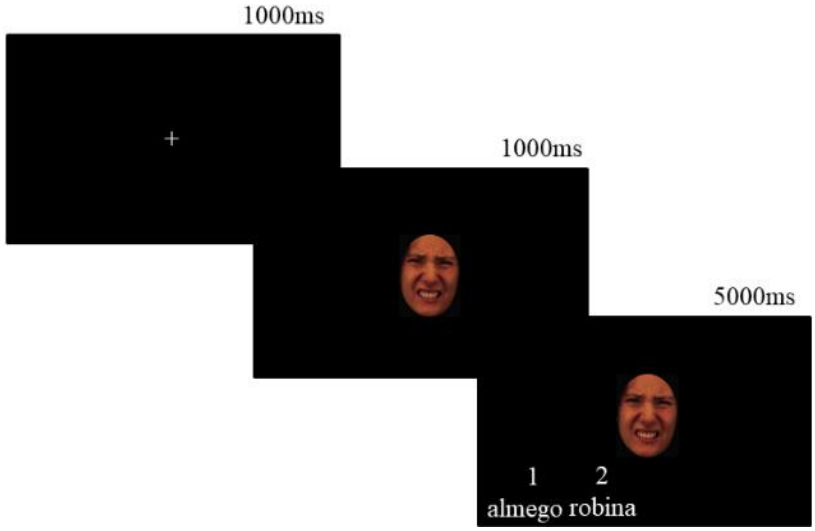
Evaluation in the Face Group. The first test was a pseudoword matching test, consisting of 30 trials (10 for each emotion) with the following sequence of events: 1000 ms fixation cross in Times New Roman font, size 30, followed by a face from the three learning blocks presented for 1000 ms, and then a pseudoword over the face in Times New Roman font, size 50 with two options of "correct" and "incorrect" at the lower-left corner of the screen in Times New Roman font, size 18 (see Figure 2 C). Participants were asked to judge whether the pairing between the pseudoword and the face was correct according to the associations acquired during the Learning Phase by pressing "1" on the keyboard for "correct" and "2" for "incorrect". The time limit for response was 5000 ms. Like in the pseudoword selection test, the matching test aimed to probe participants' memorization of the association between the faces and the pseudowords. The next two tests included in this Evaluation Phase were designed to investigate whether learned pseudowords acquired emotional connotations, rather than only associations with specific face stimuli. The within-modality generalization test proceeded in the same fashion as the pseudoword selection test, except that here the learned pseudowords of the three emotions were paired with new faces, i.e., faces not previously seen in the Learning Phase (see Figure 2 D). The participant was asked to select among the two pseudowords the one that best described the emotion expressed in the new face by pressing "1" or "2" on the keyboard as he or she did in the pseudoword selection test during the Learning Phase. The time limit for response was 5000 ms. There were 15 test trials in this test (5 for each emotion). The last test was a cross-modality generalization test, as it introduced emotional sentences rather than new faces (see Figure 2 E). The 15 test trials (5 for each emotion) began with a fixation cross presented for

1000 ms in Times New Roman font, size 30 followed by an emotional sentence presented in the middle of the screen for 1000 ms in Times New Roman font, size 30. Then two pseudowords from the previous acquisition blocks were presented at the lower-left corner of the screen in Times New Roman font, size 18. Participants were asked to select the pseudoword that best described the emotion associated with the sentence by pressing "1" or "2" on the keyboard as in the previous test. There was no time limit for response, as such a cross-modality task was more demanding than the previous ones.

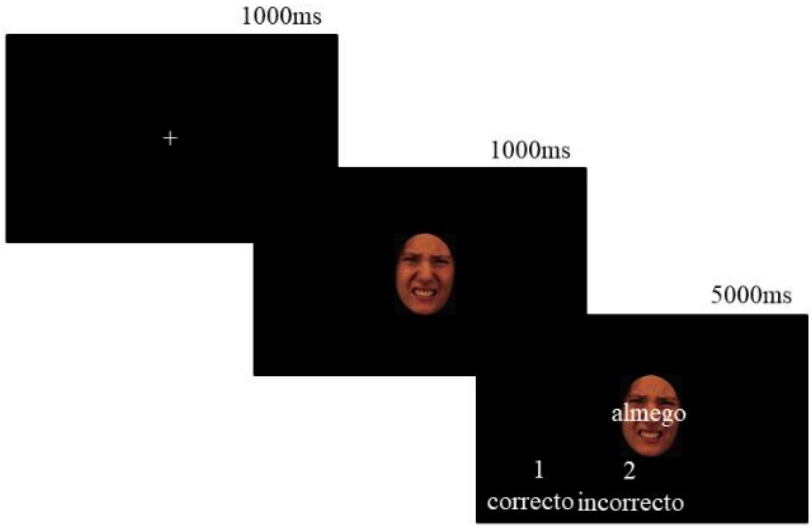
(A) Learning Trial



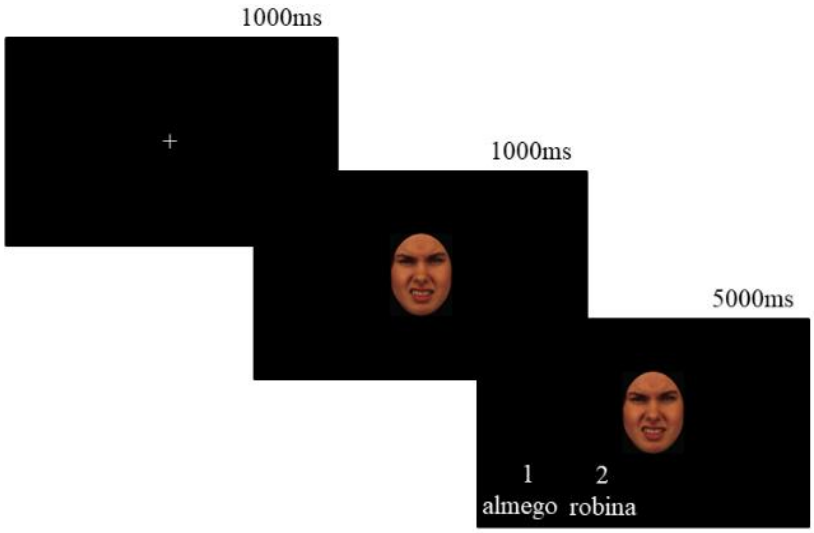
(B) Selection Test



(C) Matching Test



(D) Within-Modality Generalization Test



(E) Cross-Modality Generalization Test

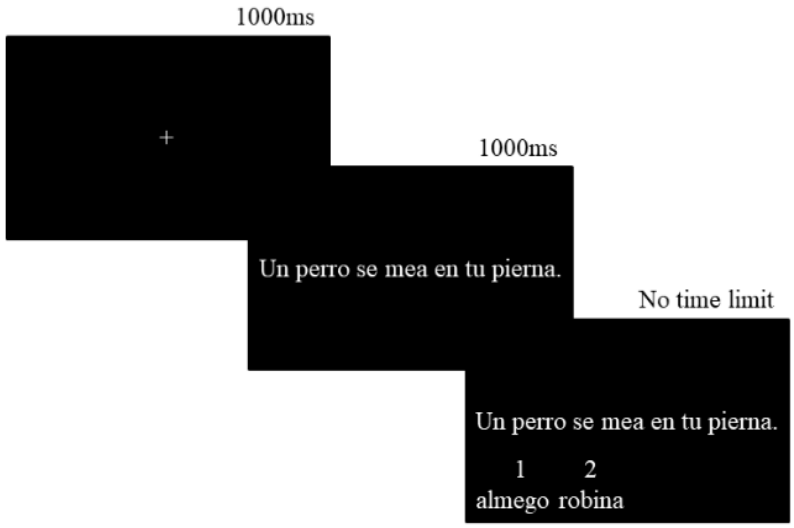
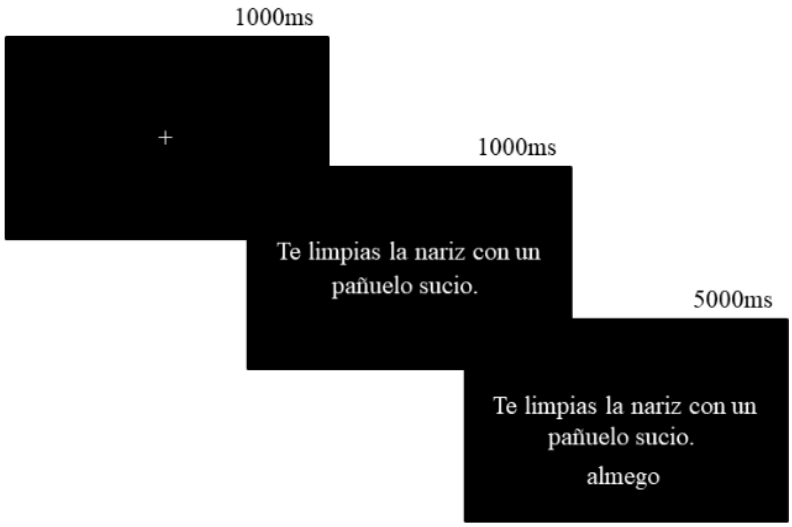


Figure 2. Examples of materials in the Face Group. The English translation of the sentence is "A dog pisses on your leg".

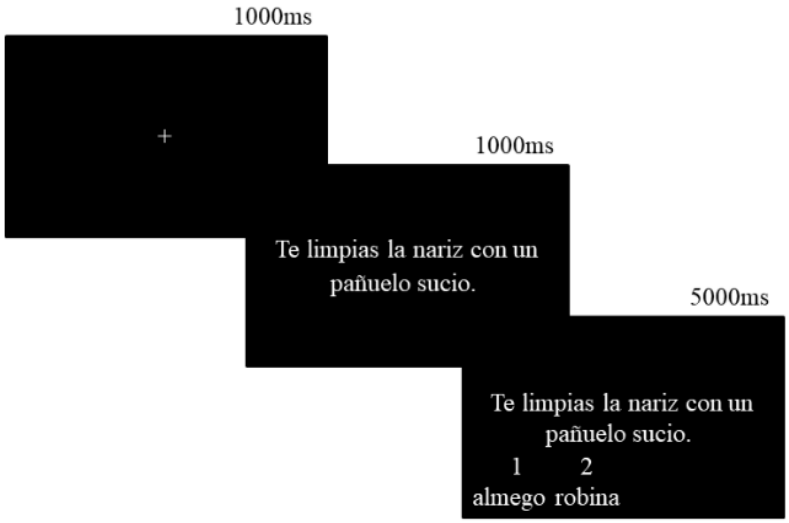
Learning and Evaluation in the Sentence Group. For the Sentence Group, the learning and test procedures were similar to those in the Face Group, except that faces were replaced by sentences in the Learning and the Evaluation Phases. Thus, in the Learning Phase, each pseudoword was presented below a sentence in the middle of the screen (see Figure 3 A).

Concerning the pseudoword selection test and the three other tests in the Evaluation Phase, the same format was applied as in the corresponding tests for the Face Group, the only difference being that the faces were replaced with sentences (see Figure 3 B and 3 C). This means that new sentences were used for the within-modality generalization test and faces were used for the cross-modality generalization test (see Figure 3 D and 3 E). Note that the generalization materials used for the within-modality and the cross-modality tests, i.e., new faces and sentences, in the Sentence Group were exactly the same as the ones employed in the Face Group for the cross-modality and the within-modality tests, respectively. All fixations and sentences were presented in Times New Roman font, size 30, the pseudowords in Times New Roman font, size 50, and the options for the tests in Times New Roman font, size 18.

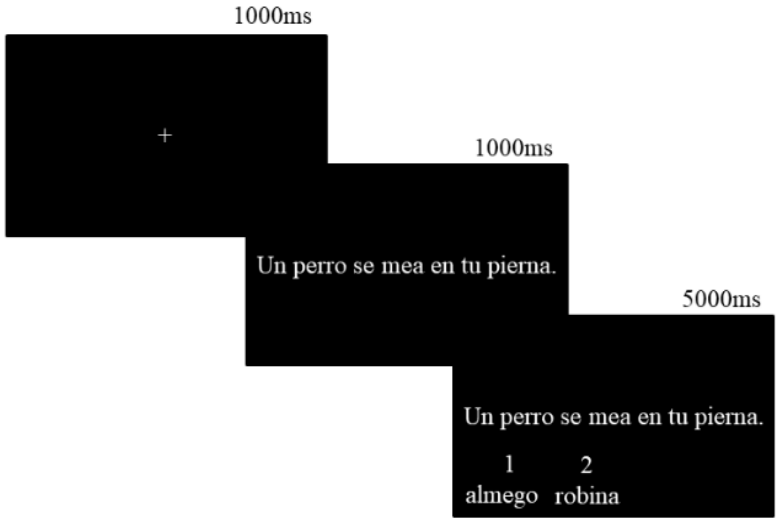
(A) Learning Trial



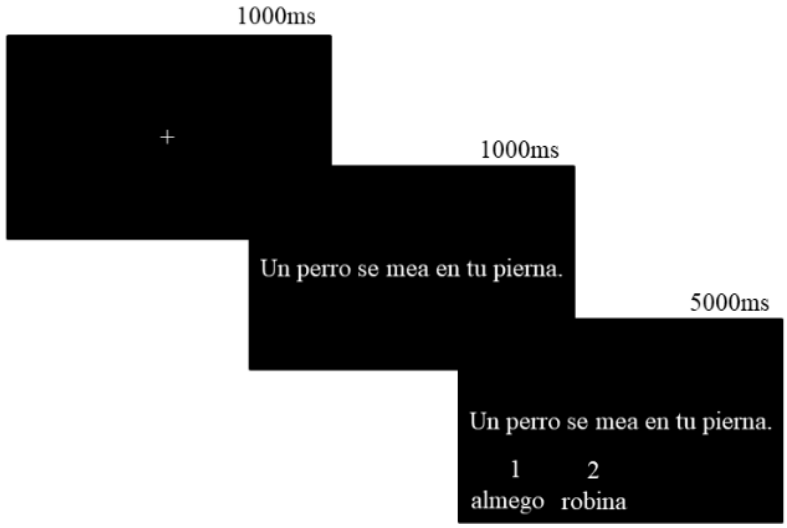
(B) Selection Test



(C) Matching Test



(D) Within-Modality Generalization Test



(E) Cross-Modality Generalization Test

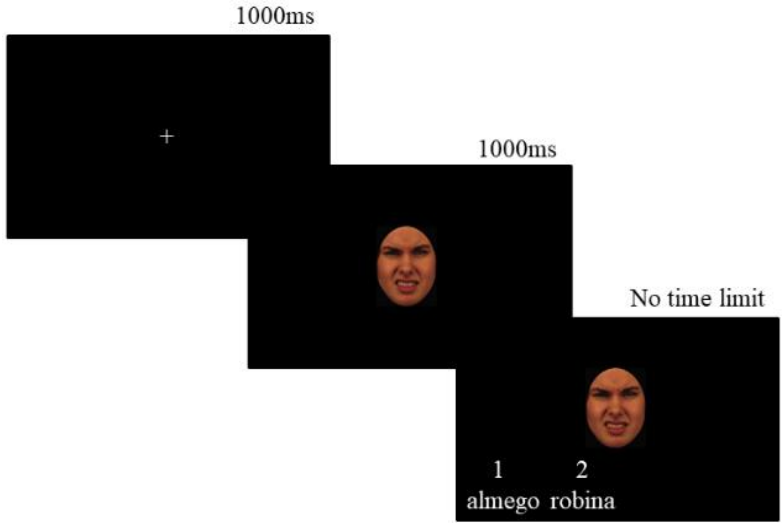


Figure 3. Examples of materials in the Sentence Group. The translation of the sentence in (A) and (B) is "You clean your nose with a dirty handkerchief", and in (C) is "A dog pisses on your leg".

RESULTS

This section reports results related to the accuracy of responses to the generalization tests (within-modality and cross-modality tests), which are the most informative measures of meaning acquisition (see Figure 4 and Table 4). In the supplementary materials, we include additional accuracy statistics for the learning tests (pseudoword selection and pseudoword matching) and the response times of all the tests, which demonstrate no major difference in data analysis.

Table 4. Means and Standard Deviations of response accuracies (percentage) in the within- and the cross-modality generalization tests as a function of learning group and emotion.

	FACE GROUP		**SENTENCE GROUP**	
	Within-Modality	Cross-Modality	Within-Modality	Cross-Modality
EMOTION	%	%	%	%
disgust	86.50 (19)	84.50 (20)	81 (26)	73.20 (24)
sadness	67.50 (22)	79 (24)	77.10 (21)	79.50 (20)
neutral	79.50 (23)	80.50 (20)	66.80 (27)	66.80 (24)
overall	78 (17)	81 (16)	75 (18)	73 (16)

Within-Modality Generalization of the Two Groups. The mixed Group (2: sentence, face) and Emotion (3: sadness, disgust, and neutral) ANOVA on accuracy rate in the within-modality generalization tests yielded a main effect of emotion, $F(2, 80) = 9.512$, $p < .001$, $\eta^2 = .099$, but not of group, $F(2, 80) = .525$, $p = .471$, $\eta^2 = .007$. This emotion effect was qualified by the significant Group x Emotion interaction, $F(2, 80) = 7.551$, $p < .001$, $\eta^2 = .079$.

For the Face Group, post-hoc comparisons revealed that the accuracies for disgust and neutral trials were significantly higher than those for sadness, $t(39) = 5.208$, $p < .001$; $t(39) = 3.674$, $p < .001$. There was no significant difference between the accuracies of disgust and neutral trials, $t(39) = 1.769$, $p = .085$. In contrast, for the Sentence Group, accuracies were higher for the two emotion categories, disgust and sadness, than for the neutral category, $t(40) = 2.916$, $p = .006$. There was no significant difference between disgust and sadness trials, $t(40) = .822$, $p = .416$.

The comparisons across the two learning groups showed higher accuracy in the Face Group than in the Sentence Group, $t(80) = 2.274$, $p = .026$, for the neutral category. In contrast, there was no reliable difference between the learning groups for both disgust and sadness $t(80) = 1.070$, $p =$

.288, $t(80) = 1.969$, $p = .052$, though for the latter there was a tendency for better performance in the Sentence group relative to the Face Group.

Cross-Modality Generalization of the Two Groups. The mixed ANOVA on accuracy rate revealed a main effect of group, $F(2, 80) = 5.153$, $p = .026$, $\eta^2 = .061$, but not of emotion, $F(2, 80) = 2.213$, $p = .113$, $\eta^2 = .026$. The accuracy in the Face Group was significantly higher than in the Sentence Group. This effect was qualified by the Group x Emotion interaction, $F(2, 80) = 3.299$, $p = .039$, $\eta^2 = .039$.

For the Face Group, there was no significant difference in accuracy among the three emotion categories, $F(2, 39) = .979$, $p = .380$, $\eta^2 = .024$. In contrast, for the Sentence Group, accuracy was higher for sadness than for the neutral category, $t(40) = 3.329$, $p = .002$, while there was no significant difference between disgust and sadness, $t(40) = 1.525$, $p = .135$, or between disgust and neutral, $t(40) = 1.305$, $p = .199$.

Finally, the comparisons across groups for each emotion revealed higher accuracy in the Face Group than in the Sentence Group for disgust, $t(80) = 2.310$, $p = .024$, and neutral, $t(80) = 2.731$, $p = .008$, while there was no significant difference between the two groups for sadness trials, $t(80) = .103$, $p = .918$.

General Comparison of Acquisition Modalities. To explore emotion acquisition efficiency for the two stimulus modalities (faces and sentences), participants' performances over the same test stimuli were analyzed.

New Face Stimuli. This comparison analyzed participants' accuracy rates on new face stimuli, i.e., the within-modality generalization test for the Face Group and the cross-modality generalization test for the Sentence Group.

The mixed ANOVA on accuracy rate revealed a main effect of emotion, $F(2, 80) = 3.547$, $p = .031$, $\eta^2 = .037$, but not of group, $F(2, 80) = 1.578$, $p = .213$, $\eta^2 = .020$. This emotion effect was qualified by the significant Group x Emotion interaction, $F(2, 80) = 13.109$, $p < .001$, $\eta^2 = .137$. The accuracy rate in the Face Group was higher than in the Sentence Group for disgust and neutral faces, $t(80) = 2.749$, $p = .007$, $t(80) = 2.392$, $p = .019$. By contrast, the accuracy rate of sadness faces was significantly higher for the Sentence Group than for the Face Group, $t(80) = 2.585$, $p = .012$.

New Sentence Stimuli. This comparison analyzed participants' performances on sentence stimuli, which would be the cross-modality generalization test of the Face Group and the within-modality generalization test of the Sentence Group.

There was no significant difference between the two groups in accuracy rate, $F(2, 80) = 2.171$, $p = .117$, $\eta^2 = .025$.

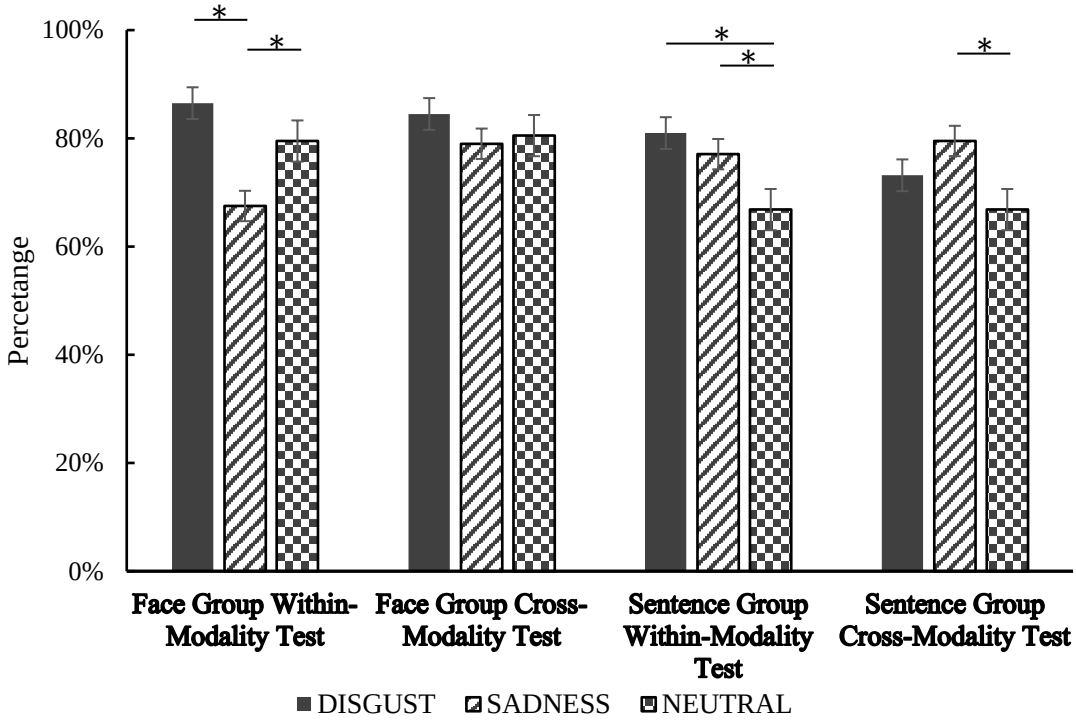


Figure 4. Means and Standard Errors of response accuracies (percentage) in the within- and the cross-modality generalization tests as a function of learning group and emotion. "*" means $p < .05$.

DISCUSSION

The present study compared two different contexts for the acquisition of specific emotional meanings of written new words. Two groups of participants acquired disgusting, sad, and neutral connotations for pseudowords, by associating them either with faces or with sentences. Both groups performed well in the initial association tests, as shown in the supplementary materials, which confirmed that participants learned the associations between specific pseudowords and specific emotionally valenced stimuli. Critically, the two groups reached good performance in the within-modality generalization tests, with non-learned faces or sentences, indicating that the two associative contexts succeeded in inducing emotional meanings and serving as mediations to process new words (Kroll & Stewart,

1994). Still, the performances of the two groups were modulated by emotions. Participants in the Face Group tested with new faces performed better at new words associated with disgust and neutral stimuli than those associated with sadness stimuli, while participants in the Sentence Group tested with new sentences did better at new words associated with disgust and sadness stimuli than those associated with neutral stimuli. The two groups showed cross-modality generalization as well. Specifically, when the Face Group was tested with sentences, the participants performed equally well for the three emotional categories, whereas when the Sentence Group was tested with facial expressions, performance was better for new words associated with sadness stimuli. Comparison between the two groups demonstrated that the Face Group outperformed the Sentence Group at new words associated with disgust and neutral stimuli while, in some analyses, the Sentence Group did slightly better at new words associated with sadness stimuli than the Face Group. To sum up, the results suggested that 1) the learning was efficient for both learning groups; 2) the two groups manifested differences; and 3) the differences were dependent on the specific emotion involved.

The acquired emotional meanings of new words were categorial in two senses. Firstly, the emotional connotations of the new words generalized to new stimuli beyond those used in the Learning Phase. This generalization even extended to stimuli in a different modality than the learned stimuli. Secondly, the new words themselves had a categorial structure, as all the pseudowords associated with a given emotion had a distinctive orthographic pattern (e.g., for some participants, pseudowords starting with “al” could be associated with disgust), thus offering a proxy of real emotional words that are often organized as morphological sets with the same root (e.g., disgust, disgusting, disgusted).

Notably, both associative learning procedures were efficient for inducing emotional meaning, despite the different cognitive and neural processes presumably involved. Concerning the processing of facial expressions, previous studies have shown that emotions can be vicariously activated in oneself by observing other people’s motor or vocal emotional expressions, relying on the mirror neuron system (Baumeister et al., 2017; Gallese et al., 2004; Niedenthal, 2007). Such an idea is further supported by studies investigating the first-person experience of disgust and the recognition of disgust in other people (Calder et al., 2000; Wicker et al., 2003). Therefore, pairing new words with emotional facial expressions, as we did with the Face Group procedure, likely results in establishing Hebbian associations (Hauk et al., 2004; Hebb, 1949) between the activation of face-related mirror neurons and the activation of neurons responsible for encoding

the orthographic and phonological features for the co-occurrent pseudowords.

In contrast, the induced emotional meanings of new words in the Sentence Group relied on purely linguistic associative processes. Linguistic context plays a well-known role in learning word meaning (Bloom, 2000; Chaffin et al., 2001; Landauer & Dumais, 1997; Lindsay & Gaskell, 2010; Nagy et al., 1987). For instance, word co-occurrence is exploited by readers to learn the meaning of low-frequency and abstract words that cannot be easily associated with perceptual experiences (Landauer & Dumais, 1997; Mestres- Missé, 2008). Linguistic context can be especially relevant to learn emotional vocabulary, given the fact that some social or introspective emotions (e.g., jealousy, envy, frustration) do not involve distinctive facial or body expressions and learning their corresponding labels may require verbal descriptions or narratives (Aragão, 2011).

Above all, which learning protocol was more efficient, the face or the sentence association? The Face Group demonstrated a general advantage in acquiring disgust and neutral meanings for new words in comparison to the Sentence Group. The pseudoword-face associative procedure seemed especially efficient in acquiring disgusting connotations, probably because of the extremely distinctive expression for this emotion, which might trigger the disgust-related mirror neuron system, as previous studies have demonstrated (Gallese et al., 2004; Wicker et al., 2003). Another explanation, suggested by studies on second language embodiment, is that bilinguals are able to simulate actions and emotions when they process words in their second languages (Baumeister et al., 2017; Dudschig et al., 2014; Macedonia, 2015; Pasfield-Neofitou et al., 2015; Sheikh & Titone, 2016). In the present study, faces served as more concrete and straightforward materials for acquiring emotional connotations for new words. Given the fact that disgust is associated with distinctive facial expressions (Rozin et al., 1994), the embodiment effect could contribute to the participants' performance in the evaluation tests. As for the Sentence Group, participants performed well, being able to use the new words to match new sentences sharing the same emotional category (within-modality generalization), but these participants were not as efficient when encountering faces (cross-modality generalization). Such patterns suggest that the sentences used for disgust acquisition had successfully induced the intended emotion, reflected by the higher accuracy in the within-modality test. However, the lower accuracies for the cross-modality test suggest that the acquisition is scenario-based and less categorial.

Another advantage of the Face Group over the Sentence Group was its participants' better performance with emotionally neutral stimuli. Neutral

stimuli have been commonly used as a control or baseline condition in studies of emotional facial expressions (Phan et al., 2002; Wager & Smith, 2003) and emotional words (Fields & Kuperberg, 2012). Though some previous studies have indicated that neutral faces may be evaluated as negative in some circumstances (Lee et al., 2008), participants in our Face Group did not confuse neutral faces with disgust or sadness during acquisition, as their high accuracy in the generalization tests demonstrated. However, the performance of the Sentence Group for neutral trials in both the within-modality and cross-modality tests was significantly worse, which could be attributed to the difficulty of maintaining the neutrality of the sentences during acquisition. Though the sentences were rated as neutral in the normative study, they were prone to be contaminated by individual differences or participants' personal experiences. For example, if the participant was late for class due to a delay of the tram, the sentence "You go to school by tram" might gain a negative valence.

Although the Face Group showed significant advantages over the Sentence Group on disgust and neutral trials, the two groups' performance on sadness trials was similar for the generalization tests. Sad facial expressions have raised some controversies in previous studies (Fernández-Dols & Crivelli, 2013; Reisenzein et al., 2013). Prototypical facial expressions of sadness are not always observed when people experience sadness as an internal state under non-social circumstances (Namba et al., 2017). Therefore, the ambiguity of the sad facial expressions might cause confusion for participants in the Face Group when they encountered new faces, especially along with another negative emotion. However, for participants in the Sentence Group, the new faces were introduced as stimuli of another modality that carried social values. These factors simplified the difficult task of decoding the faces. Nevertheless, the Face Group did well at sadness trials in the cross-modality test, that is, generalization to sentences, indicating successful emotion acquisition.

Some limitations are worth noting. Firstly, the study demonstrated strong associative learning of emotional connotations for new words but did not test whether these acquired meanings play a lexical role in linguistic contexts, such as being integrated at the sentence or the discourse level. For instance, once the association of "robinado" with sadness had been learned, would the participant understand the sentence "John's dog died in his arms and he felt robinado"? Secondly, in future experiments, it will be worth investigating the neural signatures of the new words' acquired meanings, comparing them to those of real words to verify the extent to which the lexicalization process is implemented in the brain (Fernández-Dols & Crivelli, 2013; Reisenzein et al., 2013).

CONCLUSION

The present study compared the efficiencies of two associative contexts in emotional meaning acquisition of written words: faces and sentences. Post-acquisition tests suggested that faces are more effective for learning disgust and neutral emotions, while sentences are slightly more advantageous for learning sadness. However, the advantage of sentences in learning sadness was only manifested when the words were generalized to describe faces. Taken together, facial expressions, as the first accessible channel for humans to acquire emotions, are found to be more effective than emotional sentences for acquiring emotional meanings for written words.

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