TITLE: Be aware of the rifle but don't forget the stench: differential effects of fear and disgust on lexical processing and memory.

Pilar Ferré[1], Juan Haro[1], and José Antonio Hinojosa[2]

[1] Department of Psychology and CRAMC. Universitat Rovira i Virgili. Tarragona. Spain.

[2] Pluridisciplinary Institute and Faculty of Psychology, Universidad Complutense de Madrid, Spain

Short title: Fear and disgust in word processing and memory

Keywords: Discrete emotions, word processing, memory, lexical decision task, emotional dimensions.

CORRESPONDING AUTHOR:

Pilar Ferré

Department of Psychology and CRAMC. University Rovira i Virgili

Crta. de Valls s/n., 43007. Tarragona. Spain

E-mail: mariadelpilar.ferre@urv.cat

Telephone Number: +34-977-257896

Abstract

The aim of this study was to investigate the role of discrete emotions in lexical processing and memory, focusing on disgust and fear. We compared neutral words to disgust related words and fear related words in three experiments. In Experiments 1 and 2, participants performed a lexical decision task (LDT), and in Experiment 3 an affective categorization task. These tasks were followed by an unexpected memory task. The results of the LDT experiments showed slower reaction times for both types of negative words with respect to neutral words, plus a higher percentage of errors, this being more consistent for fear related words (Experiments 1 and 2) than for disgust related words (Experiment 2). Furthermore, only disgusting words exhibited a higher recall accuracy than neutral words in the memory task. Moreover, the advantage in memory for disgusting words disappeared when participants carried out an affective categorization task during encoding (Experiment 3), suggesting that the superiority in memory for disgusting words observed in Experiments 1 and 2 could be due to greater elaborative processing. Taken together, these findings point to the relevance of discrete emotions in explaining the effects of the emotional content on lexical processing and memory.

Introduction

The interplay between cognition and emotion has been of interest largely to cognitive psychologists and neuroscientists. A common approach in the investigation of this interaction has been to study the effects of the emotional content of the stimuli in a number of cognitive domains, among them lexical processing and memory. Research in these fields has been dominated by dimensional models, according to which the human affective experience can be described in terms of continuous variations of a small number of dimensions, the most significant being valence and arousal (Bradley & Lang, 2000). Many studies have demonstrated the effect of arousal on lexical processing and memory (e.g., Kousta, Vinson, & Vigliocco, 2009; Mather & Sutherland, 2009). As for valence, positive content consistently facilitates both processes (e.g., Adelman & Estes, 2013; Ferré, García, Fraga, Sánchez-Casas, & Molero, 2010; Kousta et al., 2009). In contrast, results with negative content are mixed, as negative words have shown either an advantage in lexical processing and memory (e.g., Adelman & Estes, 2013; Kousta et al., 2009), a disadvantage (Estes & Adelman, 2008), or indeed no effect at all (Madan, Shafer, Chan, & Singhal, 2017; Scott, O'Donnell, & Sereno, 2014).

The other influential model describing the human affective space, the so-called discrete emotion model, assumes a limited number of discrete emotions with characteristic patterns of cognitive appraisals, behavioral action tendencies, and associated emotional experiences (Ekman, 1992). Such differences among discrete emotions could lead to distinct effects on cognitive processing. Hence, they may have contributed to the mixed results found in studies with negative words, in that such studies commonly involve words related to more than one discrete emotion. In the present study we seek to shed light on this issue by investigating the role of discrete emotions in lexical processing and memory.

Focusing on lexical processing, few studies have recently been conducted from the discrete emotions perspective (e.g., Briesemeister, Kuchinke, & Jacobs, 2011a; Briesemeister, Kuchinke, & Jacobs, 2011b). These studies have relied on the lexical decision task (LDT), in which participants are asked to decide if the presented strings of letters are real words in a particular language or not. In one study, disgusting words (but not fear related words) showed slower reaction times (RT) than neutral words, while there were more errors with disgust and fear related words than with neutral words (Briesemeister et al., 2011a). By contrast, another study reported a lower percentage of errors with fearful words than with neutral ones (Briesemeister et al., 2011b). Hence, whereas there seems to be a consistent processing disadvantage for disgusting words, results concerning fear are less consistent. The cause of this inconsistency could be related to differences in the lexical and affective features of words in different experiments. For instance, it is not clear whether the fearful words used also had high scores in other discrete emotions (Briesemeister et al., 2011b). In any case, what is clear from the studies mentioned above is that more research is needed in order to elucidate the role of discrete emotions in lexical processing. This is the first aim of the present study, in which we compared disgust and fear, carefully controlling for the lexical and affective variables of the experimental stimuli and making sure that words assigned to each emotion had low scores in the comparison emotion.

As with research in lexical processing, only a small number of studies have addressed the role of discrete emotions in memory; one of these tested words (Charash & McKay, 2002), and two more tested images (Chapman, Johannes, Poppenk, Moscovitch, & Anderson, 2013; Croucher, Calder, Ramponi, Barnard, & Murphy, 2011). The latter two reported an enhancement in memory for disgusting images, which was explained by the unique contaminating property of disgusting stimuli. That is, it is very important to remember disgusting objects so as to avoid contamination in the future (Chapman et al., 2013). With respect to words, although the only study conducted to date has also reported a recall advantage for disgusting words over fearful and neutral ones (Charash & McKay, 2002), the lack of control of affective dimensions (i.e., valence and arousal) precludes drawing firm conclusions as to the effects of discrete emotions on memory for words. Hence, the question of whether the advantage in memory for disgusting images is also observed for verbal stimuli remains to be explored. Although both images and words can carry affective content, there are important differences between these two types of stimuli. On the one hand, images can convey affective information directly, due to their biological relevance (i.e., there would be direct access to affective information stored in semantic networks for images), whereas the symbolic nature of words might provide only indirect access to affective information, mediated by prior lexical processing (De Houwer & Hermans, 1994). On the other hand, there are differences in the neural processing of affective words and pictures (e.g., Hinojosa, Carretié, Valcárcel, Méndez-Bértolo, & Pozo, 2009; Tempel et al., 2013). For all these reasons, it seems necessary to conduct research that explores the idiosyncratic aspects of the influence of discrete emotions on memory for verbal material. This is the second goal of the present study.

In this study, we investigated the role of discrete emotions on lexical processing and memory by focusing on disgust and fear. We chose these emotions because they are similar from a dimensional perspective (both are negative emotions associated with avoidance and both are related to higher arousal levels than other negative emotions like sadness, Russell, 1980); yet at the same time they are different from a discrete emotions perspective. On the one hand, these emotions are clearly associated with different subjective feelings (Russell, 1980). Furthermore, disgust and fear seem to depend on different brain structures (see Calder, Lawrence, & Young, 2001, for an overview) and are mediated by different peripheral systems (Levenson, Ekman, & Friesen, 1990). Moreover, the biological meaning of these two emotions is different. Thus, whereas disgust is primarily related to contamination (Rozin, Haidt, & McCauley, 2008), fear is related to a broader type of danger (Carretié, Ruiz-Pardial, López-Martín, & Albert, 2011). Finally, it has been suggested that the ultimate function of disgust and fear can lead to different patterns of exploration of the environment (Carretié et al., 2011). Namely, although disgusting events are a signal of possible danger, their exploration probably does not involve a biological cost. In fact, an in-depth exploration of a disgusting stimulus may be the most adaptive strategy, in order to determine its exact risk (i.e., to decide if it is actually dangerous or if, rather, it can be consumed). Obviously, such a strategy cannot be the most adequate when faced with a threatening stimulus. In this case, it is probably better to fight or escape than to devote excessive processing resources to it (Carretié et al., 2011).

We conducted three experiments comparing three sets of words – disgust related words, fear related words, and neutral words – in distinct paradigms, assessing lexical processing and memory. In Experiments 1 and 2, participants performed a LDT; in Experiment 3, they did an affective categorization task. These tasks were followed by an unexpected memory task. The combination of measures of lexical processing and memory in the same experiment allows us to explore the issue of whether differences in memory for words are mediated by their processing during encoding. Moreover, the use of incidental encoding tasks (i.e., participants were not told about the following memory test) clearly reduces the use of strategies, thus providing more reliable conclusions about the mechanisms involved in emotional memory. Finally, it might be that the effects of discrete emotions on cognition are modulated by the type of task. Indeed, depending on the particular emotions examined, and to the appraisal patterns and response tendencies associated with these emotions, differential effects might be expected in tasks tapping into distinct processes.

The predictions of this study are straightforward. If discrete emotions have a relevant role in lexical processing and memory, we would expect differences in performance between disgusting and fearful words, even though these words are matched in valence and arousal. Notably, if these differences appear, and considering the distinct patterns of exploration with disgusting and fearful stimuli, they could be modulated by the type of task. Regarding the LDT, we might expect a disadvantage for negative words in general since negative stimuli seem to capture attention taking away processing resources from the primary task (i.e., to decide if a string of letters is a word or not). This would lead to slower reaction times and more errors (the so-called Automatic Vigilance Hypothesis, Öhman & Mineka, 2001). However, if, as some authors have suggested, the capacity to automatically capture attention is greater for threatening stimuli, the disadvantage should be higher for fearful words than for disgusting words (Cisler, Olatunji, Lohr, & Williams, 2009). With respect to the memory tasks, and considering the previous results with images (Chapman et al., 2013; Croucher et al., 2011), we would expect a higher accuracy in memory for disgusting words. This superiority might be mediated by the capacity of disgusting stimuli to elicit an in-depth exploration. This in turn might result in a more elaborate processing for disgusting stimuli.

Experiment 1

Method

Participants

Forty-two Spanish speakers (37 women, mean age = 24.59, *SD* = 5.65) from the Universitat Rovira i Virgili (URV, Tarragona, Spain) participated in the experiment. They were undergraduate students who received academic credits for their participation.

Materials

One hundred and eight Spanish words were selected from two normative studies containing ratings for five discrete emotions (Ferré, Guasch, Martínez-García, Fraga, & Hinojosa, 2017; Hinojosa et al., 2016a): thirty-six disgust related words, 36 fear related words and 36 neutral words. The criterion to select words related to a particular emotion for the present experiment was that they had a rating higher than 2.5 (on a 1-to-5 scale) in that emotion. Furthermore, disgusting words were chosen such that they were rated low in fear (i.e., they had fear ratings lower than 2.5) whereas fearful words were rated low in disgust (i.e., they had disgust ratings lower than 2.5, see Table 2). In contrast, neutral words had ratings lower than 2.5 in the five discrete emotions (see Table 1 for the affective and psycholinguistic properties of the words and Appendix 1 for the complete stimulus list).

(Insert Table 1 about here)

Disgusting words and fearful words were matched in valence ($p = .74$) and arousal ($p = .19$). Both types of words showed lower valence ratings and higher arousal ratings than neutral words ($p < .001$ in all cases). The values for these variables were taken from several normative studies (Ferré, Guasch, Moldovan, & Sánchez-Casas, 2012; Guasch, Ferré, & Fraga, 2016; Hinojosa et al., 2016a; Hinojosa et al., 2016b; Redondo, Fraga, Padrón, & Comesaña, 2007). Furthermore, the mean rating in the discrete emotion to which the words belonged was not different between disgusting words (M = 3.43) and fearful words (M = 3.22), $t(70) = 1.71$, $p = .10$. In addition, the three sets of words were matched in terms of many lexical and semantic variables (all ps > .05).

Finally, since in the present experiment we used a LDT, we created a set of 108 pseudowords by using Wuggy (Keuleers & Brysbaert, 2010).

Procedure

Lexical decision task. The LDT consisted of 216 experimental trials. Each trial began with a fixation point ("+") appearing in the middle of the screen for 500 ms. It was replaced by a string of letters. Participants had to decide whether the string was a Spanish word or not, by pressing the "yes" or the "no" button of a keypad with their preferred or nonpreferred hand, respectively. The string of letters remained on the screen until participants responded or until 2000 ms had elapsed. After responding, a feedback message was displayed for 750 ms. The interval time between trials was 500 ms. The DMDX software (Forster & Forster, 2003) was used to display the stimuli and to record responses.

Free recall. Immediately after completing the LDT, a blank screen was presented and participants were asked to use the keyboard to write as many words as they could remember from those presented during the LDT. They were given 5 minutes to complete this task.

Results and Discussion

Lexical decision task. The criterion for the rejection of participants was that their errors amounted to more than 15% of the total; no participant was rejected for this reason. In addition, RTs that exceeded 2 *SD* of each participant's mean, or which were lower than 300 ms, were excluded from the analyses (4.6% of the whole). We calculated the means of RT for correct responses and for error rates (%E) across experimental conditions (see Table 2). These means were analysed using two one-way ANOVAs, one by participants (with type of word as a within group factor) and one by items (with type of word as a between group factor). Pairwise Bonferroni comparisons were done when the main factor was significant.

(Insert Table 2 about here)

The results of the ANOVAs on RT showed an effect of the type of word that was significant in the analysis by participants and near to significance in the analysis by items, $F_1(2,82) = 17.59$, $p < .001$, $\eta_p^2 = .30$, $F_2(2,105) = 2.89$, $p = .06$, $\eta_p^2 = .05$. Thus, participants showed slower RTs to disgusting words and to fearful words than to neutral words (both *p*s < .001).

The ANOVA on %E revealed a main effect of type of word, significant in the by-participants' analysis, $F_1(2,82) = 14.76$, $p < .001$, $\eta_p^2 = .26$, $F_2(2,105) = 2.89$, $p = .06$, $\eta_p^2 = .05$. Participants committed more errors with fearful words than with either disgusting words ($p < .01$) or neutral words ($p < .001$).

Free recall task. Only those words written exactly as they appeared in the LDT were counted as correctly remembered (see Table 2). The number of correctly remembered words was analysed with a one-way ANOVA. The effect of type of word was significant, $F(2,82) = 9.99$, $p < .00$, $\eta_p^2 = .19$, showing that disgusting words were better remembered than both fearful words ($p = .01$) and neutral words ($p = .001$).

The results of the LDT showed that both disgusting and fearful words were associated with slower RTs than neutral words. Furthermore, fearful words showed a higher %E than neutral words. These results provide only partial support for findings in Briesemeister et al. (2011a), where only disgusting words were responded to significantly more slowly than neutral words. Furthermore, their participants committed more errors with disgusting and fearful words than with neutral words. It might be that the lack of a precise correspondence between the results of that study and our own is a matter of differences in the criterion for the selection of the stimuli. We included in a particular discrete emotion category (disgust or fear) only words whose ratings in that category were higher than the middle point of the scale (i.e., >2.5). Furthermore, we made sure that words scoring high in disgust had low fear ratings, and that words scoring high in fear had low disgust ratings. Finally, we checked that the mean rating in the discrete emotion to which the words belonged was not different between disgusting words (M = 3.43) and fearful words (M = 3.22). When we examined the stimuli in Breisemeister et al. (2011a) (see Appendix 2 for a detailed analysis of the stimulus list therein), we realized that the mean disgust rating for disgusting words (M = 3.04) was significantly higher than the mean fear rating for fearful words (M = 2.72), $t(48) = 2.09$, $p = .04$. Thus, fearful words had less extreme ratings than disgusting words and also less than our fearful words (M = 3.22), $t(59) = 4.47$, $p < .001$. What remains to be established is the extent to which this could have contributed to the different pattern of results for disgusting and fearful words reported in that study.

With respect to the free recall task, an interesting finding of the present experiment was that only disgusting words were better remembered than neutral words. This result is in agreement with previous reports for disgusting images (Chapman et al., 2013; Croucher et al., 2011) and words (Charash & McKay, 2002). Also, and significantly, this is the first memory study conducted with words that has controlled for several confounding factors. Specifically, we matched valence and arousal between the distinct discrete emotions tested, and we made sure that words belonging to a particular category scored high in that emotion but low in the other category under investigation. Therefore, in accordance with the discrete emotion approach, the present results suggest that memory for emotional words may not be explained exclusively in terms of valence or arousal.

In order to shed some light on the cause of the superior memory for disgusting words, we conducted some additional analyses. Specifically, we assessed whether such higher recall accuracy might be related to performance in the LDT. To that end, we created a memory index, by calculating the number of participants who had remembered each word. The correlation between recall and RT was very low and far from significance (r = - .09, p = .35), suggesting that there is no relationship between memory for the stimuli and the amount of time devoted to processing them. Accordingly, we observed that the significant correlation between disgust ratings and memory (r = .24, p = .01) was still significant when RTs were partialled out. These results are in line with those reported in a previous study (Chapman et al., 2013), which found that participants' latencies during a discrimination task could not entirely explain the advantage for disgusting pictures in a following unexpected recall task.

Considering that disgusting words are primarily related, broadly speaking, to a specific topic (that of contamination, see Rozin et al., 2008), another factor that might contribute to their superiority in memory is their semantic cohesiveness. In fact, semantic cohesiveness has been acknowledged to contribute to the advantage in memory for emotional words in general (Talmi, 2013). This would be the case mainly for free recall tasks, in which participants can cluster together semantically related words during recall, but not in recognition tasks, as the latter do not benefit from organizational strategies (Chapman et al., 2013).

In order to know whether the memory enhancement for disgusting words observed in this experiment was produced by the type of task employed, we conducted a second experiment in which we used a recognition task.

Experiment 2

Method

Participants

Fifty-six Spanish speakers (44 women, mean age = 23.09, *SD* = 12.73) from the URV participated in the experiment. They were undergraduate students who received academic credits for their participation.

Materials

The experimental stimuli were the same as in Experiment 1. For the purposes of the recognition task, they were divided into two sets, each including 18 disgust related words, 18 fear related words and 18 neutral words. The words belonging to the three experimental conditions in each set were matched in the same lexical and semantic variables as in the whole pool (all *p*s > .05). One of the sets was used in the LDT whereas the other set was presented only during the recognition phase. We created two experimental files by counterbalancing both sets. Half of the participants were randomly assigned to each file. Finally, as the LDT included only half of the words used in Experiment 1, we selected half of the nonwords to be used in this experiment.

Procedure

The procedure was very similar to that of Experiment 1. With respect to the LDT, the only difference was that in this experiment there were half the number of trials (108 trials: 54 word trials and 54 nonword trials). Concerning the memory task, participants performed a recognition task instead of a free recall task. Thus, immediately after finishing the LDT, they were presented with a list of 108 words on screen. Fifty-four words had already been presented during the LDT (i.e., old words) whereas the other 54 had not (i.e., new words); participants had to decide if each word was old or new, indicating their decision with a mouse click.

Results and Discussion

Lexical decision task. The criterion for the rejection of participants was the same as in Experiment 1. No participant was removed. The same data trimming as in Experiment 1 was used, leading to the exclusion of 4.73% of the whole data. As in Experiment 1, we did one ANOVA by participants and one ANOVA by items. Reaction times and %E are displayed in Table 3.

(Insert Table 3 about here).

The results of the ANOVAs on RT showed an effect of the type of word that was significant only in the analysis by participants, $F_1(2,110) = 15.20$, $p < .001$, $\eta_p^2 = .22$, $F_2(2,105) = 2.34$, $p = .10$, $\eta_p^2 = .04$. Participants showed slower RTs for disgusting words ($p < .001$) and for fearful words ($p = .001$) than for neutral words.

Concerning %E, there was also an effect of the type of word, significant in the by-participants analysis, $F_1(2,110) = 9.19$, $p < .001$, $\eta_p^2 = .14$, $F_2(2,105) = 1.62$, $p = .20$, $\eta_p^2 = .03$. This effect indicated that participants committed more errors with both disgusting words ($p = .03$) and fearful words ($p < .001$) than with neutral words, *Recognition task.* We recorded the number of hits (i.e. words already presented during the LDT that participants classified as old words during the recognition task) and false alarms (i.e., words not presented during the LDT that participants misclassified as old words during the recognition task, see Table 3). These variables were analysed with one-way ANOVAs, with the type of word as a within group factor.

The ANOVA revealed a significant effect of the type of word, $F(2,110) = 14.76$, $p < .001$, $\eta_p^2 = .21$, on number of hits. Bonferroni pairwise comparisons showed that the number of hits was higher for disgusting words than for either fearful words or neutral words (all *p*s < .001). With respect to the number of false alarms, a significant effect of type of word also emerged, $F(2,110) = 4.76$, $p = .01$, $\eta_p^2 = .08$, revealing that the number of false alarms was higher for disgusting words ($p = .01$) and for fearful words ($p = .02$) than for neutral words. We also calculated a corrected recognition score (hits-false alarms), finding again a significant effect of type of word, $F(2,110) = 10.18$, $p < .001$, $\eta_p^2 = .16$. This effect showed that the corrected recognition score was higher for disgusting words than for fearful words ($p < .001$) and neutral words ($p = .01$).

The results of the present experiment showed, once again, that participants took longer to respond to both disgusting and fearful words than to neutral words in the LDT. However, there was no significant difference between disgusting words and fearful words either in RT or in %E (note, however, that the direction of the effects with %E was the same as in experiment 1, since the percentage of errors was higher for fear related words than for disgusting words, although this difference was not significant). In contrast, the results of the recognition task clearly revealed differences between the two negative emotions involved in this experiment. Indeed, in agreement with the results of Experiment 1, and also prior findings with images (Chapman et al., 2013; Charash & McKay, 2002; Croucher et al., 2011), there was a memory enhancement for disgusting words. This advantage resulted in a higher corrected recognition score for disgusting words compared to neutral and fearful words.

Semantic cohesiveness has been acknowledged to contribute to the advantage in memory for emotional words in general (Talmi, 2013). This would be the case mainly for free recall tasks, in which participants can cluster together semantically related words during recall, but not in recognition tasks, as the latter do not benefit from organizational strategies (Chapman et al., 2013). On this view, it is unlikely that the superiority in memory for disgusting words in this experiment, where participants performed a recognition task, can be explained by their high semantic cohesiveness.

On the other hand, the results of Experiment 1 showed that neither can this superiority be accounted for by a higher amount of time devoted to encode disgusting words. Another possibility is that, although the time devoted to encoding was the same for disgusting and fearful words, the type of encoding might differ, being richer, more elaborate or deeper (i.e., more effective) for the former. A way to explore this possibility is to look for an encoding task in which participants are forced to deeply elaborate all the words. In these conditions, we predict that the advantage for disgusting words would disappear. This is the approach used in Experiment 3, in which participants performed an affective categorization task during encoding. According to the levels of processing framework (Craik & Lockhart, 1972), this is a deeper task than the LDT, as it necessarily requires access to meaning.

Experiment 3

Method

Participants

Thirty-six Spanish speakers (29 women, mean age = 19.67, *SD* = 1.93) from the Universitat Rovira i Virgili (Tarragona, Spain) participated in the experiment. They were all undergraduate students, and received academic credits for their participation.

Materials

The experimental stimuli consisted of the same 108 critical words as in Experiment 2. Furthermore, for the purposes of the affective categorization task, a set of 108 positive filler words was selected (Stadthagen-Gonzalez, Imbault, Pérez Sánchez, & Brysbaert, 2017). These words had valence ratings equal or above 7 on a 9-point scale, and were matched as far as possible to the critical words in terms of arousal, word length, number of syllables, log word frequency, old20, number of neighbors, HF neighbors, and bigram frequency (all *p*s > .2).

Procedure

Affective categorization task. In this task, each trial began with a fixation point (i.e., "+") in the middle of the screen. After 500 ms, the fixation point was replaced by a word. Participants had to decide if it was a positive word or not, by pressing the "yes" or the "no" button of a keypad with their preferred and nonpreferred hands, respectively. The word was displayed until the participant's response or timeout (3500 ms). The next trial appeared after an intertrial interval of 500 ms. A practice session of 12 trials preceded the beginning of the experiment.

Recognition task

Immediately after completing the affective categorization task, participants performed a recognition task. The procedure was identical to that used in Experiment 2.

Results and Discussion

Affective categorization task. We excluded from the analyses the data from five participants who made more than 20% of errors, and the data from two participants with more than 75% of errors in the condition of neutral words. Furthermore, we removed the data from four words that elicited more than 75% of errors. Finally, RTs exceeding 2 *SD* of each participant's mean, or those lower than 300 ms or higher than 3000 ms, were also excluded from the analyses (5% of the whole). We carried out one ANOVA by participants and one ANOVA by items. Reaction times and %E are displayed in Table 4.

(Insert Table 4 about here).

The results of the ANOVAs on RT showed an effect of the type of word, $F_1(2,54) = 11.11$, $p < .001$, $\eta_p^2 = .29$, $F_2(2,103) = 5.40$, $p = .006$, $\eta_p^2 = .09$. Participants showed faster RTs to disgusting words ($p = .002$) and to fearful words ($p = .004$) than to neutral words.

Concerning %E, there was also an effect of the type of word, $F_1(2,54) = 14.69$, $p < .001$, $\eta_p^2 = .35$, $F_2(2,103) = 19.84$, $p < .001$, $\eta_p^2 = .28$. This effect indicated that participants committed fewer errors with both disgusting words ($p < .001$) and fearful words ($p = .005$) than with neutral words.

Recognition task. The number of hits and false alarms is shown in Table 4. The data were analysed with one-way ANOVAs. There was no significant effect of type of word, either on hits or false alarm rates. The difference across conditions in the corrected recognition score (hits-false alarms) was also non-significant (all *p*s >.10).

The results of this experiment revealed that, when participants were asked to decide if a particular set of words was positive, disgusting and fearful words were responded to faster and more accurately than neutral words. This finding is probably due to the nature of the task: Deciding that a neutral word is not positive is harder than deciding that a disgusting or fearful word is not positive, because the latter are clearly negative and thus more distinct from positive words than neutral ones. Importantly, the pattern of results with respect to discrete emotions was very similar to that found in Experiments 1 and 2: There was no difference between disgusting and fearful words in RTs. This absence of a difference was also observed with %E.

The most interesting finding of this experiment concerns the recognition task. In contrast to the previous experiments, we failed to find a higher accuracy in memory for disgusting words. This is consistent with an account of the disgust superiority in memory in terms of a more elaborated encoding. That is to say, under limited encoding resources (Experiments 1 and 2), the disgusting content of the stimuli would spontaneously promote an elaborate processing. When the elaborative encoding is extended to all the items (by means of a deep orienting task), the advantage would disappear. In support of this claim, if we compare the corrected recognition scores of this experiment to those of Experiment 2, both fearful and neutral words have benefited significantly from deep encoding (p = .001 and p = .008, respectively). On the contrary, the corrected recognition score for disgusting words did not differ between experiments 2 and 3 (p = .24).

General Discussion

The goal of this study was to investigate the role of discrete emotions in lexical processing and memory, by focusing on disgust and fear. Concerning lexical processing, the results of the LDT did not reveal differences in RT between disgusting and fearful words in Experiments 1 and 2. However, fear related words had a higher percentage of errors than disgusting words, this difference being significant only in Experiment 1. Regarding memory, there was an advantage for disgusting words, both in free recall (number of correctly remembered words, Experiment 1) and in recognition (corrected recognition score, Experiment 2). This advantage disappeared when a deeper encoding task was used (affective categorization, Experiment 3).

The RT results in Experiments 1 and 2 suggest that the negative content of words interferes with their lexical processing when they are related to both disgust and fear. If this interference is produced by the allocation of attentional resources to words, as the Automatic Vigilance Hypothesis suggests (Öhman & Mineka, 2001), this would mean that disgusting and fearful words have a similar capacity to capture attention. Although the RT results do not give support to the discrete emotions approach, the error data do, in that fearful words showed a higher percentage of errors not only when compared to neutral words but also to disgusting words. The results with fearful words are in agreement with the claim that people do not devote many resources to process fearful stimuli, as the most adaptive reaction is to fight or escape (Carretié et al., 2011). This strategy might lead to a high number of errors during processing. In order to see whether this pattern of results is related to attention allocation, more research should be conducted in which attentional capture is directly assessed with other experimental paradigms. Some studies with this aim have begun to appear, mainly using pictures (e.g., Carretié et al., 2011). More studies are needed that pursue the same aim with words.

The results of the LDT provide only modest support for the discrete emotions approach (i.e., only in the error data). In contrast, the advantage for disgusting words (but not for fearful words) found in free recall and in recognition more clearly supports this theoretical approach[1]. In light of these results, it could be that previous failures to obtain an advantage in memory for negative words might be related to the strategy of treating them as a single category. Thus, considering the present findings, the pattern of results observed in any memory experiment might depend on the particular proportion of negative words related to each discrete emotion included in the stimulus set. For instance, two previous studies (Madan et al., 2017; Wessel & Merckelbach, 2006) failed to find an advantage for negative words in memory. When looking for the ratings in discrete emotions of their experimental stimuli in normative databases (Stevenson, Mikels, & James, 2007), we observed that, in one of the studies, only 45% of the negative words had high disgust ratings (>2.5), whereas 50% had high fear ratings (Madan et al., 2017). Similarly, in the other study (Wessel & Merckelbach, 2006), the percentage of words having high disgust ratings was lower (50%) than the percentage of words with high fear (88%) or anger ratings (76%, see Appendix 2 for a detailed analysis of the stimulus lists used in these studies).

Apart from the methodological consequences of the superiority in memory for disgusting words, it is also interesting to explore the causes of such superiority. It could be argued that the advantage in memory for disgusting words found in Experiment 1 is a by-product of their high semantic cohesiveness, because participants could have used this as an organizational strategy during free recall (i.e., retrieving together disgust related words). However, this advantage was also observed in the recognition task (Experiment 2), where such a strategy could not be used, given that participants were presented with words and had to decide whether or not they had been presented previously. Hence, the results of Experiment 2, which cannot be attributed to semantic cohesiveness, and which are in line with studies that compared disgusting and fearful images in recognition tasks (Chapman et al, 2013; Croucher et al., 2011), suggest that disgusting stimuli might have a privileged status in memory. Such an advantage might be related to the way in which disgusting stimuli are approached.

As noted in the introduction, the most adaptive strategy when faced with a disgusting stimulus may be its in-depth exploration, as a means of deciding whether or not it is dangerous (Carretié et al., 2011). According to the levels of processing framework (Craik & Lockhart, 1972), the richness and degree of elaboration of a stimulus during encoding determines its recall. If we assume that an in-depth exploration of disgusting stimuli (among them words) allows for richer and more elaborate processing, such a mechanism might explain the superiority in memory for disgusting words. Thus, our results suggest that participants would spontaneously elaborate disgusting words more during encoding than the other words, as a consequence of their in-depth exploration. This is supported by the fact that this memory advantage disappeared when a deep orienting task (i.e., affective categorization) was used during encoding. Indeed, both neutral and fearful words, but not disgusting words, benefited from such a deep orienting task, probably because disgusting words were already being deeply encoded when the orienting task was a LDT. Although there are no previous memory studies that have manipulated the type of encoding task with stimuli related to distinct discrete emotions, our findings agree with past research with negative words in general. These studies have demonstrated that there is an advantage in memory for negative words under shallow encoding conditions, and that this advantage disappears under deep encoding conditions (Jay, Caldwell-Harris, & King, 2008; Ritchey, LaBar, & Cabeza, 2010). Therefore, the superiority in memory of emotional stimuli might be explained at least in part by a spontaneous cognitive enrichment of the details of the emotional stimuli during encoding (e.g., deeper or more elaborated processing, Christianson, 1992). What our results suggest is that such a mechanism is observed mainly with disgusting stimuli.

In summary, our results suggest that there is a disadvantage in lexical processing for negative words, and that it is more marked for fearful words. Disgusting words, in turn, show a superiority in memory. The cause may be that these words are spontaneously processed more deeply and elaborately than other words. These findings, together with others that are beginning to arise in this field, have both methodological and theoretical consequences. In terms of methodology, these findings underline the relevance of the stimulus list composition in experiments involving negative words. Concerning theory, we have to conclude, like others (Briesemeister et al., 2011a; Carretié et al., 2011), that in order to account for the emotional effects on cognition, both the dimensional approach and the discrete emotions perspective are required.

ACKNOWLEDGMENTS:

This work was supported by grants PSI2015-63525-P and PSI2015-68368-P (MINECO/FEDER), Ref 2016PFR-URV-B2-37 from the Universitat Rovira i Virgili and Ref. H2015/HUM-3327 from the Comunidad de Madrid. The second author has a grant from the Universitat Rovira i Virgili (2015PMF-PIPF-16). We would like to thank Drs. Briesemeister, Kuchinke and Jacobs for kindly providing us with their stimulus list.

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FOOTNOTE

[1] It might be argued that the differences in memory between disgusting words and fearful words can be explained by dimensions other than valence and arousal. If this is the case, the present results would not constitute evidence in favour of the discrete emotions approach. In particular, an anonymous reviewer pointed out the relevance of the dominance/potency/control dimension. In order to explore whether this dimension has contributed to our results, we collected the control values of our stimuli (we obtained the ratings for 45 words from Redondo et al., 2007, and for the remaining 63 words we conducted a questionnaire of dominance/control that was filled in by 36 participants). Then, we did an ANOVA with these ratings by including "type of word" (disgusting, fearful, neutral) as a factor. The results revealed a significant effect of type of word, $F(2, 105) = 42.29$, $p < .001$. Pairwise comparisons showed that there were differences between the three sets of words in perceived control/potency ($M = 4.49$, 3.85 and 5.38 for disgusting, fearful and neutral words, respectively).

In order to know the extent to which this difference in control may have affected our results, we looked for studies that tested the effects of this variable on lexical processing and memory. Concerning the LDT, we were able to find only a few studies evaluating the effects of dominance/control (apart from valence and activation) in this task (Wurm & Vacoch, 1996; Wurm, Vakoch, & Seaman, 2004). The results here are mixed, in that high potency scores were associated to either faster (Wurm & Vacoch, 1996) or slower (Wurm et al., 2004) RTs, depending on the study.

It should be noted, however, that the definition of "potency" in these studies does not correspond to that commonly used in the field (i.e., the definition used by Bradley & Lang, 1999). Thus, in the studies of Warm et al., the dimension of potency refers to "how strong or weak" a thing is, whereas Bradley and Lang defined potency as the capacity (power, control) that people feel when faced with that thing. For this reason, it is difficult to compare these results with ours. Regarding memory, we were able to find only a single study investigating the effects of potency/dominance (Mneimne, Wellington, Walton, & Powers, 2015). The authors there investigated the hemispheric lateralization of memory for the affective dimensions of valence and dominance. Thus, they compared memory for positive words (with high dominance) and two types of negative words (negative words having high or low dominance) that were presented to each hemisphere. When words were presented to the left hemisphere, there was no effect of dominance. In contrast, when they were presented to the right hemisphere, low dominance words were remembered better than high dominance words. Again, this study cannot be directly compared to our work due to methodological differences. However, considering the results, if low dominance is associated with better recall, fearful words should have been those remembered better in our study, which was clearly not the case.

For the above mentioned reasons, it is unlikely that our results can be explained by the dimension of control/potency. They seem to be better accounted for by a discrete emotions approach.

APPENDIX 1. Experimental words in Experiments 1, 2 and 3

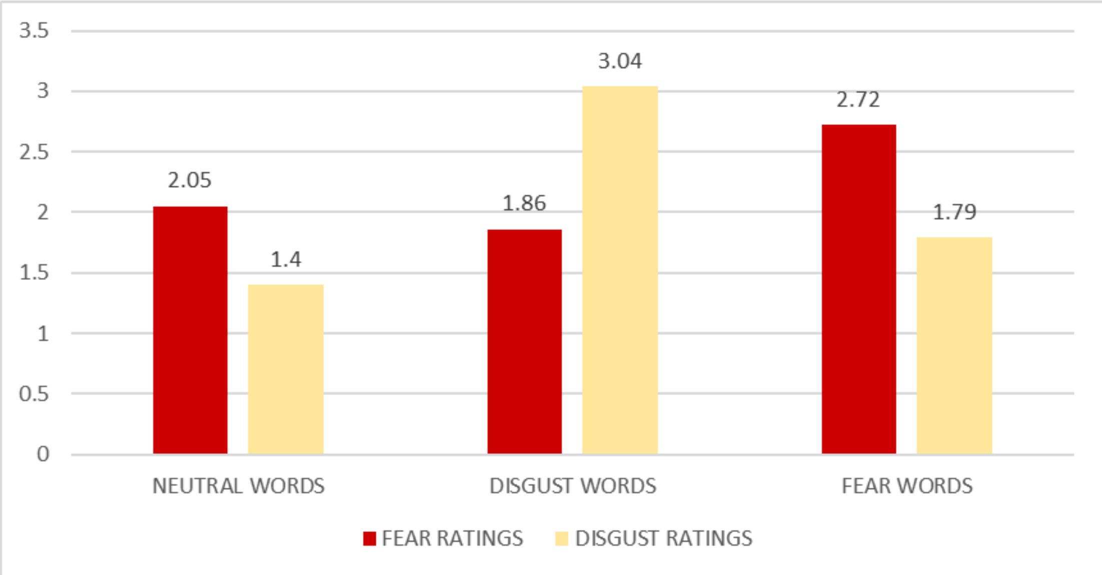
Disgust related words		Fear related words		Neutral words	
Target	**English trans.**	**Target**	**English trans.**	**Target**	**English trans.**
acidez	heartburn	abejorro	bumblebee	Arroyo	stream
acné	acne	aislamiento	isolation	artículo	article
avaricia	avarice	artefacto	explosive device	átomo	atom
basura	rubbish	bancarrota	bankruptcy	autobús	bus
borracho	drunk	barranco	precipice	avestruz	ostrich
celulitis	cellulitis	bisonte	bison	azulejo	tile
ciempiés	centipede	boxeador	boxer	bodega	cellar
desorden	disorder	bulto	lump	bolsillo	pocket
desperdicio	waste/scraps	callejón	alley	buzón	mailbox
egoísmo	selfishness	cárcel	jail	camisón	nightgown
eructo	belch	carcelero	jailer	casco	helmet
escarabajo	beetle	ciclón	cyclone	Celo	zeal/sticky tape
escoria	scum	cuchillo	knife	chaleco	vest
flemón	phlegmon	delincuente	criminal	contable	accountant
grano	spot	dentista	dentist	contenido	content
grasa	grease	desmayo	faint	corbata	tie
gusano	worm	diabetes	diabetes	cordero	lamb
hedor	stench	extinción	extinction	empresario	businessman
lombriz	worm	halcón	hawk	guardián	guardian
menstruación	menstruation	hiena	hyena	jarra	jar
mucosidad	mucus	hospital	hospital	maquinilla	safety razor
mugre	grime	infierno	hell	marqués	marquis
órgano	organ	infinito	infinite	martillo	hammer
orina	urine	intruso	intruder	monasterio	monastery
petróleo	petroleum	inundación	flood	monje	monk
piojos	lice	jaqueca	migraine	patrón	chief/pattern
porquería	refuse	médico	doctor	polo	pole/polo (sport)
pulga	flea	pozo	well	rareza	rarity
repugnancia	disgust	preso	prisoner	reflexión	reflection
repulsión	repulsion	relámpago	lightning flash	reloj	clock
resaca	hangover	rifle	rifle	secretaria	secretary

retrete	toilet	riña	fight	sustento	sustenance
saltamontes	grasshopper	rotura	break	Taza	mug
suciedad	dirt	soga	rope	tijeras	scissors
sudor	sweat	trauma	trauma	utensilio	utensil
vómito	vomit	venda	bandage	vidrio	glass

APPENDIX 2. Detailed analysis of the stimulus sets of related works

Briesemeister et al. (2011a).

We explored the convergence between the experimental words of Briesemeister et al. (2011a) and our own, since we obtained a distinct pattern of findings in the LDT despite having performed a similar manipulation. Although these authors did not include an appendix with their materials, they kindly provided us with their list of experimental words. We obtained discrete emotion ratings for those words form Briesemeister et al. (2011b). The mean fear and disgust ratings for disgusting, fearful and neutral words are shown below.



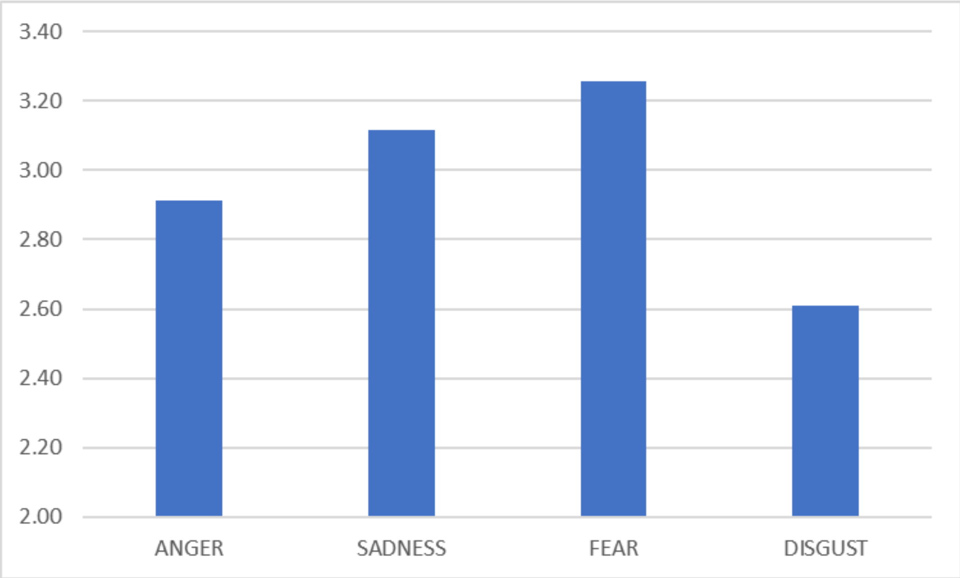
We found that the mean disgust rating for disgusting words ($M = 3.04$) was significantly higher than the mean fear rating for fearful words ($M = 2.72$), $t(48) = 2.09$, $p = .04$). Thus, fearful words in the study of Briesemeister et al. were less representative of the discrete emotion to which they belonged than disgusting words. Furthermore, they were less representative than our fearful words ($M = 3.22$), $t(59) = 4.47$, $p < .001$. This may have contributed to the differences across the studies. Namely, it might be that Briesemeister et al. only found a significant difference in RTs between disgusting and neutral words because fearful words had a less extreme rating than disgusting words. Concerning the criterion to select the words related to a particular emotion, we chose words with a rating higher than 2.5 in that emotion. Furthermore, disgusting words were chosen such that they were rated low in fear (i.e., they had fear ratings lower than 2.5) whereas fearful words were rated low in disgust (i.e., they had disgust ratings lower than

2.5, see Table 2). Finally, neutral words had ratings lower than 2.5 in the five discrete emotions. In contrast, the criterion of Briesemeister et al. in selecting their stimuli was that their rating in a particular emotion was higher than in the other discrete emotions. When looking at their stimuli, we realized that 9 fearful words (from 26) and 10 disgusting words (from 26) did not reach a rating of 2.5 in their reference emotion, while 6 neutral words (from 26) had fear ratings above 2.5.

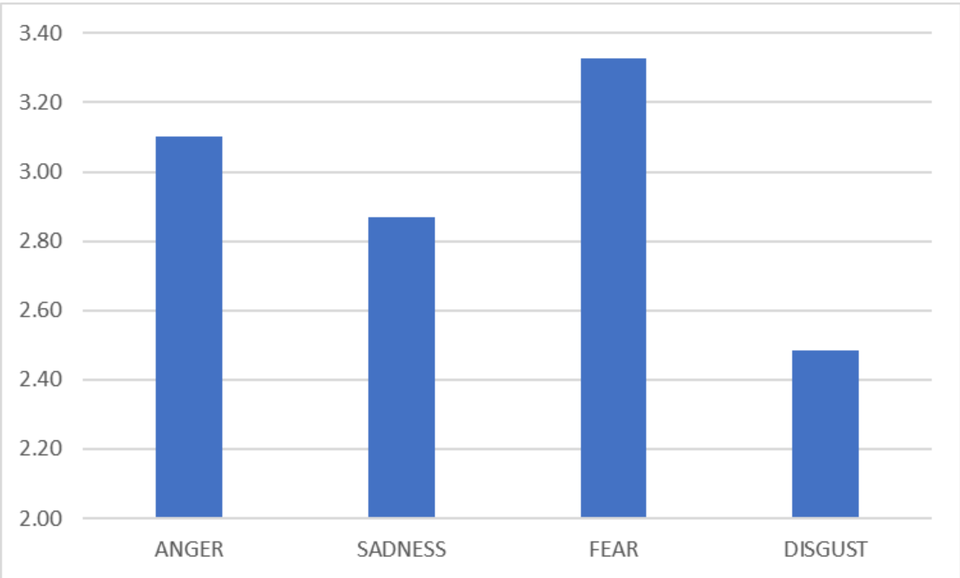
Finally, we also looked at the overlap between the words of Briesemeister et al. and our own. The overlap was very low. Concerning disgust, only 2 of our 36 disgusting words were included in the study of Briesemeister et al. There were another 6 words that, although not being translation equivalents of any disgusting word of Briesemeister et al., had a similar meaning to 6 words of that study. Regarding fearful words, there was no direct correspondence between the two datasets. In fact, there were only 3 of our fearful words which had a word similar in meaning in the study of Briesemeister et al.

Lexical Decision studies with emotional words from a dimensional perspective

We analyzed several relevant studies on lexical processing that included an appendix with the experimental materials. Our aim was to look at whether the percentage of words belonging to each discrete emotion included in the experimental set can influence the pattern of results obtained. If it were the case, this factor might have contributed to the mixed findings with negative words in this field. With this aim, we looked for the ratings in discrete emotions (Stevenson, Mikels, & James, 2007) of the stimuli in Kousta et al. (2009), who found an advantage for negative words in a LDT in comparison to neutral words. We were able to find ratings in discrete emotions for only 65% of the negative words. The ratings of these words in the five discrete emotions are shown below.



Similarly, we looked for the ratings on discrete emotions of the experimental words of Scott, O'Donnell, Leuthold, and Sereno (2009). In this case, we were able to find ratings for 97% of the negative words. In that study, negative words were responded to faster in the LDT than neutral words. The ratings in the five discrete emotions are shown below.



As can be seem from the above, we cannot draw firm conclusions concerning the role of discrete emotions in the experimental findings with negative words. There is, however, a coincidence in the two studies. Namely, in both cases, disgust ratings were the lowest. This might explain, at least partially, why the disadvantage for negative words was not found in these studies (as both Briesemeister et al. and ourselves have demonstrated the relationship of high disgust ratings with such a disadvantage). On the other hand, words in both studies, apart from having high values in fear, had also high values (above 2.5) in the other discrete emotions: anger and sadness. We do not at this stage know how this fact could have influenced results.

As for coincidences across different studies, when we examined the stimuli of Kousta et al. we realized that only 4 of their 38 negative words were also used in our experiment (and all of them belonged to the condition of fearful words). Concerning the study of Scott et al., the coincidence was also very low. Only 5 of their 80 negative words were included in our study, again corresponding to fearful words.

Memory studies

Similarly to our analysis of LDT studies, we examined the stimuli used in some memory studies. For our purposes, the most notable study is that of Charash and McKay (2002). Here, 15 disgusting and 15 fearful words were compared, and an advantage for the former with respect to the latter was found. We were able to find values in discrete emotions (Stevenson et al., 2007) only for 5 disgusting words and 6 fearful words. When looking at these ratings, we realized that 1 of the 5 disgusting words had a score higher than 2.5 in fear, and that 3 of the 6 fearful words had high ratings on disgust. Of note, the number of stimuli with available ratings are too low to draw any conclusion. We also looked for coincidences, finding that only 4 of the 15 disgusting words and only 1 of the fearful words were included in our study.

We also considered the negative stimuli in other memory studies (from a dimensional perspective) that have failed to find an advantage for negative words (Madan et al., 2017; Wessel & Merckelbach, 2006). When looking for the ratings in discrete emotions of their experimental stimuli (Stevenson et al., 2007), we realized that only 45% of the negative words in the study of Madan et al. had high disgust ratings (>2.5), whereas 50% had high fear ratings. Similarly, the percentage of words having high disgust ratings in the study of Wessel and Merckelbach was lower (50%) than the percentage of words with high fear ratings (88%) or anger ratings (76%). As for the coincidences, they were again very low. Nine of the 40 experimental words of Madan et al. were included in our study (5 disgusting words and 4 fearful words). With respect to the study of Wessel and Merckelbach, only 4 of their 30 experimental stimuli were repeated in our stimulus set (2 disgusting words and 2 fearful words). Thus, although the data are insufficient for firm conclusions to be made, it seems that in both studies the number of disgusting words was low, and this might have contributed to the absence of an advantage in memory for negative words.

The above discussion makes it clear that it is difficult to draw conclusions from previous studies in the field. On the one hand, many studies do not include an appendix with their experimental stimuli. Focusing on those that do include such information, when looking at the normative databases, there are ratings in discrete emotions for a low percentage of words. Finally, as these studies were not designed to investigate the role of discrete emotions, in many cases the words have high values in more than one discrete emotion. It would be very interesting to carry out studies in lexical processing and memory that directly compare experimental lists including words related to distinct discrete emotions with lists including words related to a single discrete emotion. Ideally, these words would be uniquely related to a particular emotion. This might contribute to a better understanding of the discrepancies found in previous studies.