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RUNNING TITLE: Emotions in reading

Emotions in reading: disgust, empathy and the contextual learning hypothesis

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Abstract

Emotion effects in reading have typically been investigated by manipulating words' emotional valence and arousal in lexical decision. The standard finding is that valence and arousal can have both facilitatory and inhibitory effects, which is hard to reconcile with current theories of emotion processing in reading. Here, we contrasted these theories with the contextual-learning hypothesis, according to which, sensitivity to a *specific* emotion – disgust in the present study- rather than valence or arousal affects lexical decision performance. Participants were divided into two groups (high versus low disgust sensitivity). Results showed that participants with high disgust sensitivity showed an inhibitory effect, whereas participants with low-disgust sensitivity showed a facilitatory effect. Individual differences in lexical decision performance were predicted by disgust sensitivity but not valence, arousal, or general emotion sensitivity. These findings highlight the need to focus on individual differences both in studies and theories of emotion processing in reading.

Keywords: disgust, empathy, arousal, valence, lexical decision, contextual-learning

1. Introduction

Words are more than purely linguistic symbols. When reading a novel, a comic strip, or a newspaper, words evoke emotions. Yet, compared to the fast-growing literature on basic processes in reading (e.g., Grainger, Dufau, Montant, Ziegler, & Fagot, 2012), studies of emotion effects in reading are still sparse (for review see Briesemeister, Kuchinke, & Jacobs, 2011b). Most of the research on emotions in reading has focused on manipulating words' emotional valence and arousal. Emotional valence specifies whether a stimulus is pleasant or unpleasant, whereas emotional arousal describes the emotional intensity that a stimulus can elicit. It has been found that lexical decision performance (i.e., deciding whether a letter string is a word or not) is facilitated (i.e., faster and more accurate) when words are of positive valence (e.g., Bayer, Sommer, & Schacht, 2011; Hofmann, Kuchinke, Tamm, Vö, & Jacobs, 2009; Kissler & Koessler 2011; Kuchinke, Jacobs, Grubich, et al., 2005, Kuchinke, Vö, Hofmann, & Jacobs, 2007; Kanske & Kotz, 2007; Schacht & Sommer, 2009). In some studies, this processing advantage is also found for negatively valenced stimuli, but only if words are of high emotional arousal (Hofmann et al., 2009; Kanske & Kotz, 2007; Larsen, Mercer, Balota, & Strube, 2008). Conversely, when words with negative valence have low levels of arousal, lexical decision performance is inhibited compared with neutral words (Hofmann et al., 2009; Larsen et al., 2008).

The most common theoretical approaches on emotion processing in reading are *dimensional* - they are based on the idea that emotions can be described in terms of continuous variations of a word's valence and arousal. According to the *two-dimensional model of emotion processing* (e.g., Bradley & Lang, 1999, 2000), perceiving highly

valenced stimuli will elicit faster approach or withdrawal responses (Lang, 1995; Lang, Bradley, & Cuthbert, 1990). In both cases, an overall facilitatory effect is predicted, which might be modulated by a word's degree of arousal. In contrast, the *automatic vigilance hypothesis* (Estes & Adelman, 2008) predicts an overall inhibitory effect of negative emotions on word reading (e.g., Algom, Chajut, & Lev, 2004; Pratto & John, 1991; Wentura, Rothermund, & Bak, 2000) because of the privileged role of the aversive system, which is attention-demanding, thus taking away processing resources from the primary reading task.

Given that both facilitatory and inhibitory effects have been reported for negatively valenced stimuli in a lexical decision task, it is fair to say that none of these approaches seems to be able to fully account for the existing data. A similar point has recently been made by Briesemeister et al. (2011b) who reported *discrete* effects of emotions that cannot be reduced to variations in valence or arousal. They investigated the effects of five primary emotions on word processing (disgust, fear, anger, happiness, and sadness). It was found that the discrete status of emotions explained more variance in lexical decision performance than the words' underlying emotional valence or arousal. Importantly, in one of the experiments, words were perfectly matched for valence and arousal, and yet lexical decision latencies were different for different kinds of emotions (e.g., disgust produced stronger inhibitory responses than fear).

As previously argued by Briesemeister et al., (2011a), evidence for discrete emotion effects that cannot be reduced to variations in valence or arousal is hard to reconcile with current theories. In fact, one elegant way to account for the existence of discrete emotion effects is in terms of the *contextual-learning hypothesis* (Barrett, Lindquist, & Gendron, 2007), which claims that the nature of emotion effects depends on

a person's experience with that emotion within a real-life context, which might go back to a person's childhood. Such an explanation resonates with Panksepp's (2011) proposal that emotion-based brain systems are "evolutionarily engraved, but experientially refined" (p. 550), implying a dynamic interaction in which learning and experience throughout the individual's history plays an important role.

Therefore, in line with the contextual learning hypothesis, a promising way to shed new light on the debate is to focus on subjects (e.g., Armstrong, Divack, David, Simmons, Benning, et al., 2009) rather than items (typically, their valence or arousal). Indeed, the contextual learning hypothesis makes the strong, yet untested, prediction that the nature of emotion effects in reading should depend on a subject's sensitivity to the emotion that is being manipulated, beyond levels of valence or arousal.

To test this prediction, we conducted a lexical decision experiment with words that were either disgusting or not. Disgust was chosen as the primary negative emotion of interest because it is culturally acquired and can be assessed individually using a validated questionnaire, the *Disgust Scale (DS)* (Haidt, McCauley, & Rozin, 1994; French version: Gil, Rousset, & Droit-Volet, 2009). In the present study, we focused on *core disgust* that is related to its phylogenetically ancient function of signaling threat of contamination rather than so-called *evolved* types of disgust that are related to social and moral matters (e.g., Haidt, Rozin, McCauley, & Imada, 1997; Rozin, Haidt, & McCauley, 2008).

The key prediction was straightforward. It was hypothesized that the facilitatory versus inhibitory nature of the disgust effect in the lexical decision task should depend on a person's sensitivity to disgust as measured by the DS. That is, we expected that a person with high disgust sensitivity should show stronger inhibitory effects of disgust in

a lexical decision task (longer latencies and more errors to disgust than to neutral words) than a person with low disgust sensitivity. On the basis of Briesemeister et al.'s findings, we further predicted that sensitivity to disgust should explain more interindividual variance in the lexical decision task than the perceived levels of valence or arousal of our stimuli.

To exclude the possibility that specific emotion effects related to disgust could be simply explained by a person's general emotion sensitivity, we also obtained a person's *Empathy Quotient* (*EQ*, Baron-Cohen & Wheelwright, 2004; French version: Berthoz, Wessa, Kedia, Wicker, & Grèzes, 2008). Although the *EQ* measures empathy rather than general emotion sensitivity, it should be noted that empathy is a critical ability at the heart of the social brain, allowing individuals to swiftly recognize emotions and adaptively respond to social signals in everyday life interaction (e.g., de Vignemont & Singer, 2006; Dunbar, 1998; Singer, 2006). Thus, in the absence of a better measure for general responsiveness to emotional states, the *EQ* seems a reasonable index for general emotion sensitivity.

2. Material & Methods

2.1. Participants

Sixty-three native French university students (39 women), aged 17–31 years ($M = 21.5$; $SD = 3.47$), took part in the experiment. They were neurologically healthy and had no language or speech impairments according to self-report. All participants gave informed written consent and received 10 Euros for their participation.

2.2. Questionnaires

Participants' sensitivity to disgust was assessed using the *DS* (Haidt et al., 1994; French version: Gil et al., 2009). The *DS* is a 32-item self-report questionnaire in which participants are asked to evaluate how disgusting particular experiences would be, considering several domains of disgust sensitivity, including: (a) *food* (food that has spoiled, or that is culturally unacceptable); (b) *animals* (animals that are slimy or live in dirty conditions); (c) *body products* (e.g., body odours); (d) *body envelope violations* (body envelope violations or mutilations); (e) *death* (e.g., dead bodies); (f) *sex* (involving culturally deviant sexual behaviour); (g) *hygiene* (violations of culturally expected hygiene practices); and (h) *sympathetic magic* (stimuli without infectious qualities but that were once in contact with contaminants, e.g., a sweater worn by an ill person). Sixteen items are evaluated as being true (T) or false (F), while the remaining items are rated on a 3-point scale ranging from *not disgusting at all* (0) to *very disgusting* (2).

General emotion sensitivity was measured using the *EQ* (*EQ*, Baron-Cohen & Wheelwright, 2004; French version: Berthoz et al., 2008). The *EQ* is a 60-item self-report questionnaire, with 40 questions tapping empathy (e.g., *I really enjoy caring for other people; I find it hard to know what to do in a social situation*), and 20 filler items (e.g., *I try to keep up with the current trends and fashions; I dream most nights*). Participants are asked to indicate on a 4-point Likert scale whether they 'strongly agree', 'slightly agree', 'slightly disagree' or 'strongly disagree' with a statement.

An analysis of the rating results of the 63 subjects who participated in our study showed an average sensitivity to disgust ($M = 16.17$; $SD = 3.92$) with no differences between males and females ($M_{\text{male}} = 15.3$; $M_{\text{female}} = 16.6$; $F(1, 61) = 1.7$, $p = .19$). Results from the empathy questionnaire also showed that participants, on average, had a normal ability for understanding emotional states ($M = 41.97$; $SD = 9.27$) with significant

differences between males and females ($M_{male} = 36.2$; $M_{female} = 45.5$; $F(1, 61) = 19.403$, $p = .00004$), which replicates previous normative studies (e.g., Baron-Cohen & Wheelwright, 2004). Overall, the mean scores on both scales are highly similar to those obtained in previous studies using the *DS* (Haidt et al., 1994; Gil et al., 2009), as well as the *EQ* (Baron-Cohen & Wheelwright, 2004; Berthoz et al., 2008) in typical populations.

2.3. Materials

A set of 213 words from the on-line database LEXIQUE3.55 (New, Pallier, Ferrand, & Matos, 2001; <http://www.lexique.org/>), including 93 neutral (e.g., *géant*, *statue*, *pirate*), and 120 disgust words (e.g., *excrement*, *morve*, *vomit*) was selected and pre-tested. Eighteen subjects rated all the stimuli for emotional valence (from -3, *very negative*, to +3, *very positive*), arousal (from 1, *unstimulating*, to 5, *very stimulating*), and imageability (from 1, *very imageable*, to 7, *very unimageable*). The final selection included 50 neutral, and 50 disgust words. As can be seen in Appendix A, the two groups of items differed in emotional valence but were matched on arousal and imageability. In addition, words were carefully matched on a variety of psycholinguistic variables that affect lexical decisions (Balota, Cortese, Sergent-Marshall, Spieler, & Yap, 2004). One hundred pseudowords served as items for the “no”-trials; they were matched to words in terms of letter, mean bigram, and mean trigram frequencies.

2.4. Procedure

Participants were tested individually in a quiet room. Prior to the experiment, the *DS* and the *EQ* questionnaires were completed. Subjects who scored below the median score ($M = 16.17$; $SD = 3.92$) of the published *DS* norms (Gil et al., 2009) were assigned

to the low-sensitivity group (N=28); subjects who scored above were assigned to the high-sensitivity group (N= 35). The two groups did not differ in gender or age (both $ps > .1$).

In the lexical decision experiment, each trial began with a centred fixation cross (500 ms). Stimuli were presented in the centre of the screen in white lowercase (Arial font, size 18) on black background, they remained on the screen until a response was given. Participants were instructed to indicate as quickly and accurately as possible whether the item was a word or not. Responses were made using a key pad. The inter-trial interval was 1000 msec. Following twelve practice items (3 neutral, 3 disgust words, and 6 pseudowords), the 200 stimuli (50 neutral, 50 disgust words and 100 pseudowords) were presented randomly. After the experiment, participants were asked to rate all the stimuli for emotional valence (from -3, *very negative*, to +3, *very positive*) and arousal (from 1, *unstimulating*, to 5, *very stimulating*).

3. Results

Table A1 presents mean reaction times (RTs) for correct responses and error rates (ERs) for both groups in each condition. The data of 5 items (3 disgust and 2 neutral words) were removed because of high error rates (>30%), which makes the use of RTs unreliable. RT outliers were removed using a 3 standard deviation cut-off (1.96% and 1.36% excluded trials in the disgust and neutral conditions, respectively).

Table A1. Means and standard deviation of response times (in msec) and error rates (in %) per condition, for both groups.

	<i>High-sensitivity Group</i>		<i>Low-sensitivity Group</i>	
	N = 35		N = 28	
	<i>Mean</i>	<i>SE</i>	<i>Mean</i>	<i>SE</i>
<i>Response Times (in ms)</i>				
Neutral Words	639.5	18.8	637.9	14.5
Disgust Words	653.2	19.2	630.2	15.8
Pseudowords	779.5	24.5	732.4	27.3
<i>Error Rates (in %)</i>				
Neutral Words	2.8	0.6	4.2	0.7
Disgust Words	4.6	0.6	3.3	0.6
Pseudowords	5.1	0.8	4.4	0.9

An analysis of variance (ANOVA) was performed using Group (high vs. low sensitivity) as between-participant factor and Emotional Valence (disgust vs. neutral words) as a within-participant factor for both ERs and RTs, separately. Results showed a significant two-way interaction between the effects of Group and Emotional Valence [ERs: $F(1, 61) = 12.050, p < .001, \text{partial } \eta^2 = .165$; RTs: $F(1, 61) = 10.469, p < .002, \text{partial } \eta^2 = .146$]. As can be seen in Figure A1, the high sensitivity group showed an inhibitory effect of emotional valence ($t(1, 34) = 2.93, p < .003$), whereas the low-sensitivity group showed a small facilitatory effect ($t(1, 27) = -1.69, p < .05$). The critical interaction remained highly significant even when gender was added as covariate both for ERs [$F(2, 59) = 5.768, p < .01, \text{partial } \eta^2 = .164$] and RTs [$F(2, 59) = 5.602, p < .01, \text{partial } \eta^2 = .160$].

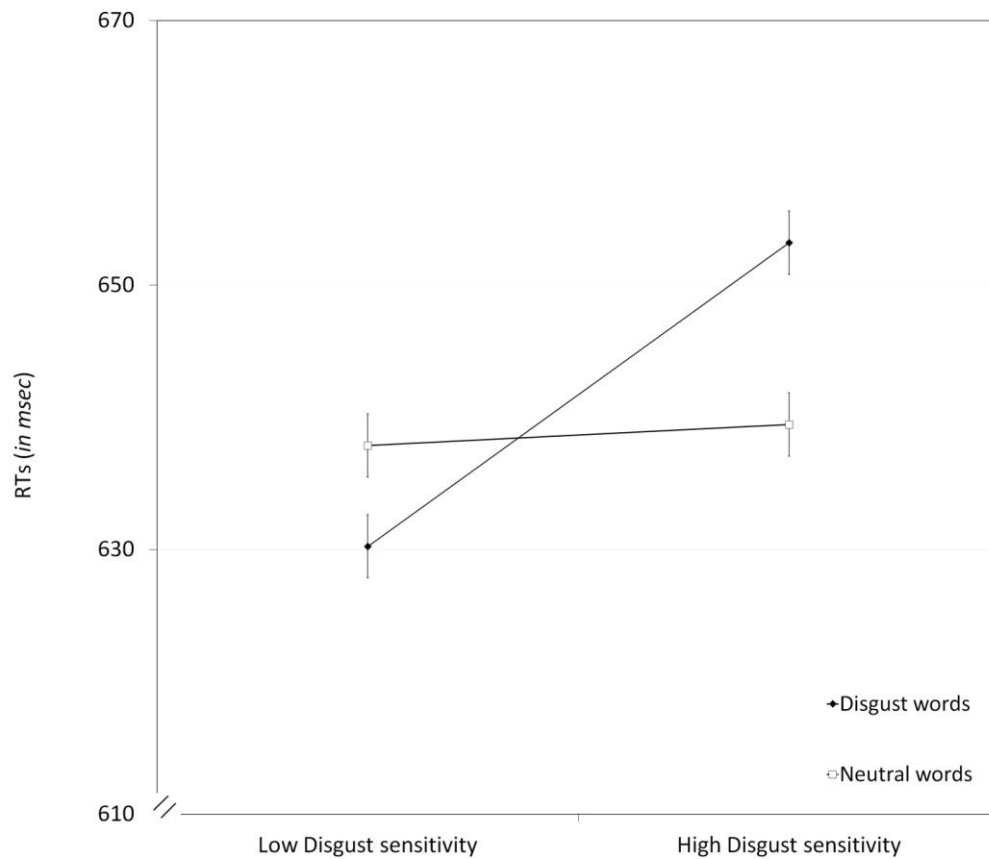


Figure A1. Two-way interaction between Group (Low vs. High Disgust sensitivity) and Emotional valence (disgust vs. neutral words). Error bars are within-subject standard errors.

To further explore inter-individual differences, we looked at the correlations between participants' disgust effect and the various ratings. The individual net disgust effect was calculated by subtracting RTs and ERs for disgust words from those of neutral words. Correlations were performed on z-transformed data (see Faust, Balota, Spieler, & Ferraro, 1999). Z-scores were sign-changed such that negative difference z-scores signal an inhibitory effect of disgust (longer RTs and more errors to disgust than to neutral words), whereas a positive difference z-score indicate a facilitatory effect. The Pearson correlation coefficients between the net disgust effect (difference z-scores) and the different ratings (disgust score, empathy quotient, valence index, arousal index, valence

ratings of disgust words and arousal ratings of disgust words) are shown in Table B1. The valence and arousal indices were simply calculated by computing the difference in the valence or arousal ratings of each participant for disgust words as opposed to neutral words¹. The valence index was sign-changed such that higher values indicate greater sensitivity to valence.

Table B1. *Correlation Matrix*

	1	2	3	4	5	6	7	8
1 Disgust Effect (RTs)	-							
2 Disgust Effect (ERs)	.27*	-						
3 <i>DS</i> Scores	-.47**	-.35*	-					
4 <i>EQ</i> Scores	-0.01	-0.02	0.1	-				
5 Valence Index	-0.05	-0.19	0.16	0.11	-			
6 Arousal Index	-0.08	0.06	-0.01	0.01	-0.23	-		
7 Valence Disgust Words	-.25 *	-0.21	.27*	0.11	.81**	0.04	-	
8 Arousal Disgust Words	0.02	0.01	0.001	0.05	0.06	.71**	0.2	-

* $p < .05$, ** $p < .001$; *DS*, disgust sensitivity; *EQ*, empathy quotient.

¹ Note there were no significant gender differences in valence ratings for either disgust ($M_{female} = -1.6$; $SD = 0.54$, $M_{male} = -1.5$; $SD = 0.54$) or neutral stimuli ($M_{female} = 0.2$; $SD = 0.40$, $M_{male} = 0.2$; $SD = 0.39$; $F(1, 61) = .175$, $p = .7$). Similarly, no significant gender differences were found in the arousal ratings of either disgust ($M_{female} = 0.8$; $SD = 0.74$, $M_{male} = 0.8$; $SD = 0.85$) or neutral words ($M_{female} = 1.3$; $SD = 0.66$, $M_{male} = 1.2$; $SD = 0.8$; $F(1, 61) = .109$, $p = .70$).

As can be seen in Table B1, DS scores correlated significantly with the net disgust effect obtained in lexical decision both for RTs ($r = -.47, p < .0001$) and ERs ($r = -.35, p < .01$). The correlation was negative reflecting the fact that the higher a person's sensitivity to disgust the stronger the inhibitory effect (i.e., longer latencies and more errors). This correlation is plotted in Figure B1. Importantly, neither empathy nor valence or arousal indices showed significant correlations with lexical decision performance. Apart from DS scores, only valence ratings of disgust words showed a significant correlation with the net disgust effect ($r = -.25, p < .05$), which is likely to be due to the correlation between DS and the valence ratings of disgust words. Indeed, when DS, EQ, and valence ratings for disgust words were entered into a multiple regression analyses, only DS scores were significant predictors of the net disgust effect in lexical decision performance ($\beta = -.471, t = -3.66, p < .001$).

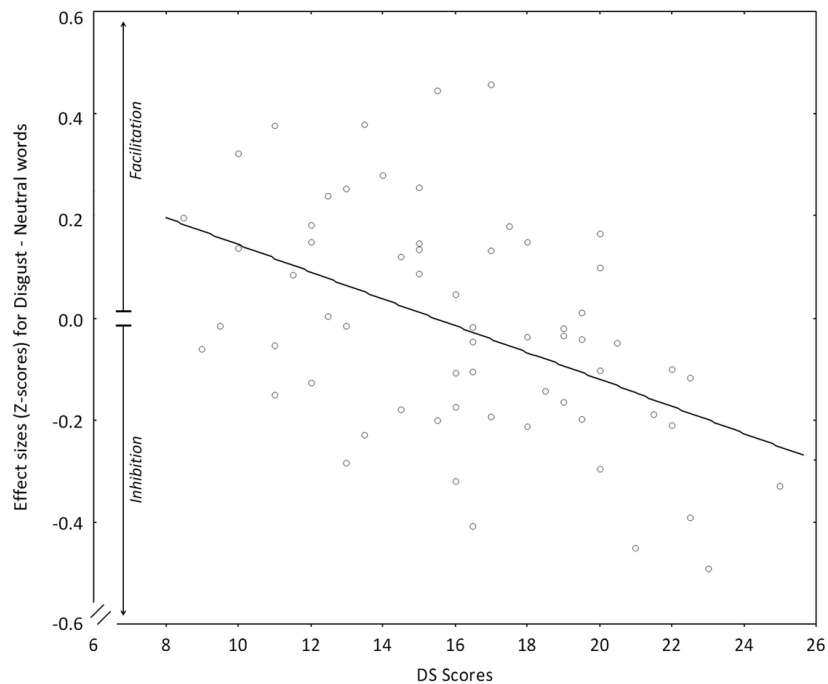


Figure B1. Correlation between the net disgust effect (difference z-scores) for each participant and his or her sensitivity to disgust as measured by the Disgust Scale (DS, Haidt et al., 1994).

To further test the influence of disgust sensitivity on lexical decision performance, we conducted an analysis of covariance (ANCOVA) using the *DS* scores as a covariate. Results showed that when sensitivity to disgust was taken into account by using it as a covariate, the inhibitory main effect of emotional valence (disgust versus neutral) was highly significant both on ERs [$F(1, 61) = 8.263, p < .01, \text{partial } \eta^2 = .119$] and RTs [$F(1, 61) = 16.438, p < .0001, \text{partial } \eta^2 = .212$].

4. Discussion

The results are straightforward. As predicted by the contextual learning hypothesis, only subjects with high disgust sensitivity showed an *inhibitory* effect of disgust both on RTs and errors. Interestingly, subjects with low disgust sensitivity showed a facilitatory effect. This in itself is a remarkable finding as previous studies reported both facilitatory as well as inhibitory effects of emotional valence on lexical decision performance. Indeed, our results suggest that individual sensitivity to a specific emotion needs to be taken into account to fully understand the nature of emotion effects in reading. If our findings were to extend to other emotions, such as anger or fear, the implications for behavioural and brain imaging studies would be tremendous (e.g., Herbert, Herbert, & Pauli, 2011).

The correlation and regression analyses further support the predictions of the contextual learning hypothesis, namely disgust sensitivity was the main variable accounting for inter-individual differences in lexical decision performance. Importantly,

EQ scores did not show a significant correlation with lexical decision performance, which suggests that *unspecific* emotional responsiveness, as measured with the EQ, cannot account for the effects of *specific* emotion sensitivity on lexical decision performance. Moreover, neither valence nor arousal indices (as measured by individual ratings) showed significant correlations with lexical decision performance. The latter finding is even more striking given that valence and arousal were assessed using the exact *same* items that were presented in the lexical decision task, whereas disgust sensitivity was assessed with a totally independent questionnaire. Valence ratings of disgust words showed a weak correlation with lexical decision, which is probably due to the fact that the DS scores and valence ratings for disgust words are slightly correlated ($r = .27$). However, when both variables were entered into a multiple regression together with EQ scores, only DS had a significant influence on lexical decision performance. Thus, the absence of a significant contribution of valence and arousal once the specific nature of the emotion has been taken into account replicates - at the subject level - the findings reported by Briesemeister et al. (2011b) at the item level.

Although the present study was not designed to disentangle current theories of emotion processing in reading, the present results nevertheless speak to this issue. Indeed, the two-dimensional model of emotion processing would have predicted a positive correlation between arousal and/or valence and lexical decision performance, whereas the automatic vigilance hypothesis would have predicted a negative correlation between emotional valence and lexical decision performance. The present results challenge both theories as neither valence nor arousal predicted lexical decision performance at the subject level. In contrast, the present findings together with those of Briesemeister et al. (2011b) are in favor of the contextual learning hypothesis (Barrett, 2006; Barrett et al., 2007; Barrett, Mesquita, Ochsner, & Gross, 2007), which is the only

theory that predicted inter-individual differences over and above the effects of valence and arousal.

4.1. Conclusion

The current findings support the assumption that the nature of the emotion effect depends on an individual's experience with a specific emotion rather than general affective properties of words. According to this account, emotions are more than pleasant or unpleasant states. They include additional knowledge, previously acquired in a particular, context-specific fashion (Barrett, 2006; Barrett et al., 2007; Barrett, Mesquita et al., 2007). As such, previous learning modulates the way in which people interpret emotional cues and adapt their behavior accordingly. This is consistent with the idea that discrete emotions are subserved by dedicated brain circuits that involve evolutionary prewired connections that are tuned by extensive learning and experience throughout the individual's history.

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Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

Appendix A. Characteristics of the Word Stimuli used

Variable	Word category						<i>p</i> *
	Neutral		Disgust-related		Pseudo words		
	<i>N</i> = 50		<i>N</i> = 50		<i>N</i> = 100		
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	
<i>Emotional valence</i>	0.03	0.73	-1.30	0.51	—	—	0.00001
<i>Arousal</i>	1.15	0.54	1.08	0.37	—	—	0.5
<i>Imageability</i>	5.30	1.31	4.93	1.28	—	—	0.2
<i>Number of letters</i>	6.20	1.67	5.98	1.52	—	—	0.5
<i>Number of syllables</i>	1.86	0.70	1.74	0.63	—	—	0.4
<i>Number of orthographic neighbors</i>	3.48	4.07	4.52	5.11	—	—	0.3
<i>Frequency of use</i>	21.44	32.13	25.23	66.38	—	—	0.7
<i>Mean letter frequency</i>	79081.48	13915.55	82670.46	12958.47	80972.56	13596.96	0.4
<i>Mean bigram frequency</i>	9795.28	2982.49	10345.16	3019.48	10091.23	3001.91	0.7
<i>Mean trigram frequency</i>	1476.28	1378.36	1204.86	585.35	1237.14	895.59	0.3

* One-way ANOVA comparisons

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