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Stop what you are not doing! Emotional pictures interfere with the task not to respond

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Previous research has shown that emotional stimuli interfere with ongoing activities. One explanation is that these stimuli draw attention away from the primary task and thereby hamper the correct execution of the task. Another explanation is that emotional stimuli cause a temporary freezing of all ongoing activity. We used a go/no-go task to differentiate between these accounts. According to the attention account, emotional distractors should impair performance on both go and no-go trials. According to the freezing account, the presentation of emotional stimuli should be detrimental to performance on go trials, but beneficial for performance on no-go trials. Our findings confirm the former prediction: Pictures high in emotional arousal impaired performance on no-go trials.

One of the most pervasive and robust effects of emotional stimuli is that they interfere with ongoing activities. For instance, participants have greater difficulties in solving math problems that are presented together with emotionally arousing stimuli (Schimmack, 2005), and they are commonly slower to name the color of emotional words versus that of neutral words (for a review, see Williams, Mathews, & MacLeod, 1996). It is still not clear, however, why emotional stimuli have this effect. Estes and Verges (2008) discussed two types of accounts (see McKenna & Sharma, 2004, for the discussion of another mechanism). First, according to the *attentional account*, emotional stimuli command attentional resources (see, e.g., Fox, Russo, Bowles, & Dutton, 2001; Schimmack, 2005; Wyble, Sharma, & Bowman, 2008). Fox et al., for instance, hypothesized that attentional dwell time is longer for threatening stimuli than for other stimuli, which aids the processing of the evaluative properties of these stimuli. The fact that emotional stimuli command attention, however, is also detrimental to ongoing processing of other stimuli or other stimulus properties (see, e.g., McKenna & Sharma, 1995), thereby impairing performance on tasks that require the processing of these other stimuli or stimulus properties.

The second account, the *freezing account*, centers on the idea that emotional stimuli cause a temporary freezing of all ongoing activity (see, e.g., Algom, Chajut, & Lev, 2004; Flykt, 2006; Öhman, Flykt, & Esteves, 2001). This view is based on animal studies about fear bradycardia, a heart-rate deceleration in response to threat (see, e.g., Campbell, Wood, & McBride, 1997). It has been postulated that the function of this defensive immobility is that it helps the animal avoid attracting predators' attention (see, e.g., Lang, Bradley, & Cuthbert, 1997). Recent studies with human participants have examined motor inhibition in response to threatening pictures. Wilkowski and Robinson (2006), for instance, have shown that negative primes decrease the speed of motor execution. Moreover, several studies (e.g., Azevedo et al., 2005; Facchinetti, Imbiriba, Azevedo, Vargas, & Volchan, 2006) have revealed that participants' body sway was reduced significantly when they were presented with negative pictures. This has been taken as support for the freezing account.

In sum, the attention account and the freezing account differ with regard to the mechanism that is assumed to be responsible for interruption effects (i.e., attention being drawn away from the main task vs. freezing of all activity) and the function that this mechanism serves (i.e., prioritized processing of the emotional features of stimuli vs. avoiding detection by predators). They also lead to different predictions. According to the attention account, emotional stimuli should interfere with all effortful tasks (i.e., tasks that require mental resources). According to the freezing account, however, emotional stimuli should facilitate the performance of tasks that involve the freezing of ongoing activity.

We know of only one set of experiments that has provided information about this differential prediction. Verbruggen and De Houwer (2007) examined the impact of emotional stimuli on performance during a stop-signal task. In such a task, participants are required to perform a simple speeded response task (press the left key when "#" is presented, and press the right key when "@" is presented) but to refrain from responding when a stop signal (a tone) is presented immediately after the target. Verbruggen and De Houwer found that the presentation of a highly arousing distractor interfered not only with responding to the targets, but also with stopping. The latter finding

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argues against a freezing account if one assumes that stopping an action involves the freezing of ongoing activity. One could argue, however, that stopping an action is an act of control (see, e.g., Logan & Cowan, 1984). From this point of view, the interfering effect of emotional stimuli on stopping can be seen as a result of a temporary freezing of the stopping action. Verbruggen and De Houwer therefore refrained from making strong theoretical conclusions on the basis of their findings.

In the present article, we report a study in which we examined the effects of emotional pictures on performance in a go/no-go task. In this task, participants were required to always respond to a go target but to never respond to a no-go target. Responding to the go target can be seen as an effortful task that requires mental and motor activity. Hence, both the attention and freezing accounts would predict that the presence of emotional pictures will deteriorate performance on go trials. The task of not responding to a target can also be seen as effortful within a context in which go and no-go trials are presented randomly in quick succession. According to the attention account, emotional pictures should thus interfere with performance on no-go trials as well; that is, more responses should be made on no-go trials when an emotional stimulus is present. If emotional pictures lead to a freezing of all ongoing activity, however, they should reduce the likelihood of a response on no-go trials. According to the freezing account, therefore, emotional pictures should improve performance on no-go trials.

Like Schimmack (2005) and Verbruggen and De Houwer (2007), we examined whether the effects of emotional pictures on performance are driven by the arousal value of the pictures or by their valence. For this purpose, we used five sets of pictures: *negative high-arousing*, *positive high-arousing*, *negative low-arousing*, *positive low-arousing*, and *neutral* pictures. In earlier studies (Schimmack, 2005; Verbruggen & De Houwer, 2007), arousal value seemed to be the main determinant of the effects, even though there have been some reports in which effects appeared to be based on valence (e.g., Estes & Verges, 2008).

METHOD

Participants

Fifty-one female psychology students at Ghent University participated in this experiment in exchange for course credit.

Stimuli and Materials

We selected 50 pictures from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 1999). The pictures were the same as the ones that Vogt, De Houwer, Koster, Van Damme, and Crombez (2008) used for female participants. Ten pictures were high arousing and negative, 10 pictures were low arousing and negative, 10 pictures were high arousing and positive, 10 pictures were low arousing and positive, and 10 pictures were neutral (see the Appendix). According to IAPS norms, both sets of positive pictures were significantly more positive than both sets of negative pictures (all ts > 13.41). As expected, neither the mean valence of the two sets of positive pictures ($t < 1$) nor the mean valence of the two sets of negative pictures [$t(9) = 1.73$] differed significantly. Both sets of high-arousing pictures were more arousing than both sets of low-arousing pictures (all ts > 7.12). The negative and positive high-arousing pictures did not differ in arousal [$t(9) = 1.83, p = .10$], but the negative low-arousing pictures were somewhat more arousing than the positive low-arousing pictures [$t(9) = 3.46, p = .007$]. The latter difference was difficult to avoid because of a negative correlation between arousal and valence in the IAPS norms.

Six additional pictures were selected for the practice block. All pictures were 12 cm wide × 10.5 cm high. Targets were the symbols § and #, which were presented in black in the middle of a white frame measuring 12.5 cm wide × 11 cm high. The frame always appeared in the center of a black screen. Inquisit software (Version 1.32, Millisecond Software) was used to implement the experiment on a standard Pentium PC with a 17-in. CRT monitor.

Procedure

Participants were tested individually in a dimly lit room. They were seated in front of the computer screen at a distance of approximately 45 cm. Participants received written instructions informing them that they would repeatedly see a picture followed by a symbol. They were told that only the symbol was important and were asked to press the space bar of the keyboard after seeing Symbol A (either § or #, counterbalanced across participants). They were told that when Symbol B appeared, they should do nothing. They were urged to respond as quickly as possible, because there would be very little time to respond. If they did not respond quickly enough, they were told, they would see a message stating that they were too slow. Participants were told that it did not matter too much if they occasionally pressed the space bar after Symbol B, as long as they always pressed quickly after seeing Symbol A. These instructions were designed to ensure that participants would give responses on no-go trials. Such errors were necessary to test the hypothesis that emotional pictures influence the number of errors on no-go trials. Participants were informed that the experiment would consist of one block of 24 practice trials and two test blocks of 106 trials each. Finally, they were told that the entire task would take about 20 min.

Each practice and test trial started with the presentation of the white rectangle in the center of the screen. After 500 msec, one of the IAPS pictures appeared in the center of the square for 250 msec. At the offset of the picture, a target appeared in the middle of the screen until the participant responded or 400 msec elapsed. If participants did not respond within 400 msec, "Te Traag" (too slow) appeared on the screen for 200 msec. No other feedback was provided. The next trial started after an intertrial interval of 600 msec.

The experiment started with a block of 24 practice trials in which the 6 neutral practice pictures were presented four times, two times followed by the go symbol and two times followed by the no-go symbol. Afterward, two test blocks were presented, each starting with 6 warm-up trials followed by 100 test trials. The warm-up trials were drawn randomly from the practice block. During the test trials, each of the 50 emotional pictures was followed once by the go symbol and once by the no-go symbol. Go and no-go trials were intermixed. The order of the test trials was determined randomly for each test block and for each participant separately.

Data Analysis

We calculated the proportion of incorrect responses for the go test trials (i.e., go trials on which the space bar was not pressed within the response window) and for the no-go test trials (i.e., no-go trials on which the space bar was pressed) as a function of picture type. We also calculated mean reaction times for each type of go test trial. Prior to calculating the mean reaction times, we removed reaction times smaller than 150 msec from the data set and log transformed all remaining reaction times. When a participant did not respond within 400 msec on a go trial, the reaction time was set at 400 msec and was entered into the calculation of the mean reaction time. All data were analyzed using 2 (arousal of picture: high, low) × 2 (valence of picture: positive, negative) repeated measures ANOVAs. We also used t tests to compare trials using emotional pictures with trials

Table 1
Reaction Times (RTs, in Milliseconds) and Proportions of Errors for Go and No-Go Trials

Picture Set	Go Trials: RTs *M*	Go Trials: RTs *SD*	Go Trials: Proportion of Errors *M*	Go Trials: Proportion of Errors *SD*	Proportion of Errors on No-Go Trials *M*	Proportion of Errors on No-Go Trials *SD*
Positive high arousing	347	19	.22	.16	.10	.10
Positive low arousing	346	19	.23	.16	.09	.10
Negative high arousing	351	17	.24	.17	.13	.12
Negative low arousing	346	17	.21	.13	.09	.08
Neutral	341	19	.20	.14	.09	.08

using neutral pictures. The relevant means can be found in Table 1. For ease of interpretation, mean untransformed reaction times are listed in Table 1.

RESULTS

Errors on No-Go Trials

The ANOVA of the proportion of errors on no-go trials revealed a significant main effect of arousal [$F(1,50) = 7.12$, $p = .01$, $\eta^2 = .125$], showing that participants made more errors on trials with a high-arousing picture. There was no main effect of valence [$F(1,50) = 2.19$, $\eta^2 = .042$] and no interaction ($F < 1$, $\eta^2 = .013$). Additional t tests showed that the proportion of errors on neutral trials differed only from the proportion of errors on negative high-arousing trials [$t(50) = 3.31$, $p = .002$, $d = .46$; all other ts < 1.55, all other ds $< .22$].

Reaction Times and Errors on Go Trials

The ANOVA of the mean reaction times on the go trials also revealed a main effect of arousal [$F(1,50) = 5.79$, $p = .02$, $\eta^2 = .104$], but not a main effect of valence [$F(1,50) = 2.27$, $\eta^2 = .043$] or an interaction [$F(1,50) = 2.54$, $\eta^2 = .048$]. Reaction times were longer on high-arousing trials than on low-arousing trials. The mean reaction time on neutral go trials was shorter than that on positive high-arousing [$t(50) = 3.73$, $p < .001$, $d = .52$], positive low-arousing [$t(50) = 2.98$, $p = .004$, $d = .42$], negative high-arousing [$t(50) = 6.44$, $p < .001$, $d = .90$], and negative low-arousing [$t(50) = 2.85$, $p = .006$, $d = .40$] go trials.

The ANOVA of the proportion of errors on go trials revealed a marginally significant interaction between arousal and valence [$F(1,50) = 3.31$, $p = .08$, $\eta^2 = .062$] but not a main effect of valence ($F < 1$, $\eta^2 = .001$) or a main effect of arousal [$F(1,50) = 1.27$, $\eta^2 = .025$]. Arousal tended to increase errors for negative pictures [$t(50) = 1.94$, $p = .06$, $d = .27$] but did not affect errors on trials with positive pictures ($t < 1$, $d = .06$). The proportion of errors on neutral go trials was smaller than that on negative high-arousing trials [$t(50) = 2.62$, $p < .01$, $d = .37$] and tended to be smaller than that on positive low-arousing trials [$t(50) = 2.00$, $p = .05$, $d = .27$], but it did not differ from the proportion of errors on positive high-arousing trials [$t(50) = 1.51$, $p = .14$, $d = .21$] or from that on negative low-arousing trials ($t < 1$, $d = .09$).

DISCUSSION

We compared two influential hypotheses regarding interference effects of emotional stimuli: the attention account, which suggests that emotional stimuli interfere with the correct application of a task by attracting attention away from the task (see, e.g., Schimmack, 2005), and the freezing account, according to which the presentation of emotional stimuli elicits a freezing of all ongoing activity (see, e.g., Flykt, 2006). In line with the predictions of the attention account but contrary to the predictions of the freezing account, we found that emotionally arousing stimuli interfered with performance on the no-go trials of a go/no-go task. It is difficult to see how a general freezing of activity could lead to the execution of a response on a no-go trial and, thus, how the effect of emotionally arousing stimuli on no-go performance could be mediated by a general freezing of activity. The effect of emotionally arousing stimuli on no-go performance could, however, be due to the fact that emotionally arousing stimuli draw attention away from the effortful task of not responding when response speed is emphasized on other trials. More specifically, it appears to be the case that emotionally arousing stimuli increase the probability that an incorrect target–response rule is applied.

One could argue that because the instructions emphasized speeded responding on go trials, the task resembled a stop-signal task in which participants prepared a response on every trial and inhibited responding when a no-go signal was presented. In this case, our study would add little to the stop-signal study of Verbruggen and De Houwer (2007). The idea that participants approached our task as a stop-signal task is difficult to reconcile with the fact that there were about twice as many errors on go trials as on no-go trials, however. Executing a prepared response on go trials should require less effort and should thus be associated with fewer errors than inhibiting a prepared response on no-go trials. Moreover, it is unlikely that participants would have recoded the task as a stop-signal task, because performing a stop-signal task requires much more effort than performing a go/no-go task (Verbruggen & Logan, 2008).

Whereas we found a significant main effect of arousal in both the analyses of the error data on the no-go trials and the analyses of the reaction time data on the go trials, these analyses did not reveal a main effect of valence or an interaction between valence and arousal. This supports the conclusion of previous studies (e.g., Schimmack, 2005; Verbruggen & De Houwer, 2007; Vogt et al., 2008) that the effect of emotional stimuli on task performance is driven primarily by their arousal value. Effects of valence on emotional interference effects have been observed in previous studies, however, even when arousal was controlled for (see, e.g., Estes & Verges, 2008). Some aspects of our data also suggest that valence might not be entirely irrelevant. Table 1 shows that, numerically, the effect of arousal tended to be stronger for negative pictures than for positive pictures. In the ANOVA of the errors on go trials, this interaction approached significance. There are, however, a number of reasons why our results do not allow for strong conclusions regarding the effect of valence. First, the absence of significant effects of valence could be due to a lack of statistical power. Second, because of a general correlation between negative valence and arousal (Lang et al., 1999), we were unable to perfectly match the different types of stimuli (see the Method section). Although further research is needed to determine whether or when valence contributes to emotional interference effects, our data do confirm that arousal is an important factor, including in tasks that require participants not to respond.

AUTHOR NOTE

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APPENDIX
International Affective Picture System (IAPS) Numbers, Valence Ratings, and Arousal Ratings (IAPS Norms for Women) of Selected Pictures

Picture Set	IAPS Number	Valence		Arousal	
		M	*SD*	*M*	*SD*
Negative high-arousing pictures	1052	2.20	0.63	6.98	0.47
	1120				
	2730				
	3500				
	6230				
	6313				
	6350				
	6821				
	8230				
	8480				
Negative low-arousing pictures	2490	2.79	0.98	4.38	0.72
	2702				
	2722				
	2800				
	3181				
	4635				
	9090				
	9220				
	9280				
	9830				
Positive high-arousing pictures	2216	7.71	0.33	6.50	0.48
	4572				
	4660				
	5621				
	5629				
	5910				
	8080				
	8185				
	8190				
	8370				
Positive low-arousing pictures	1610	7.89	0.42	3.67	0.35
	1620				
	1750				
	1812				
	2304				
	2311				
	2360				
	2370				
	5001				
	5982				
Neutral pictures	2214	4.90	0.19	4.14	1.61
	5510				
	5531				
	5920				
	7006				
	7009				
	7025				
	7034				
	7640				
	8160				

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