RUNNING HEAD: EMOTIONAL INTERFERENCE

# Stop what you are not doing!

## Emotional pictures interfere with the task not to respond

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In press. *Psychonomic Bulletin & Review*.

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Abstract

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 distracters should impair performance on both go and no-go trials. According to the freezing account, the presentation of emotional stimuli should be detrimental for performance on go trials, but beneficial for performance on no-go trials. Our findings support 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 compared to neutral words (for a review see Williams, Mathews, & MacLeod, 1996). It is, however, still not clear why emotional stimuli have this effect. Estes and Verges (2008) discuss 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 (e.g., Fox, Russo, Bowles, and 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. However, the fact that emotional stimuli command attention is at the same time detrimental for ongoing processing of other stimuli or other stimulus properties (e.g., McKenna & Sharma, 1995) thereby impairing performance on tasks that require the processing of these other stimuli or stimulus properties.

The second account centers on the idea that emotional stimuli cause a temporary freezing of all ongoing activity (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 (e.g., Campbell, Wood, & McBride, 1997). It is reasoned that the function of this defensive immobility is that it aids the animal to avoid attracting predators' attention (e.g., Lang, Bradley, & Cuthbert, 1997). Recently, studies with human subjects have examined motor inhibition in response to threatening pictures. Wilkowski and Robinson (2004), 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) 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 freezing account differ with regard to the mechanism that is assumed to be responsible for interruption effects (i.e., attention 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 studies that provides 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 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 distracter interfered not only with responding to the targets, but also with stopping. The latter finding argues against a freezing account if one assumes that stopping an action involves the freezing of ongoing activity. One could, however, argue that stopping an action is an act of control (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 paper, 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 one go target but to never respond to another 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 account predict that the presence of emotional pictures deteriorates performance on go trials. The task of not responding to a target can also be seen as effortful within a context where go and no-go trials are presented randomly in quick succession. According to the attention account, emotional pictures should thus interfere with performance also on no-go trials. That is, more responses should be made on no-go trials when an emotional stimulus is present. If, however, emotional pictures lead to a freezing of all ongoing activity, they should reduce the likelihood of a response on no-go trials. Hence, according to the freezing account, 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: high arousing negative, high arousing positive, low arousing negative, low arousing positive, and neutral pictures. In earlier studies (Schimmack, 2005; Verbruggen and De Houwer, 2007), arousal value seemed to be the main determinant of the effects even though there are 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 credits.

### *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, ten pictures were low arousing and negative, ten pictures were high arousing and positive, ten pictures were low arousing and positive, and ten pictures were neutral (see Appendix). According to IAPS norms, both sets of positive pictures were significantly more positive than both sets of negative pictures, *t*s > 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, *t*s > 7.12. The negative and positive high arousal 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 and 10.5 cm high. Targets were the symbols "§" and "#" that were presented in black ink in the middle of a white frame of 12.5 cm wide and 11 cm high. The frame always appeared in the centre of a black screen. Inquisit software (Millisecond Software, 2001) was used to implement the experiment on a standard Pentium PC with a 17 inch 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 which informed 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 spacebar of the keyboard after seeing Symbol A (either "§" or "#", counterbalanced across participants). When Symbol B appeared, they should do nothing. They were urged to respond as quickly as possible because there would be only very little time to respond. If they did not respond quickly enough, 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 spacebar after Symbol B, as long as they would always quickly press 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 minutes.

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

The experiment started with a block of 24 practice trials in which the six neutral practice pictures were presented four times, two times followed by the go symbol and two times followed by the no-go symbol. Afterwards, two test blocks were presented that each started 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 each participant separately.

*Data-analysis*

We calculated the proportion of incorrect responses for the go test trials (i.e., go trials on which the spacebar was not pressed within the response window) and no-go test trials (i.e., no-go trials on which the spacebar was pressed) as a function of the 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 ms from the data set and log transformed all remaining reaction times. When a participant did not respond within 400 ms on a go trial, the reaction time was set at 400 ms and entered into the calculation of the mean reaction time. All data were analyzed using 2 (arousal of picture: high, low) x 2 (valence of picture: positive, negative) repeated measures ANOVAs. We also used *t*-tests to compare trials with emotional pictures to trials with 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 highly arousing picture. There was no main effect of valence, $F(1, 50) = 2.19$, $\eta^2 = .042$, nor an 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 $t$s $< 1.55$, $d$s $< .22$.

### *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 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 go trials, $t(50) = 2.85$, $p = .006$, $d = .40$.

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 on negative high arousing trials, $t(50) = 2.62$, $p < .01$, $d = .37$, tended to be smaller than on positive low arousing trials, $t(50) = 2.00$, $p = .05$, $d = .27$, but did not differ from the proportion of errors on positive high arousing trials, $t(50) = 1.51$, $p = .14$, $d = .21$, or 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 (e.g. Schimmack, 2005) and the freezing account according to which the presentation of emotional stimuli elicits a freezing of all ongoing activity (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, however, difficult to reconcile with the fact that there were about twice as many errors on go trials than on no-go trials. 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 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 and De Houwer, 2007; Vogt et al., 2008) that the effect of emotional stimuli on task performance is driven primarily by their arousal value. On the other hand, effects of valence on emotional interference effects have been observed in previous studies, even when arousal was controlled for (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 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, also in tasks that require participants not to respond.

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Helen Tibboel is a Research Assistant of the Flemish Research Foundation (FWO - Vlaanderen). The preparation of this manuscript was supported by GOA Grant BOF/GOA2006/001 of Ghent University.

We thank Bertold Dewaele and Jeffrey De Winne for collecting the data.

Table 1

*Mean RTs in ms and proportion of error for go and no-go trials*

| | Positive high arousing | | Positive low arousing | | Negative high arousing | | Negative low arousing | | Neutral | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| Go trials | | | | | | | | | | |
| RTs | 347 | 19 | 346 | 19 | 351 | 17 | 346 | 17 | 341 | 19 |
| Errors | .22 | .16 | .23 | .16 | .24 | .17 | .21 | .13 | .20 | .14 |
| No-go trials | | | | | | | | | | |
| Errors | .10 | .10 | .09 | .10 | .13 | .12 | .09 | .08 | .09 | .08 |

# Appendix

An overview of the IAPS numbers of the selected pictures. The mean valence rating and the mean arousal rating (IAPS norms for women) are in parentheses.

*negative/ high arousal*: 1052, 1120, 2730, 3500, 6230, 6313, 6350, 6821, 8230, 8480

(Mean valence = 2.20, *SD* = 0.63; mean arousal = 6.98, *SD* = 0.47)

*negative/ low arousal*: 2490, 2702, 2722, 2800, 3181, 4635, 9090, 9220, 9280, 9830

(Mean valence = 2.79, *SD* = 0.98; mean arousal = 4.38, *SD* = 0.72)

*positive/ high arousing*: 2216, 4572, 4660, 5621, 5629, 5910, 8080, 8185, 8190, 8370

(Mean valence = 7.71, *SD* = 0.33; mean arousal = 6.50, *SD* = 0.48)

*positive/ low arousing*: 1610, 1620, 1750, 1812, 2304, 2311, 2360, 2370, 5001, 5982

(Mean valence = 7.89, *SD* = 0.42; mean arousal = 3.67, *SD* = 0.35)

*filler*: 2214, 5510, 5531, 5920, 7006, 7009, 7025, 7034, 7640, 8160

(Mean valence = 4.90, *SD* = 0.19; mean arousal = 4.14, *SD* = 1.61)