Research Report

The Impact of Emotion on Perception

Bias or Enhanced Processing?

René Zeelenberg,[1] Eric-Jan Wagenmakers,[2] and Mark Rotteveel[2]

[1]*Erasmus University Rotterdam, Rotterdam, The Netherlands, and* [2]*University of Amsterdam, Amsterdam, The Netherlands*

ABSTRACT—***Recent studies have shown that emotionally significant stimuli are often better identified than neutral stimuli. It is not clear, however, whether these results are due to enhanced perceptual processing or to a bias favoring the identification of emotionally significant stimuli over neutral stimuli. The present study used a two-alternative forced-choice perceptual identification task to disentangle the effects of bias and enhanced processing. We found that emotionally significant targets were better identified than neutral targets. In contrast, the emotional significance of the foil alternative had no effect on performance. The present results support the hypothesis that perceptual encoding of emotionally significant stimuli is enhanced.***

Are emotionally significant stimuli, such as happy faces, pictures of mutilations, or words such as *death* and *love*, processed more efficiently than neutral stimuli? Research seems to indicate that this is the case. For example, under attentional-blink conditions, emotionally significant words are more often correctly identified than neutral words (Anderson & Phelps, 2001). Also, in brain-damaged patients, visual extinction occurs less often for faces with happy or angry expressions than for neutral faces (Vuilleumier & Schwartz, 2001). Additional evidence was obtained in a recent study measuring event-related potentials for participants viewing pleasant, neutral, and unpleasant pictures (Schupp, Junghöfer, Weike, & Hamm, 2003). Compared with neutral pictures, pleasant and unpleasant pictures were associated with relatively early negativity over temporo-occipital sites, suggesting that the emotional content of the pictures affected perceptual encoding of these stimuli.

Although these findings indicate that the processing of stimuli is affected by their emotional significance, they do not unequivocally demonstrate that perceptual encoding of such stimuli is enhanced in the sense that more information is available for the identification process. An alternative explanation is that emotionally significant stimuli are subject to an implicit bias that favors their identification (e.g., Labiouse, 2004; Zeelenberg, Wagenmakers, & Raaijmakers, 2002). Consider, for example, the literature on implicit memory. Many studies have shown that the presentation of a stimulus results in faster and more accurate responding to the same stimulus on a later occasion. Recent studies indicate that such repetition priming effects are largely due to bias (Ratcliff & McKoon, 1996, 1997; Rouder, Ratcliff, & McKoon, 2000).[1] For example, Ratcliff and McKoon (1996) showed that object naming was facilitated by prior study of the target object, but harmed by prior study of a visually similar object. Thus, participants were slower to name the picture (i.e., a black-on-white line drawing) of a hot-air balloon if they were previously exposed to the picture of a similarly shaped lightbulb than if they were not exposed to a visually similar object.

In a similar vein, performance for emotionally significant stimuli may be improved at the expense of performance for neutral stimuli. The model proposed by Ratcliff and McKoon (1997) includes two different bias mechanisms: a processing bias and a resting-level bias. A processing bias is present when nondiscriminative perceptual information (i.e., information that does not discriminate the target from competitors) is more likely to be interpreted by the system as evidence for one type of

Address correspondence to René Zeelenberg, Erasmus University Rotterdam, Department of Psychology, Woudestein, T13-31, P.O. Box 1738, 3000 DR Rotterdam, The Netherlands, e-mail: zeelenberg@fsw.eur.nl.

[1]Several studies indicate that repetition priming effects for high-frequency words are entirely due to bias (Bowers, 1999; McKoon & Ratcliff, 2001; Wagenmakers, Zeelenberg, & Raaijmakers, 2000).

stimulus (e.g., an emotionally significant stimulus) than for another type of stimulus (e.g., a neutral stimulus). A resting-level bias is present when one type of stimulus (e.g., an emotionally significant stimulus) has a higher resting level of activation than another type of stimulus (e.g., a neutral stimulus). The performance advantage observed for emotionally significant stimuli in previous studies may have been due to either type of bias. Of course, this advantage may also have been due to enhanced perceptual encoding of emotional stimuli.

The results of Schupp et al. (2003) indicate that the emotional significance of stimuli affects relatively early perceptual processing, and one might conclude that their study demonstrates enhanced perceptual encoding of emotional stimuli. However, although these results are indeed consistent with such an interpretation, they are also consistent with an interpretation in terms of an early perceptual bias. Results obtained in the repetition priming paradigm are consistent with the latter interpretation. For example, Masson (2002) recently showed that bias is affected by study-to-test changes in modality of presentation. Bias was more pronounced if stimuli were presented in the same modality during study and test than if they were presented in different modalities (i.e., auditory presentation at study and visual presentation at test).

To summarize, the fact that the emotional significance of a stimulus improves performance in a perceptual identification task does not necessarily imply that perceptual processing is enhanced. In order to demonstrate enhanced perceptual encoding of emotionally significant stimuli, one must use a paradigm that allows the effects of bias and enhanced processing to be disentangled. To this aim, we (Zeelenberg et al., 2002) have proposed using the forced-choice perceptual identification paradigm. In this paradigm, a stimulus (e.g., *good*) is briefly presented and then masked. Subsequently, the participant chooses which of two alternatives (e.g., target: *good*, foil: *nice*) corresponds to the briefly flashed target. Independently manipulating the emotional status of the target and foil alternatives makes it possible to separate the effects of bias and enhanced processing.

To assess whether or not a certain variable results in bias, that variable is manipulated only with respect to the foil alternative. Thus, to assess a bias due to the emotional significance of the stimulus, a condition with an affective target and a neutral foil can be compared with a condition with an affective target and an affective foil. The important point is that the affective-target, neutral-foil condition and the affective-target, affective-foil condition are equated with respect to the emotional significance of the target stimulus, so that any difference between these two conditions is not due to a difference in the efficiency of processing the flashed target word. Instead, a difference between these two conditions is due to a preferential bias for an affective alternative over a neutral alternative. Likewise, bias can be estimated by comparing a neutral-target, neutral-foil condition with a neutral-target, affective-foil condition.

In order to assess whether or not a certain variable results in enhanced processing, this variable is manipulated between conditions, but kept constant within each condition. Thus, to demonstrate enhanced processing of emotionally significant stimuli, a condition with an affective target and an affective foil can be compared with a condition with a neutral target and a neutral foil. Within each of these two conditions, the target and foil alternatives have identical affective status. Hence, a bias to perceive an emotionally significant stimulus will not affect the results. Instead, better performance in the affective condition would indicate enhanced processing of emotionally significant target stimuli. Thus, the effects of bias and enhanced processing can be disentangled by including the following conditions: (a) neutral-target, affective-foil; (b) neutral-target, neutral-foil; (c) affective-target, affective-foil; and (d) affective-target, neutral-foil.

The primary goal of the present study was to investigate whether the emotional significance of a stimulus enhances perceptual encoding. To investigate whether the valence of stimuli (i.e., positive or negative) differentially affects perceptual processing, we extended the design just mentioned by independently manipulating the valence (positive, neutral, negative) of the target and the foil, resulting in a design with nine experimental conditions. Evidence for enhanced processing of emotionally significant stimuli would be obtained if performance was better for positive and negative targets than for neutral targets (with the valence of the foil alternative kept constant). Evidence for bias would be obtained if the valence of the foil affected performance.

METHOD

Participants

Twenty-nine students at the University of Amsterdam, The Netherlands, participated for course credit. All participants were native speakers of Dutch and reported normal or corrected-to-normal vision.

Design and Stimulus Materials

The valence of the target and foil were manipulated independently, resulting in a design with nine conditions having 16 trials each. The experimental stimulus set consisted of 96 positive words, 96 neutral words, and 96 negative words. Within each of the three sets there were 18 four-letter words, 18 five-letter words, 30 six-letter words, 16 seven-letter words, and 14 eight-letter words. The mean log word frequencies per million (Baayen, Piepenbrock, & van Rijn, 1993) were 1.35, 1.37, and 1.31 for the positive, neutral, and negative words, respectively.

To the extent possible, stimuli were rotated through the different conditions of the experiment. Thus, across lists, each word was paired with three different choice alternatives (a positive, a neutral, and a negative alternative) and served both as a target and as a foil. The target and foil alternatives within a pair had the same number of letters. Each subject received one of the six resulting stimulus lists.

Apparatus

Stimuli were presented on a Hewlett Packard digital display module, Model 1345A. The HP1345A display is a point-plot display that allows direct control of the position of the beamer. As a consequence, the presentation time of stimuli can be adjusted in smaller steps than is possible with more common raster-type displays such as those used in desktop computers (for details, see Zeelenberg, Plomp, & Raaijmakers, 2003). The software used to program the display module allows variation of the presentation time in steps of 2 ms. Stimulus presentation and response collection were controlled by a computer running under DOS.

Procedure

Experimental stimuli were presented in a single block of 144 trials. A different random order was used for each participant. Each test trial started with the presentation of a row of minus signs for 400 ms, followed by a 300-ms blank screen (see Fig. 1). Subsequently, the test word was flashed. Flash time of the target was determined individually for each participant (see the next paragraph). After presentation of the target, a 300-ms mask consisting of eight mask characters immediately covered the entire area where the test word had been presented. Ten different mask characters were used, each consisting of seven randomly oriented lines. For each of the eight positions in the mask, a mask character was sampled at random (with replacement) from the set of 10 mask characters. Immediately following the mask, two words were presented side by side on the line below. Participants pressed the "z" key with their left index finger to indicate they thought the left-hand word was the flashed test word and the "?/" key with their right index finger to indicate the right-hand word was the flashed test word. For each trial, the location of the correct choice (left-hand or right-hand alternative) was randomly determined.

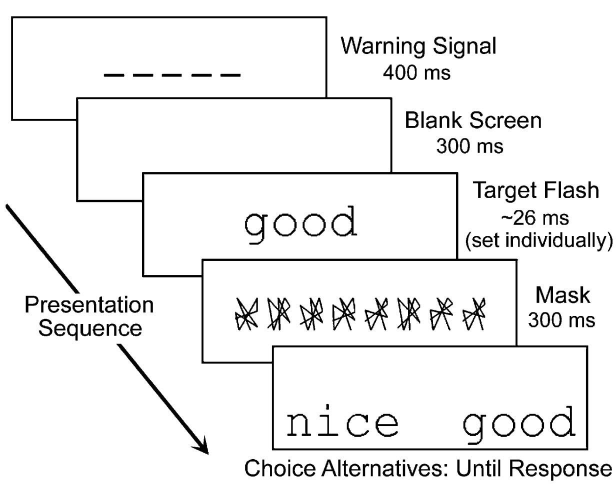

Fig. 1. Illustration of the display sequence for trials in the experiment.

On the first 4 trials, the test words were flashed for 100 ms in order to make sure the requirements of the experiment were clear to the participant. Next, 60 calibration trials, subdivided in four blocks of 15 trials each, were presented to estimate the flash time resulting in 70% correct performance. For this purpose, we used an adaptive algorithm in which the flash time in calibration block N was adjusted on the basis of performance in calibration block $N - 1$. The resulting mean flash time used in the main experiment was 25.0 ms ($SD = 6.2$).

After completing the forced-choice experiment, participants were asked to rate the valence of all stimuli used in the experiment on a 7-point scale (1 = *very negative*, 4 = *neutral*, and 7 = *very positive*). The ratings confirmed that the manipulation of valence was successful. The mean ratings were 1.90 ($SD = 0.56$), 3.86 ($SD = 0.35$), and 5.17 ($SD = 0.54$) for the negative, neutral, and positive words, respectively.

RESULTS

Table 1 shows the percentage of correctly identified targets as a function of the emotional valence of both the target and the foil. As the table shows, the valence of the foil had no effect. Collapsed across the three target conditions, mean performance was almost identical in the positive-foil condition ($M = 72.6$), the negative-foil condition ($M = 72.9$), and the neutral-foil condition ($M = 73.9$). Thus, the emotional significance of the stimuli did not result in a bias effect. The valence of the target, however, did affect performance in forced-choice perceptual identification: Performance was better for positive targets ($M = 74.6$) and negative targets ($M = 75.1$) than for neutral targets ($M = 69.5$). In other words, there was an enhanced processing effect for emotionally significant stimuli.

These conclusions were supported by a two-way analysis of variance with valence of the target (positive, neutral, negative) and valence of the foil (positive, neutral, negative) as within-subjects factors. The main effect of target valence was significant, $F(2, 56) = 5.34, p < .01, \eta^2 = .16$. Neither the main effect of foil valence nor the interaction between target and foil valence reached significance, both Fs < 1. A Tukey HSD test showed

TABLE 1

Percentage Correct in Forced-Choice Perceptual Identification as a Function of the Emotional Valence of the Target and the Foil

	Foil		
Target	Positive	Neutral	Negative
Positive	73.1	75.9	75.0
Neutral	69.0	71.1	68.5
Negative	75.6	74.6	75.2

that positive targets and negative targets were more often correctly identified than neutral targets. The difference between positive and negative targets was not significant.

DISCUSSION

The results of the present experiment clearly showed that the processing of emotionally significant stimuli was enhanced, whereas there was no indication of a bias effect. This does not mean that bias never plays a role in the processing of emotionally significant stimuli. For example, the counter model (Ratcliff & McKoon, 1997) predicts that a perceptual processing bias is limited to alternatives that are visually similar (e.g., *house* vs. *mouse*). In the present study, visually dissimilar alternatives (e.g., *good* vs. *nice*) were used because there are simply not enough visually similar alternatives for the experimental design that we used. Therefore, we cannot rule out that some bias effect might have been observed had we been able to use visually similar alternatives.[2] Regardless of the issue of bias, however, the important finding of the present study is that the emotional significance of a stimulus enhances its perceptual processing.

The exact mechanisms responsible for this enhanced processing have not yet been identified. However, several lines of research indicate that the amygdala is involved in the modulation of the perceptual encoding of emotionally significant stimuli. For example, healthy participants, but not patients with left and bilateral amygdala damage, more often correctly identify emotionally significant words than neutral words in an attentional-blink paradigm (Anderson & Phelps, 2001). Moreover, in primates, there are substantial projections from the amygdala to sensory brain areas (Amaral, Price, Pitkanen, & Carmichael, 1992). On the one hand, visual information could reach the amygdala via the same visual cortices that it subsequently modulates (Adolphs, 2004). On the other hand, research suggests that the amygdala could be reached directly via subcortical pathways involving the colliculi superior (Morris, Öhman, & Dolan, 1998, 1999; see also LeDoux, 1986, 1996). In either case, there is an assumption that information is passed on to the amygdala before perceptual processing has been fully completed.

A different explanation is that the effect of emotional significance on perceptual processing is due to stronger representations for emotionally significant than for neutral words. Although in the present experiment emotional and neutral words were matched on normative word frequency, it seems plausible that the impact of past experiences with a stimulus strongly depends on its emotional significance. The fact that explicit memory performance is often better for emotionally significant stimuli than for emotionally neutral stimuli (e.g., Hamann, Ely, Grafton, & Kilts, 1999) is consistent with this possibility. It may well be that the emotional significance of a stimulus enhances the formation of long-term memory traces, thereby improving performance in explicit memory tasks, as well as tasks that tap memory in a more indirect manner, such as perceptual identification tasks.

[2]A bias effect due to differences in the resting level of activation is predicted irrespective of the similarity of the alternatives. This kind of bias is, therefore, not supported by our data.

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