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Load-dependent modulation of affective picture processing

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Because of the biological significance of emotional stimuli, their processing is considered largely automatic. In the study reported herein, we tested the alternative hypothesis—namely, that the processing of emotional stimuli requires some level of attention. Our experiments utilized highly negative and arousing visual stimuli comprising mutilated bodies. All experiments employed a single task, which consisted of determining whether two peripheral bars were like oriented or not, thereby eliminating potential task-difference confounds that may have contaminated prior studies. Our results revealed that task-irrelevant unpleasant images slowed reaction time during the performance of the main task. Such interference was modulated by task difficulty as well as by alcohol consumption, showing that the processing of emotional visual stimuli is not immune to attentional manipulations. These results suggest that it is essential to utilize attentional manipulations that more fully consume attentional resources in order to demonstrate that the processing of emotional stimuli is resource limited.

Understanding the impact of the processing of emotion-laden visual information on behavior is of great interest. Humans exhibit fast, involuntary autonomic responses to emotional stimuli, such as aversive pictures or faces with fearful expressions (Codispoti, Bradley, & Lang, 2001; Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000; Hagemann, Waldstein, & Thayer, 2003). A body of data supports the notion that the processing of affective items is prioritized relative to that of emotionally neutral stimuli. For instance, subjects are faster at detecting fearful or threatening target faces than they are at detecting neutral ones (Ishai, Pessoa, Bikle, & Ungerleider, 2004; Öhman, Lundqvist, & Esteves, 2001) and show facilitated search for fear-relevant pictures among fear-irrelevant pictures (Öhman, Flykt, & Esteves, 2001). In addition, growing evidence has demonstrated that affective processing is modulated by several factors, including attention and cognitive regulation (Ochsner & Gross, 2005; Pessoa, 2005). For example, manipulating the focus of spatial attention has been shown to eliminate differential signals evoked by fearful faces in both functional magnetic resonance imaging (fMRI) and event-related potential (ERP) studies (Eimer, Holmes, & McGlone, 2003; Pessoa, McKenna, Gutierrez, & Ungerleider, 2002). In addition, cognitively changing the meaning of emotionally evocative stimuli (i.e., emotional regulation) affects evoked responses in the amygdala and other brain areas (Ochsner, Bunge, Gross, & Gabrieli, 2002; Ochsner et al., 2004).

The goal of the present study was to probe how attention and other task-related factors affect the processing of emotion-laden visual stimuli. One of the functions of attention is to selectively enhance the perception of visual objects, thereby increasing accuracy and decreasing time needed to react to them (e.g., Posner, 1980; Posner & Cohen, 1984; Rizzolatti, Riggio, Dascola, & Umiltà, 1987). Paying attention to a location in space (or an ob-

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ject) improves its associated neural processing, increasing the likelihood that it will affect action. At the same time, there is increasing evidence that the processing of objects outside the focus of attention is largely reduced and, under certain circumstances, even eliminated (Joseph, Chun, & Nakayama, 1997; Lavie, 1995, 2005; Mack & Rock, 1998; Rensink, 2002; Rensink, O'Regan, & Clark, 1997; Simons & Rensink, 2005). For example, during *inattentional blindness*, subjects are sometimes asked to focus on certain aspects of a visual scene and, by doing so, are incapable of reporting a salient event occurring outside of the focus of attention (Mack & Rock, 1998). Interestingly, inattentional blindness is less severe for facial expressions of emotion, which is consistent with the view that the processing of affective items is prioritized relative to that of emotionally neutral stimuli, as stated above. Taken together, inattentional blindness and *change blindness* argue for the limited capacity of visual processing. There is also evidence that the difficulty of a task at the focus of attention is a key determinant of the extent to which unattended information is processed. Specifically, the amount of processing devoted to items outside the focus of attention has been proposed to be a function of the resources that are consumed by a central task (Lavie, 1995, 2005; Lavie & Tsal, 1994; Rees, Frith, & Lavie, 1997). Thus, the exclusion of an unattended item from processing depends not only on the subject's intention to ignore it, but also on the extent to which a primary task consumes processing resources.

In this context, a few studies have investigated the responses evoked by fearful faces when subjects were engaged in very demanding tasks. In one study, when subjects performed a difficult bar-orientation task, no differential activation was observed in the amygdala when responses evoked by (unattended) fearful and neutral faces were compared (Pessoa, McKenna, et al., 2002). In a second study, subjects performed a challenging perceptual task involving the comparison of the length of two line segments. In this case, differential ERP responses were completely eliminated (Eimer et al., 2003). Thus, although brain responses, especially in the amygdala, have at times been shown to be of similar magnitude in the presence of attentional manipulations (Anderson, Christoff, Panitz, De Rosa, & Gabrieli, 2003; Vuilleumier, Armony, Driver, & Dolan, 2001), some studies have revealed cases in which responses to unattended affective items are modulated.

One concern with previous studies revealing attentional effects is that they employed emotional faces, which are thought to be relatively weak affective stimuli (Ochsner et al., 2002). Would similar results be observed even with more potent emotion-laden stimuli? It is possible, for instance, that stronger affective stimuli would be less susceptible to attentional manipulations. Another concern with some of the previous studies is that the comparison of "attended" and "unattended" conditions entailed comparing two different tasks, such as determining the sex of faces presented centrally or the orientation of peripheral bars (Pessoa, McKenna, et al., 2002). Such task-related differences make the interpretation of the imaging results less straightforward because the decision type varied among conditions (Compton, 2003).

The present behavioral study addressed both of these issues. Instead of face stimuli, we utilized images of mutilated bodies, which are highly negative and arousing stimuli (Lang, Bradley, & Cuthbert, 1999) and lead to robust visual cortex activation; such activation is, in fact, greater than that evoked by faces (Bradley et al., 2003). To eliminate a potential task-difference confound, all experiments employed a single task, which consisted of determining whether two peripheral bars were like oriented or not. Thus, affective images were always task irrelevant, and subjects were instructed to ignore them. To manipulate the demands of the bar-orientation task, we varied its difficulty parametrically.

EXPERIMENT 1

Viewing emotional stimuli has been shown to interfere with visual processing. For example, Hartikainen, Ogawa, & Knight (2000) had subjects determine the orientation of a target triangle stimulus (upright or inverted) that was briefly flashed (150 msec) and randomly presented in the right or left visual hemifield following the presentation of emotional or neutral pictures in either the same or the opposite hemifield as that of the target (Hartikainen et al., 2000). The authors observed an interference of right-hemisphere function when subjects viewed emotional stimuli, as evidenced by slower reaction times (RTs) when the targets were shown in the left visual field, independently of the picture presentation field. Unpleasant stimuli showed a greater effect than pleasant stimuli. Tipples and Sharma (2000) have also reported a slowing of responses on choice tasks by the presentation of emotional pictures, again stronger for unpleasant pictures.

The goal of Experiment 1 was to test whether the parametric increase in task difficulty of the main task would decrease the interference of task-irrelevant affective stimuli, as indexed by a slowing down of RT. The main task involved indicating whether or not two peripheral bars were oriented in the same manner while a distractor image was presented in the center of the visual field (see Figure 1). To vary the processing load of the main task, we employed three difficulty levels of the bar-orientation task.

Method

Twenty-four subjects (12 men) with a mean age of 21 (±2.7) years participated in the study. Volunteers were selected among students from the Federal Fluminense University (Niterói, Brazil) and had normal or corrected-to-normal vision. They reported no psychiatric or neurologic problems and were not under medication with nervous system action. Subjects were naive as to the purpose of the experiment. The experiment was approved by the local ethics committee, and subjects gave informed consent.

The experiment was conducted in a sound-attenuated room with indirect lighting. The subjects sat 57 cm from the display (the position was fixed via the use of a chinrest). The stimuli were presented with Micro Experimental Laboratory (MEL, Version 2.0; Psychology Software Tools Inc., Pittsburgh, PA).

Figure 1 illustrates the trial structure. Each trial was initiated with a fixation cross, which was shown for 1,500 (±200) msec. Then, a

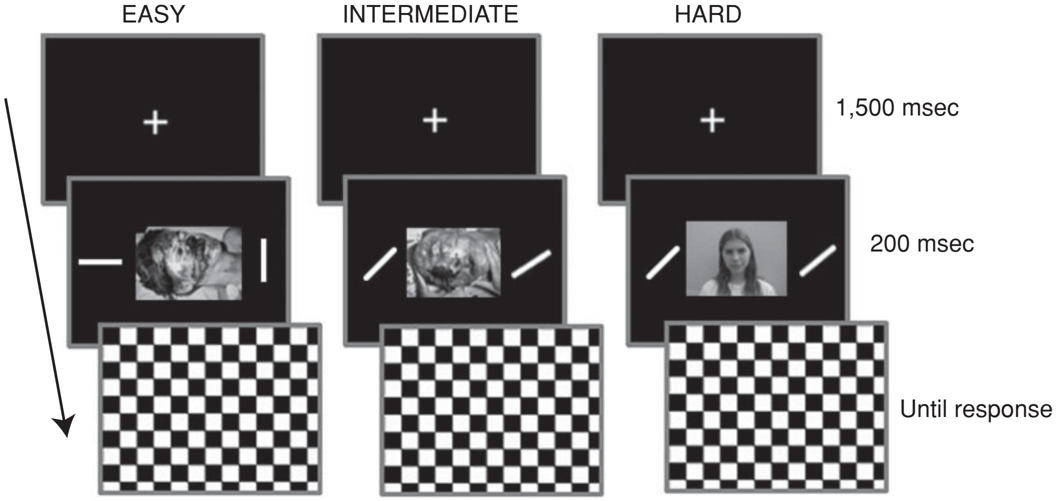

Figure 1. Experimental design: A centered fixation cross was presented for 1,500 msec (±200), followed by a central picture and two peripheral bars, presented simultaneously (for 200 msec) to the right and left of fixation (stimulus not drawn to scale). Then a checkerboard-like mask was presented; this remained on the screen until the response was made or 1,500 msec had elapsed. Subjects were instructed to ignore the central picture and attend to the peripheral bars, responding with a fingerpress as quickly and accurately as possible as to whether the bars were in the same or a different orientation.

central picture (9º × 12º) and two peripheral bars (0.3º × 3.0º) were shown for 200 msec. The bars were presented at 9º to the right and left of the center of the picture. A whole-screen checkerboard mask was then shown, and it remained on the screen until the subject responded or 1,500 msec had elapsed. The subjects were instructed to ignore the task-irrelevant central images and to respond as quickly and as accurately as possible, indicating whether or not the orientations of the peripheral bars were the same. Keypresses (with the right or left index finger) corresponding to same/different orientations were counterbalanced across subjects.

Two classes of images were employed: neutral and unpleasant. Neutral images consisted of photographs of people, and unpleasant images consisted of photographs of mutilated bodies. We utilized 156 figures, 78 neutral and 78 unpleasant. Forty-two images (14 neutral and 28 unpleasant) were taken from the International Affective Picture System (IAPS) developed by Lang and colleagues (Lang et al., 1999), and the remaining ones were obtained from the Internet. Following the protocol developed by Lang and colleagues, all images were assessed on a 1–9 scale in terms of valence (from *negative* to *positive*) and arousal (from *low* to *high*) by a group of graduate students with ages similar to the subjects'. Overall, images in the neutral category had mean valence ratings of 5.0 and mean arousal ratings of 3.3; images in the unpleasant category had mean valence ratings of 2.2 and mean arousal ratings of 6.4.

The experimental session started with three training blocks containing 20 trials each, which were followed by three regular blocks of trials (52 trials each). The order of neutral and unpleasant images within a block was randomized. During training blocks, all images were photographs of objects, such as tools and furniture. Experimental blocks contained the same number of neutral and of unpleasant images, which were matched for valence and arousal levels for each block type. During each block, the difficulty of the bar-orientation task was fixed. "Easy," "intermediate," and "hard" blocks were obtained by manipulating the angular difference of the bars on nonmatch trials: 90º in easy blocks, 24º in intermediate blocks, and 12º in the hard blocks. Each block contained the same number of match and nonmatch trials. For training blocks only, subjects received feedback, which indicated anticipatory responses (RT less than 100 msec), slow responses (RT greater than 1,500 msec), as well as whether an incorrect key was pressed; during training, the RT was also indicated on the screen. Experimental blocks, which followed the training blocks, lasted approximately 5 min each, and their order was randomized and counterbalanced across subjects. All anticipatory and slow responses were excluded from further analyses; eliminated trials were infrequent (0.3% of the trials; worst case for a given subject: 1.6%).

The RT results were analyzed by performing a stimulus category (two levels: neutral and unpleasant) × load (three levels: easy, intermediate, and hard) repeated measures ANOVA with median RT for correct trials as the dependent variable. Post hoc tests employed the Newman–Keuls method, and the alpha level for statistical significance was $p = .05$.

Results and Discussion

An ANOVA on the RTs of correct responses revealed main effects of stimulus category [$F(1,23) = 20.8$, $p < .001$] and of load [$F(2,46) = 5.17$, $p < .01$]; their interaction was not statistically significant [$F(2,46) = 0.51$, $p > .1$]. Figure 2 shows that RTs for viewing unpleasant images (679, 684, and 725 msec during easy, intermediate, and hard blocks, respectively) were slower than RTs for viewing neutral images (629, 650, and 682 msec). As expected, RTs increased with increasing levels of load. The pattern of error rates followed the one observed for RT closely, indicating that no speed–accuracy trade-off occurred: easy, neutral, 3.4%; easy, unpleasant, 6.4%; intermediate, neutral, 9.7%; intermediate, unpleasant, 13.3%; hard, neutral, 15.5%; and hard, unpleasant, 21.3%.

The results of Experiment 1 show that task-irrelevant, unattended emotional images interfered with the processing of the main bar-orientation task by slowing RT. The amount of interference was approximately the same across levels of difficulty (50, 34, and 43 msec, for easy, intermediate, and hard blocks, respectively). This pattern of results suggests that task-irrelevant unpleasant images were processed effectively even during relatively diffi-

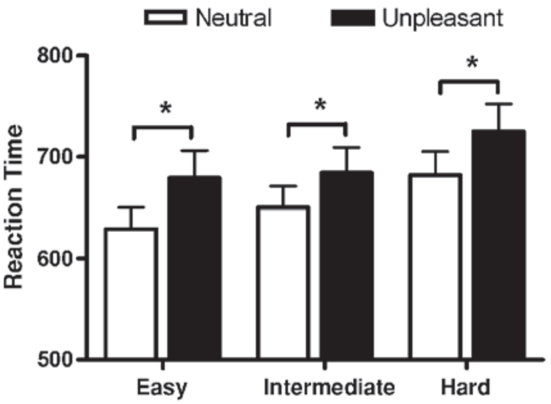

Figure 2. Mean reaction times (in milliseconds) for correct responses in Experiment 1, during the easy, intermediate, and hard blocks. Subjects were slower to respond to the bars when central unpleasant pictures (black bars) were presented as distractors, as opposed to neutral pictures (white bars). Mean reaction times were also slower as a function of task difficulty. Error bars indicate the standard errors of the means. $^*p < .05$.

cult conditions (performance on the main task was 79% correct), and it is consistent with the view that negative emotional images are processed even when they are task irrelevant. Thus, even during difficult blocks, enough capacity was available to process task-irrelevant distractors. The following two experiments addressed the possibility that task demands may not have sufficiently depleted processing resources.

EXPERIMENT 2

During the most difficult condition in Experiment 1, the subjects were correct 79% of the time. In Experiment 2, we increased task demands by making the bar-orientation task harder, decreasing the angular difference between the bars in nonmatch trials.

Method

Thirty-six subjects (18 men) with a mean age of 21.3 (+2.7) years participated in the study. The subjects were selected among students from the Federal Fluminense University (Niterói, Brazil) and had normal or corrected-to-normal vision. They did not report any past psychiatric or neurological problems and were not under medication with nervous system action. The experiment was approved by the local ethics committee, and subjects gave informed consent. The images employed were the same as in Experiment 1, but the pictures used as distractors in the easy condition of Experiment 1 were now used in the very hard condition; the distractors used in the hard condition of Experiment 1 were now used in the easy condition.

The goal of Experiment 2 was to test whether an increase in the difficulty of the bar-orientation task beyond the levels employed in Experiment 1 would eliminate the interference effect in the RT task. The experimental design of Experiment 1 was used, except that only two difficulty levels were employed for the bar-orientation task: easy (90º difference between bars) and very hard (6º difference). Subjects performed one block of trials of the easy condition and two blocks of trials of the very hard condition. We employed two blocks of the very hard condition to attempt to obtain a reasonable total number of correct responses to be utilized in the RT analysis—error rates during this condition were expected to be quite high. Each block was composed of 40 trials with 20 unpleasant and 20 neutral images, randomly presented. As no significant differences in RT were observed for the two very hard blocks, their data were collapsed. Presentation times and experimental sequences were the same as those used in Experiment 1.

Results and Discussion

An ANOVA on the RTs revealed main effects of load [$F(1,35) = 34.17$, $p < .01$] and stimulus category [$F(1,35) = 7.40$, $p < .05$]; their interaction was not statistically significant [$F(1,35) = 0.43$, $p > .1$]. Figure 3 shows that for the easy condition, mean RTs while subjects viewed unpleasant distractors (610 msec) was slower than during trials with neutral distractors (585 msec), as previously observed. Critically, during the very hard condition, RTs did not differ significantly during unpleasant (765 msec) relative to neutral distractors (749 msec). These results show that high processing demands during the execution of the bar-orientation task eliminated the interference effect of task-irrelevant unpleasant distractors. As before, RTs increased as a function of load. The error rates were as follows: easy, neutral, 4.7%; easy, unpleasant, 5.4%; very hard, neutral, 38.3%; very hard, unpleasant, 39.5%.

Although we did not observe a significant load × stimulus category interaction, we believe that the absence of slower RT during the unpleasant condition at high load is an important finding. Further analyses of our data revealed that, although a paired *t* test for the easy condition was highly significant ($p = .0003$), no significant difference was obtained for the very hard condition ($p = .37$). Moreover, the addition of subjects is unlikely to have resulted in a significant difference for the very hard condition. If we treat our results as "pilot data," the very hard condition exhibited a small effect size ($d = 0.18$; Cohen, 1988), and approximately 195 subjects would have been needed to obtain a 0.8 power level, which is considered

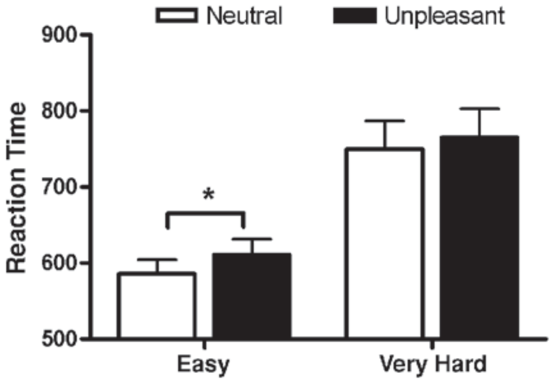

Figure 3. Mean reaction times (in milliseconds) for correct responses in Experiment 2. Unpleasant-distractor interference was observed only during the easy block. During very hard blocks, reaction times did not differ whether unpleasant or neutral distractors were shown. Error bars indicate the standard errors of the means. $^*p < .05$.

desirable (or 85 subjects, for 0.5 power, which is considered medium). Given that, due to random sampling, pilot data actually tend to overestimate effect size (Maxwell & Delaney, 2004), in all likelihood, adding subjects to our subject pool would not have resulted in a significant difference under the alternative hypothesis.

EXPERIMENT 3

The aim of this experiment was to manipulate the processing of emotion-laden stimuli by employing acute alcohol intoxication. Specifically, we employed acute alcohol intoxication in an attempt to increase task demands. Under the effect of alcohol, overall processing capacity is reduced and directed toward more immediate and relevant events (Josephs & Steele, 1990; Steele & Josephs, 1990). We reasoned that under alcohol intoxication, subjects would have to increase the allocation of attention to execute the main task, so that fewer resources would be available for the processing of emotional distractors. Experiment 3 was identical to Experiment 1 except for the alcohol consumption by the participants.

Method

Thirty male subjects with a mean age of 22.3 (±1.7) years participated in the study. The subjects were selected among students from the Federal Fluminense University (Niterói, Brazil) and had normal or corrected-to-normal vision. They did not report any psychiatric or neurologic problems and were not under medication with nervous system action. The subjects were naive as to the purpose of the experiment. The experiment was approved by the local ethics committee, and the subjects gave informed consent.

The subjects were screened on the basis of their reported alcohol consumption. Prior to the study, potential subjects completed a drinking habit questionnaire (Cahalan & Cisin, 1968), which provided measures of their drinking history in terms of frequency and dosage so that only moderate social drinkers would be recruited. The subjects had their body mass index (BMI = weight/height^2) determined in order to exclude over- and underweight individuals (Kuczmarski & Flegal, 2000).

Subjects fasted for 2 h and abstained from alcohol for 48 h prior to the experimental session. Each participant was given a mixture of vodka (40% alcohol by volume) and orange juice (1:1 ratio). The amount of alcohol consumption that would lead to a peak blood alcohol concentration of 0.06% was determined for each individual on the basis of his weight. The subjects were instructed to drink the beverage within a period of 5 min; the experimental session started 30 min after consumption. Blood alcohol concentration was measured indirectly by means of a breath alcohol analyzer every 5 min for the duration of the experiment, resulting in four measurements before, four measurements during, and four measurements after the acquisition of the experimental data. At the end of the session, the subjects were given some food and, after the experimenter had verified that their blood alcohol concentration had decreased, they were thanked and debriefed.

The apparatus, procedures, and experimental design were identical to those in Experiment 1. Each subject participated in one experimental session, which consisted of three blocks of 52 trials each. Instructions and practice trials took place before alcohol consumption.

Blood alcohol concentrations were analyzed by performing a 3 (period of measurement: before, during, and after the task) × 4 (time: the first through fourth measurements) factorial repeated measures ANOVA. RT was analyzed as in Experiment 1.

Results and Discussion

Blood alcohol concentration. An ANOVA on blood alcohol concentration (BAC) revealed a significant main effect of period of measurement [$F(2,58) = 4.07, p < .05$] and a significant period of measurement × time interaction [$F(6,174) = 3.43, p < .01$]; the effect of time was not statistically significant [$F(3,87) = 1.5, p > .1$]. Post hoc analyses revealed that alcohol levels before and during the experiment did not differ from each other; however, the levels before and after differed from each other, and this was consistent with a decrease of intoxication at the end of the experiment. Thus, there was no major decrease of BAC levels during the performance of the task.

Reaction time task. Because of increased variability in RT when the subjects were under the influence of alcohol, we eliminated extreme values that were more than 3 standard deviation units from the mean of an individual's RTs (typically, RTs less than 300 or greater than 1,000 msec), which constituted 3.6% of the trials. An ANOVA on the RTs revealed that the main effect of load [$F(2,58) = 17.82, p < .001$] and of stimulus category [$F(1,29) = 11.24, p < .01$], as well as their interaction [$F(2,58) = 4.69, p = .01$], were statistically significant.

Figure 4 shows that RTs while subjects viewed unpleasant images were slower than RTs while subjects viewed neutral images in the easy (568 vs. 554 msec; $p < .01$) and intermediate (625 vs. 599 msec; $p < .001$) blocks. However, during the hard block, there was no significant difference in RTs for unpleasant and neutral images (632 vs. 628 msec; $p = .39$). As expected, there was an increase in RT as a function of task load. These results revealed that the slowing of RT during the viewing of unpleasant images occurred only in the easy and intermediate blocks. Critically, such interference was not observed in the hard block, suggesting that the administration of alcohol was effective in lowering attentional capacity. Thus, the combination of alcohol administration and a demanding task

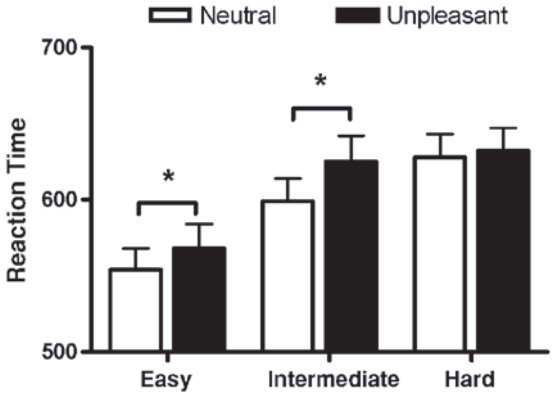

Figure 4. Mean reaction times (in milliseconds) for correct responses in Experiment 3. The interference effect of unpleasant distractors was observed only during the easy and intermediate conditions, and not during the hard condition. Mean reaction times were also slower as a function of task difficulty. Error bars indicate the standard errors of the means. $^*p < .05$.

in the hard block likely reduced resources that would have been needed to process the unattended images. Under such conditions, neutral and unpleasant images did not have differential effects on RT. Note that these results are not due simply to a general impairment of performance owing to alcohol. In fact, the subjects performed the bar-orientation task in Experiment 3 at nearly the same levels of accuracy as did those in Experiment 1; error rates for the three difficulty levels were 6.4%, 13.3%, and 21.3% during Experiment 1 and 6.0%, 10.0%, and 18.0% during Experiment 3.

GENERAL DISCUSSION

The results of our three experiments revealed that task-irrelevant, unpleasant images slowed RT during the performance of the main bar-orientation task relative to the RT during presentation of neutral stimuli. We showed that such interference was modulated by task difficulty (Experiment 2) and by alcohol consumption (Experiment 3). Critically, when the bar-orientation task was very demanding and subjects were under alcohol intoxication, no significant interference was observed.

The capability of emotional stimuli to affect ongoing visual processing is well documented (Bradley et al., 2003; Fontana et al., 2003; Hartikainen et al., 2000; Ishai et al., 2004; Lane, Chua, & Dolan, 1999; Lang et al., 1998; Mourão-Miranda et al., 2003; Pessoa, Kastner, & Ungerlider, 2002; Pessoa, McKenna, et al., 2002; Simpson et al., 2000; Tipples & Sharma, 2000). In particular, the viewing of pictures of mutilated bodies is especially powerful (Azevedo et al., 2005; Bradley et al., 2003; Pereira et al., 2004). The results of the present experiments strengthen the view that the processing of emotional stimuli is prioritized, as is indicated by the interference of unpleasant pictures. Even though unpleasant pictures were task irrelevant, they slowed the responses for the bar-orientation task. This was the case even though the pictures were shown for only 200 msec (and followed by a mask), indicating that the processing of fairly complex images, such as the mutilated bodies shown here, occurs within 200 msec or less (see also Li, VanRullen, Koch, & Perona, 2002). These results are consistent with the findings of Kawasaki et al. (2001) that neurons in the human ventral prefrontal cortex evoke differential responses to unpleasant and neutral stimuli within 120–160 msec, perhaps implementing a form of rapid and coarse stimulus categorization, as the authors suggested (see also Bar, 2004).

Although the effects of affective stimuli are quite rapid, in general they are not inevitable or fixed. Several studies have investigated the neural systems engaged when subjects are asked to view emotionally charged stimuli and reappraise them. In most cases, subjects have been asked to down-regulate the aversive effects of the stimuli by, for instance, reinterpreting the stimuli so that they no longer elicit a negative response (Ochsner et al., 2002). In such cases, responses in regions such as the amygdala and insula are decreased relative to when no reappraisal is involved. In addition, subjects report a decrease in experienced negative affect that is correlated with responses evoked in the cingulate cortex, which is hypothesized to regulate emotional responses (Ochsner et al., 2002). The effects of affective stimuli can also be modulated by altering the task performed on such stimuli. For instance, decreased amygdala responses are observed when subjects judge the expression rather than the sex of fearful, angry, and happy faces (Hariri, Bookheimer, & Mazziotta, 2000). Finally, modulations of affective processing have been probed in studies in which the spatial focus of attention was manipulated. Although some researchers have reported that amygdala responses are independent of the focus of attention (Anderson et al., 2003; Vuilleumier et al., 2001), other investigations indicate that such responses are in fact dependent on attention (Eimer et al., 2003; Pessoa, Kastner, & Ungerleider, 2002; Pessoa, McKenna, et al., 2002). Although the reasons for such discrepancies are, at present, not entirely clear, one possibility is that the effects of attention are evinced only when relatively difficult tasks are used to divert attention away from task-irrelevant affective stimuli (see below).

In the present study, we investigated how task difficulty modulated behavioral effects of viewing emotion-laden visual stimuli. One concern with some of the previous studies is that comparisons of attended and unattended conditions involved different tasks—for example, sex discrimination during the attended condition and bar-orientation judgment during the unattended condition (Pessoa, McKenna, et al., 2002). Moreover, in previous studies suggesting an effect of attention, researchers have employed face stimuli, which are believed to be relatively weak emotional stimuli (Ochsner et al., 2002). To address these concerns, in the present study, we employed images of mutilated bodies as emotional stimuli in a single task. The effect of attention was gauged by increasing the demands of the main bar-orientation task by manipulating task difficulty. In Experiment 1, no effect of difficulty on the interference effect was observed. Although RTs were slower as a function of task difficulty, interference was observed for the easy, intermediate, and hard levels. The results of Experiment 1 are thus consistent with the notion that affective stimuli have a privileged status. Even though the aversive pictures of mutilated bodies were task irrelevant and subjects were instructed to ignore them, they slowed RTs. The results of Experiments 2 and 3 revealed, however, conditions in which interference did not take place. During the hard condition of Experiment 1, performance was 79% correct. Although this task was relatively challenging, such levels were not nearly as demanding as those used, for example, by Pessoa, McKenna, et al. (2002) when no differential fMRI responses were observed (64% correct). Consequently, in Experiment 2, we increased the task difficulty of the bar-orientation task by decreasing the orientation difference between the bars. This manipulation attained the desired effects; task performance was reduced to 62% correct. Under such conditions, emotional distractors did not interfere with processing, as assessed by RT. In Experiment 3, we investigated how the consumption of alcohol would affect the processing of task-irrelevant emotional distractors. The same difficulty levels as in Experiment 1 were used. Interference effects were observed for the easy and intermediate conditions but, critically, not for the hard condition.

Collectively, our results show that, although affective picture processing is privileged, under some conditions interference does not occur. What eliminates the interference effect? One possibility is that interference will occur only if sufficient resources are available to process task-irrelevant information. Lavie and colleagues (Lavie, 1995; Lavie & Tsal, 1994; Rees et al., 1997) have proposed that the amount of distractor processing is a function of the load of the main, attended task. Our results are consistent with such views. Affective stimuli interfered with bar-orientation judgment when this task was relatively easy, but not when it was very demanding (Experiment 2).

In Experiment 3, we observed that alcohol consumption also eliminated the interference effect. How does alcohol eliminate the slowdown of RT during the hard condition? In general, alcohol can produce psychomotor, behavioral, cognitive, and emotional effects (Bartholow et al., 2003; Curtin, Lang, Patrick, & Stritzke, 1998; Marczinski & Fillmore, 2003). In the context of our task, one possibility is that alcohol reduced the effect of unpleasant pictures via a general suppression of emotional processing. This possibility is unlikely, however, because the effect of alcohol on performance was specific, as indicated by the load × condition statistical interaction. In a similar vein, it is unlikely that disinhibition due to alcohol would produce such a selective effect. In addition, the error rates in Experiment 3 were nearly the same as those in Experiment 1, indicating that an overall decline in performance did not occur. In general, the disinhibition hypothesis as an explanation of alcohol-related disregulated behavior has received limited empirical support (Gustafson & Källmén, 1990). Another explanation of the lack of an interference effect is that, under the effect of alcohol, overall processing capacity was possibly reduced in such a way that negative pictures had a reduced capacity to interfere with the bar-orientation task (Josephs & Steele, 1990; Steele & Josephs, 1990). Such a view is consistent with current proposals that the effect of alcohol on behavior is largely mediated by its effect on cognitive systems. In particular, alcohol produces marked impairments on divided-attention tasks involving the simultaneous processing of competing stimuli (Moskowitz, Burns, & Williams, 1985; Moskowitz & Sharma, 1968). For example, Curtin and Fairchild (2003) showed that during a Stroop task, alcohol intoxication reduced frontal ERP components that index evaluative and regulative cognitive control processes. Fillmore and Selst (2002) showed that alcohol reduces the capacity to process information necessary for the execution and suppression of responses in dual-task, but not single-task, conditions. Finally, Curtin, Patrick, Lang, Cacioppo, and Birbaumer (2001) showed that, during intoxication, reductions in fear response (assessed via startle potentiation) occurred only under dual-stimulus conditions and coincided with reduced attentional processing of threat cues as evidenced by brain responses (indexed via P3 ERPs). Thus, overall, our results fit very well with such findings and the general view that alcohol consumption affects the processing of unattended information by reducing the resources available to process them.

In summary, collectively, the present experiments reveal that task difficulty is a key factor in determining whether task-irrelevant affective distractors will interfere with task performance. We suggest that these results may bear light on previous discrepancies in the neuroimaging literature in which some studies have shown no effects of attentional manipulation on amygdala responses, and other investigations have shown the contrary. In fact, in a recent study, we found that differential amygdala responses during the viewing of fearful and neutral faces were observed during low-load conditions, but not during more challenging ones (Pessoa, Padmala, & Morland, 2005).

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