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BRIEF REPORT

Aversive picture processing: Effects of a concurrent task on sustained defensive system engagement

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Abstract

Viewing a series of aversive pictures prompts emotional reactivity reflecting sustained defensive engagement. The present study examined the effects of a concurrent visual task on autonomic, somatic, electrocortical, and facial components of this defensive state. Results indicated that emotional activation was largely preserved despite continuous visual distraction, although evidence of attenuation was observed in startle reflex and electrocortical measures. Concurrent task-specific reactivity was also apparent, suggesting that motivational circuits can be simultaneously activated by stimuli with intrinsic survival significance and instructed task significance and that these processes interact differently across the separate components of defensive engagement.

Descriptors: Emotion, EMG, EEG/ERP, Startle blink, Electrodermal, heart rate

PSYCHOPHYSIOLOGY

Aversive pictures capture attention, prompting a cascade of reflex responses mediated by limbic motivational circuits that enhance perceptual processing and mobilize for defensive action (e.g., Lang & Bradley, 2010). Research further suggests that viewing a prolonged series of aversive pictures prompts a sustained affective state in which defensive responses are maintained, and can increase, across a viewing period (Bradley, Cuthbert, & Lang, 1996; Smith, Bradley, & Lang, 2005). The current study examined effects of distraction on such a state, assessing differences in psychophysiological response modulation when a series of aversive pictures was viewed either with or without a concurrent perceptual task.

Ochsner and Gross (2005) have indicated that distraction can be a strategy for regulating unpleasant emotion that can involve both visual and internal cognitive processes. Studies employing rapidly presented aversive pictures (e.g., 300 ms) have found that distraction by a perceptual task can interfere with amygdala activation (Blair et al., 2007) or with early components of the visual evoked potential (Schupp et al., 2007), although Hajcak, Dunning, and Foti (2007) found that affective modulation of the late positive electrocortical response was unaffected by concurrent mental arithmetic. Neuroimaging studies using longer (4–8 s) picture presentations, however, found that both self-reported negative affect and amygdala activity are attenuated by concurrent cognitive tasks such as mental arithmetic (Van Dillen, Heslenfeld, & Koole, 2009) or working memory (McRae et al., 2009).

In the above studies, aversive images were presented intermixed with neutral and pleasant pictures. In general, these data suggest that distraction can interfere with reactions to single aversive pictures in a dynamically changing context. Considering that more persistent emotional reactions are central to anxiety and affective disorders, we assessed distraction here in the context of a prolonged aversive state, evoked by the viewing of a continuous series of unpleasant pictures. We judged that the most obvious competing task would be in the same perceptual domain as the pictures and from which participants could not divert visual attention. Thus, participants were required to continuously process a series of rapidly changing numbers presented in the center of the visual field and superimposed on the picture. Control picture series were a series of neutral pictures as well as a series of highly pleasant/moderately arousing pictures that were intended to prompt a positive state and to be more engaging than the neutral series. Participants viewed all three series both with and without a concurrent task.

According to a motivational theory of emotion (e.g., Lang & Bradley, 2010; Lang & Davis, 2006), affects are prompted by the activation of limbic survival circuits that tune sensory systems, increase attention and perceptual processing, and mobilize for action. In addressing the effects of attenuation by distraction, the present research assessed a full array of emotion measures: mobilization of the sympathetic system in aversive affect is expected to increase skin conductance response frequency, heart rate deceleration indexes increased attention to threat, augmented motor action is shown by startle potentiation, facial expressivity

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(i.e., corrugator EMG) reflects social communication of threat, and an electrocortical measure (the late positive potential [LPP]) monitors the selective motivational significance of aversive cues (Bradley, 2009).

The present research examines whether a distracting perceptual task attenuates aversive emotional engagement and, if so, if this is a general process or one limited to specific defense reflexes.

Method

Participants

Fifty-one (25 male) University of Florida psychology students received course credit for study participation, approved by the University of Florida Institutional Review Board. Because of equipment or experimenter error, final *N*s were 38 and 49 for corrugator EMG and LPP, respectively.

Materials and Design

Stimuli were 60 aversive, 60 neutral, and 60 positive pictures selected from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008). Mean (*SE*) valence ratings for pictures in the aversive, neutral, and positive series were 2.44 (0.11), 4.97 (0.03), and 7.49 (0.06), respectively; mean (*SE*) arousal ratings were 6.26 (0.09), 3.21 (0.09), and 5.25 (0.12), respectively.

Across the study, nine different picture series were presented. Each series consisted of 20 pictures of the same hedonic content (aversive, neutral, positive), presented for 3 s with no interpicture interval. Three series were presented for free viewing as well as during two slightly different task conditions. All three series (aversive, neutral, positive) were viewed within a condition (i.e., free viewing or concurrent task) prior to a shift. The order of affective content (aversive, neutral, positive) within each distraction condition was counterbalanced for each participant.

In free viewing, a fixation cross continuously appeared at the center of the picture screen. In each of two different concurrent task conditions, the cross was replaced by a small circle at fixation (0.75° of visual angle) containing a number (1–9) that changed every 750 ms. Participants performed either a target detection task (button press to a target number) or a one-back task (button press to a target preceded by an odd number). Twenty-five participants completed free viewing followed by the two tasks (free viewing, one-back, detection); 26 participants performed the two tasks followed by free viewing (one-back, detection, free viewing).

Color pictures were displayed via an LCD projector on a screen 1.5 m from the participant. Acoustic startle stimuli (50 ms, 98 dB) were presented over headphones at three intervals (separated by approximately 20 s) during each picture series. VPM (Cook, 2001) controlled data acquisition. For startle, 4-mm Ag-AgCl electrodes were placed over the left orbicularis oculi muscle (Fridlund & Cacioppo, 1986). Raw signals were sampled at 1000 Hz, amplified by 30,000, filtered (28–500 Hz), and integrated (20 ms time constant).

Left corrugator EMG was recorded from 4-mm electrodes, amplified by 30,000, filtered (13–1000 Hz,) and integrated (500 ms time constant). Skin conductance was recorded from 8-mm electrodes filled with 0.5 M NaCl paste on the hypothenar eminence of the left palm. Heart rate was recorded from 8-mm electrodes on each forearm. A Schmitt trigger detected R-waves; interbeat intervals were reduced to half-second bins.

Event-related potentials were sampled at 250 Hz using a 129-sensor array, and bandpass filtered (0.1–100 Hz) with a vertex reference. Data were filtered off-line (BESA) at 30 Hz, and stimulus-locked epochs were extracted from 100 ms before to 900 ms after picture onset; ocular artifacts were removed, and an average reference was computed and baseline corrected (100 ms before picture onset).

Procedure

Participants sat comfortably in a sound-attenuated, dimly lit room and were instructed to look at each picture during free viewing and to perform the task as accurately as possible for the task conditions.

Data Reduction and Analysis

Blinks were scored using a peak-scoring algorithm (Cook, 2001); magnitudes were transformed to T scores for each participant, (scores $>$ 3 standard deviations were excluded). As in other studies measuring state effects (Bradley et al., 1996; Smith et al., 2005), the number of skin conductance responses (>0.05 μS) during each series was calculated. The LPP was scored as the mean amplitude over 18 centro-parietal sites 400 to 800 ms after picture onset. Raw heart rate and corrugator activity were averaged for each picture series.

Analysis of task performance revealed that, although accuracy was slightly lower and reaction time slightly slower in the one-back compared to the detection task, emotional modulation did not differ as a function of task and the data were averaged into a single distraction condition.[1] Accordingly, a 2 (task: free viewing, concurrent task) × 3 (content: aversive, neutral, positive) within-subjects design was employed, with Greenhouse–Geisser corrections used when relevant. A nonparametric test (Friedman's χ^2) evaluated the effect of picture content on task accuracy because the score distribution violated normality.

Results

Skin Conductance

More skin conductance responses were elicited when a concurrent task was performed, compared to free viewing: task, $F(1,50) = 32.48$, $p < .001$, $\eta_p^2 = .394$, and this was found for the aversive as well as for the neutral and positive comparison series: Task × Content, $F(2,100) = 1.02$, $p = .36$ (see Table 1). Overall, more skin conductance responses were elicited during the aversive compared to the neutral ($p = .002$) or positive series ($p = .001$): content, $F(2,100) = 9.19$, $p < .001$, $\eta_p^2 = .155$).

Heart Rate

Heart rate increased during concurrent task performance compared to free viewing: task, $F(1,50) = 22.8$, $p < .001$, $\eta_p^2 = .313$, which was evident for the aversive as well as neutral and positive

[1]Two tasks were initially included to investigate effects of task difficulty on responding. Although reaction time was slightly slower during the one-back task (mean: 690 ms) compared to the detection task (mean: 556 ms), $F(1,46) = 31.6$, $p < .001$, and accuracy was slightly reduced (one-back mean: 0.85, detection mean: 0.95; Friedman's $\chi^2 = 13.9$, $p < .001$), ANOVAs using task (detection or one-back) and content (aversive, neutral, or positive) found no significant interactions involving task and content for any affect measure, and therefore the data were averaged into a single distraction condition for simplicity of reporting.

Table 1. *Mean (SE) for Each Dependent Measure as a Function of Picture Series Content, Separately for Free Viewing (No Task) and Task Contexts*

	Aversive	Neutral	Positive
Skin conductance (no. of responses)			
Free viewing	2.7 (0.5)	1.6 (0.3)	2.0 (0.4)
Concurrent task	4.3 (0.5)	3.6 (0.4)	3.5 (0.4)
Heart rate (beats per min)			
Free viewing	72.4 (1.4)	74.5 (1.4)	72.7 (1.3)
Concurrent task	74.1 (1.3)	76.3 (1.4)	74.9 (1.3)
Corrugator EMG (μV)			
Free viewing	10.2 (8.1)	8.5 (5.6)	8.3 (5.3)
Concurrent task	10.0 (7.0)	9.5 (6.1)	9.5 (6.2)
Startle magnitude (T score)			
Free viewing	53.5 (1.0)	50.2 (1.0)	50.3 (1.1)
Concurrent task	50.5 (0.5)	49.2 (0.5)	48.7 (0.6)
Late positive potential (μV)			
Free viewing	2.0 (0.2)	0.7 (0.2)	1.2 (0.3)
Concurrent task	0.9 (0.2)	− 0.1 (0.1)	0.8 (0.2)
Task accuracy (% correct)	632 (15)	626 (18)	626 (15)
Task reaction time (ms)	91 (.02)	92 (.01)	87 (.02)

Note: Values reflect startle reflex magnitude (*T*-score: mean within-subject = 50), skin conductance (number of skin conductance responses greater than 0.05 μS), average heart rate, average corrugator muscle activity, and amplitude of the late positive potential (mean over 18 centroparietal sensors, 400–800 ms after picture onset). Reaction time and accuracy scores are presented for the concurrent task condition.

comparison series: Task × Content, $F(2,100) < 1.0$ (see Table 1). Overall, compared to the neutral picture series, heart rate was slower during aversive ($p < .001$) and positive ($p < .001$) viewing: content, $F(2,100) = 26.5$, $p < .001$, $\eta_p^2 = .346$.

Corrugator EMG

Corrugator tension increased slightly during distraction compared to free viewing: task, $F(1,37) = 4.0$, $p = .05$, $\eta_p^2 = .10$. A marginally significant interaction suggested that effects of picture content on corrugator activity differed by task: Task × Content, $F(2,74) = 3.0$, $p = .06$, $\eta_p^2 = .08$; overall content, $F(2,74) = 4.3$, $p = .04$, $\eta_p^2 = .10$. As illustrated in Figure 1 (top), during free viewing, corrugator tension was enhanced for the aversive compared to neutral ($p = .05$) and positive ($p = .03$) series: simple effect of content, $F(1,37) = 5.3$, $p = .03$, $\eta_p^2 = .13$. During concurrent task performance, picture content no longer modulated corrugator activity: simple effect of content, $F(1,37) = 2.5$, $p = .12$. Separate tests for each picture content indicated greater activity during concurrent task performance compared to free viewing, for neutral ($p = .03$, one-tailed) and positive ($p = .004$) series versus commensurate increases for aversive picture series ($p > .05$).

Startle Magnitude

Across picture contents, differences in startle magnitude as a function of task did not reach significance: task, $F(1,48) = 3.2$, $p = .08$, $\eta_p^2 = .06$. Larger startle blinks were elicited by probes presented during aversive picture series versus neutral ($p = .01$) or positive ($p = .008$) series: content, $F(2,96) = 6.4$, $p = .003$, $\eta_p^2 = .117$ (see Table 1), and this overall pattern did not differ as a function of distraction: Task × Content, $F(2,96) = 1.23$, $p = .30$. On the other hand, specific a priori comparisons indicated that startle magnitude was significantly larger during aversive series presented during free viewing as compared to distraction, $t(48) = 2.3$, $p = .025$.

Late Positive Potential

The amplitude of the LPP was smaller during distraction compared to free viewing: task, $F(1,48) = 61.8$, $p < .001$, $\eta_p^2 = .41$ (Figure 1, bottom panel). Independently, LPP amplitude was larger for aversive compared to both the neutral ($p < .001$) and the positive series ($p = .002$): content, $F(2,96) = 27.8$, $p < .001$, $\eta_p^2 = .37$). A marginal Task × Content interaction, $F(2,96) = 3.2$, $p = .056$, $\eta_p^2 = .059$, suggested enhanced positivity for aversive compared to positive series during free viewing ($p = .002$), whereas no such difference emerged during distraction ($p = .44$). On the other hand, either aversive or positive series prompted significantly larger LPPs than the neutral series during both free viewing and distraction ($ps < .05$).

Task Performance

Picture content did not significantly modulate task accuracy (Friedman's $\chi^2 = 4.42$, $p = .11$; see Table 1) or reaction time, $F(2,92) < 1.0$).

Discussion

Overall, the results show that sustained aversive picture viewing prompted emotional reflex activation and ongoing defensive engagement, evident in most measures regardless of whether a concurrent task was performed. Additionally, for any picture series, performance of a concurrent task was associated with heightened reactivity that was similar to, yet separate from, affective engagement. The interaction of these two processes differed across defense response components.

Viewing of aversive pictures, compared to neutral or positive, prompted relative heart rate deceleration, a greater number of skin conductance responses, and startle reflex potentiation. These responses likely reflected enhanced attentional orienting, sympathetically mediated response mobilization, and heightened defensive action preparation, respectively. Such response modulation persisted despite distraction—a pattern that was also found for electrocortical responses indexing processing of motivational significance. Indeed, the viewing of aversive compared to neutral picture series was associated with an enhanced late positive potential, an effect also observed when distraction involves internal subtraction rather than an external visual task (Hajcak et al., 2007). These findings together suggest that attentional and sympathetic response mobilization components of defensive responding are activated despite concurrent distraction.

Regarding selective cortical processing, it is noteworthy that, although LPP amplitude was modulated by picture content during distraction, the pattern was not identical during free viewing. Whereas arousing aversive pictures prompted a larger LPP than the moderately arousing positive series during free viewing (as expected), the LPP for aversive pictures did not differ from that for positive content during distraction. One interpretation is that distraction can attenuate selective processing of aversive pictures. Startle reflex data also suggested relative attenuation of somatic action preparation during distraction, whereas startle was potentiated during aversive processing regardless of task context; potentiation was larger when there was no distraction. Although effects suggesting attenuated aversive processing were relatively small here, they are in line with recent work reporting reduced amygdala activation during concurrent task performance (e.g., Van Dillen et al., 2009).

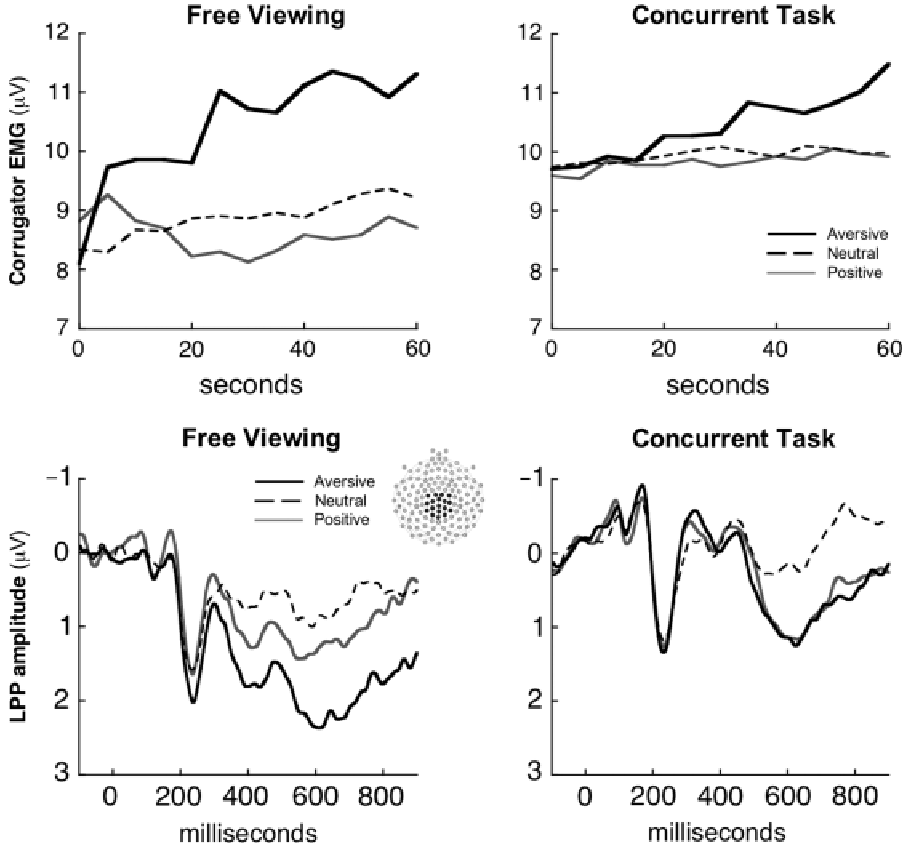

Figure 1. Top panel: Corrugator electromyographic activity for aversive, neutral, and positive picture series during free viewing (left) or distraction (right). Bottom panel: Event-related potentials for aversive, neutral, and positive pictures during free viewing (left) or distraction (right).

Differing from other affect measures, the specific facial frowning increase for aversive pictures during free viewing, relative to the neutral and positive series, was not seen during distraction. Instead, corrugator tension increased overall during the concurrent task, bringing all three series to the same level. These results are consistent with findings that facial muscle tension increases with greater task demand (Tassinary, Cacioppo, & Vanman, 2007), suggesting that facial tension associated with concentration on the number task overshadowed threat-specific facial action.

In addition to increased facial muscle tension, task performance was associated with more skin conductance responses and increased heart rate overall. As enhanced autonomic activity occurs with task effort (e.g., Kalamas, Gruber, & Rypma, 1999), active task participation likely recruited orienting and response mobilization systems regardless of picture content. It is notable, however, that this did not seem to impact engagement of the same systems by ongoing aversive processing. A similar overall task effect was observed for late cortical positivity as LPP amplitude was reduced during distraction. From a resource-sharing perspective (e.g., Desimone, 1998), an index of motivational significance could be somewhat reduced when subjects are simultaneously processing other stimuli with instructed significance.

In summary, although many components of ongoing defensive engagement were preserved during continuous visual distraction, evidence of attenuation was observed in startle reflex and electrocortical measures, and independent task-specific reactivity was also apparent. These findings are consistent with the view that motivational circuits are activated when stimuli have intrinsic survival significance as well as when motivational significance is instructed. The degree to which affective and task stimuli activate these systems may determine the level of defensive reactivity observed in a given response component. Indeed, considering high accuracy rates (over 80%) in the current study, it is likely that more difficult tasks could further reduce or even eliminate components of defensive responding other than facial expressivity, which is an interesting research avenue to pursue. Finally, future studies using this dual-task paradigm may prove useful in assessing emotion control in anxious and affective pathology.

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