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Unmasking emotion: Exposure duration and emotional engagement

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Abstract

Effects of exposure duration on emotional reactivity were investigated in two experiments that parametrically varied the duration of exposure to affective pictures from 25–6000 ms in the presence or absence of a visual mask. Evaluative, facial, autonomic, and cortical responses were measured. Results demonstrated that, in the absence of a visual mask (Experiment 1), emotional content modulated evaluative ratings, cortical, autonomic, and facial changes even with very brief exposures, and there was little evidence that emotional engagement increased with longer exposure. When information persistence was reduced by a visual mask (Experiment 2), differences as a function of hedonic content were absent for all measures when exposure duration was 25 ms but statistically reliable when exposure duration was 80 ms. Between 25–80 ms, individual differences in discriminability were critical in observing affective reactions to masked pictures.

Descriptors: Emotion, Masking, Duration, Affect, Pictures, Affective perception

Motivationally relevant cues elicit a broad range of emotional responses, involving autonomic, cortical, and subjective changes that reflect the motivational system that is engaged (i.e., defensive or appetitive) and its intensity of activation (Bradley & Lang, 2007). Many studies have found that when participants view pictures for a sustained period of time (e.g., 6 s), cortical and peripheral changes co-vary either with system engagement (valence) or with motive intensity (arousal). For instance, compared to neutral pictures, both pleasant and unpleasant pictures prompt a marked positive late potential (LPP; e.g., Codispoti, Ferrari, & Bradley, 2007; Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000), as well as larger skin conductance changes (e.g., Lang, Greenwald, Bradley, & Hamm, 1993). On the other hand, corrugator electromyographic (EMG) activity varies with affective valence, with larger corrugator EMG responses when viewing unpleasant, compared to pleasant or neutral, pictures (e.g., Lang et al., 1993).

For a variety of methodological, conceptual, and theoretical reasons, however, experimental exposure to affective pictures can vary from brief to sustained durations. In this study, we explore effects of exposure duration on emotional reactivity when pictures are presented from 25 ms to 6 s, comparing affective modulation of the late positive potential of event-related potential (ERP), electrodermal responses, facial muscle activity, and evaluative judgments. The resulting database provides information regarding whether brief exposures are sufficient to elicit affective reactions in a variety of response systems, as well as whether the magnitude of emotional reactivity increases or decreases as exposure duration changes.

In studies that have explored effects of an exposure less than 6 s, evidence of affective modulation was evident in both the late positive potential (e.g., De Cesarei & Codispoti, 2006; Johnston & Wang, 1991; Kayser et al., 1997; Schupp, Junghöfer, Weike, & Hamm, 2004) as well as in skin conductance change (e.g., Codispoti, Bradley & Lang, 2001; Globisch, Hamm, Esteves, & Öhman, 1999). Nonetheless, in the absence of a direct comparison across a variety of exposure durations, it is not clear whether presentation duration modulates the magnitude of emotional reactivity, or whether there is a minimal duration necessary to elicit measurable changes. In the current study, we assessed the effects of exposure duration on affective responding by parametrically varying exposure duration from 25–6000 ms while measuring evaluative, facial, and autonomic responses, as well as the late positive component of the ERP.

In the absence of a perceptual masking stimulus that immediately follows picture presentation, visual processing can continue, due to information persistence (Coltheart, 1980; Loftus, Duncan, & Gehrig, 1992). Thus, even with the brief durations previously explored (e.g., 100 ms), it is possible that affective modulation reflects this facet of perceptual processing. To more specifically assess the effects of exposure duration alone, in Experiment 2 we reduced information persistence by presenting a visual pattern mask immediately following picture offset. Pictures were presented for either 25, 40, 50, 80, 150, 250, or 1000 ms and followed by a 1 s visual pattern mask, while evaluative,

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electrodermal, and electrocortical responses were again measured. The primary goal of Experiment 2 was to assess at what exposure duration emotional engagement is reliably obtained, whether the same duration is effective in eliciting modulation in each dependent measure, and how individual differences in the ability to evaluatively discriminate among picture contents is related to differences in physiological engagement.

EXPERIMENT 1

Method

Participants

Participants were 99 (54 female) students from the University of Bologna.

Materials and Design

Ninety-six pictures were selected from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2005) including 32 pleasant, 32 neutral, and 32 unpleasant pictures.

Exposure duration was 80, 500, 2000, or 5000 ms in one group of participants ($n = 50$) and 25, 250, 1500, or 6000 ms in another group of participants ($n = 49$). Intertrial intervals varied from 10 to 20 s.

Pictures were presented 1.8 m from the participant's eyes, subtending 8.85° horizontally and 6.65° vertically, using an Ektagraphic III E projector (Kodak, Rochester, NY) equipped with a high-speed M.41010A shutter (Lafayette Instrument Co., Lafayette, IN) situated in a room adjacent to the experimental room. Photodiode measurements assured accurate exposure duration (Wiens, 2006). Pictures were equivalent in brightness, contrast, and mean spatial frequency in each category. Three orders varied picture order, and four timing orders completely counterbalanced exposure duration for a specific picture.

An acoustic startle probe was presented at 3 s following picture onset; these data are not reported here.

Physiological Recording and Data Reduction

Stimulus control and physiological data acquisition were accomplished using VPM software (Cook, 1997). All physiological signals were acquired using a Labmaster A/D board (Scientific Solutions, Mentor, OH) controlled by a personal computer.

Corrugator EMG activity was measured using miniature electrodes placed above the left eye. The raw EMG signal was bandpass filtered between 30 Hz–1000 Hz, and rectified and integrated using a time constant of 100 ms using a UF-12/72BA amplifier (SA Instrumentation Co., San Diego, CA). Skin conductance was recorded with two large electrodes filled with appropriate paste and placed on the hypothenar eminence of the left palm. The signal was acquired using a V71-23 module (Coulbourn Instruments, Whitehall, PA). Data were averaged in half-second bins, and deviated from the 1 s preceding picture onset. Corrugator EMG response was scored as the average change over the 6-s viewing interval.[1] Skin conductance (SC) was scored as the maximum change occurring between 1–4 s from picture onset and log transformed.

EEG (30 Hz high frequency cut off; 10 s time constant) was sampled at 125 Hz at Fz, Cz, and Pz and over the mastoids (A1, A2) using a UF-12/72BA amplifier; vertical and horizontal eye movements were also measured. Each channel was referenced to Cz and re-referenced off-line to linked mastoids with a 120 ms baseline; 9.3% of the trials were offscale and excluded. Eye movement correction (Miller, Gratton, & Yee, 1988) was applied to single EEG trials. Based on visual inspection and previous studies (e.g., Cuthbert et al., 2000), statistical analyses were conducted using the mean voltage in a time window between 400–800 ms over Pz.

Pleasure and arousal were rated on a 9-point scale using the Self-Assessment Manikin (SAM; Lang, 1980).

Procedure

Following informed consent, sensors were attached and the participant was instructed that a series of pictures would be presented, either briefly or for a longer duration. Participants were instructed to comfortably maintain fixation on a central point throughout the study. Participants rated each picture 10 s after onset.

Data Analysis

Because not all subjects contributed data at each exposure duration, the main ANOVAs used picture (i.e., $n = 96$) as the random factor. In these analyses, responses were determined for each participant and for each trial and were averaged for each picture and exposure duration. Picture content (pleasant, neutral, unpleasant) was a between-picture factor and exposure duration (8 levels) a within-picture factor. There were at least 42 subjects contributing to each data point. Two analyses are reported when the data were from the same set of subjects (e.g., effects of content at each duration), using picture as the random factor (F_{pic}) and using subject as the random factor (labeled F_{sub}). Huynh–Feldt correction was used when appropriate. Orthogonal polynomial contrasts (linear and quadratic) were employed to establish whether individual measures followed a pattern of valence or arousal modulation. The partial eta squared statistic (η^2), indicating the proportion of the variance explained by one experimental factor and the total variance, has been calculated and is reported.

Results

Evaluative Judgments

Figure 1 illustrates the affective space formed by plotting each picture by its mean pleasantness and arousal rating, separately for each exposure duration.

Pleasure Rating. The main effect of Picture Content was significant, $F_{pic}(2, 141) = 371.8$, $p < .001$, $\eta^2 = .84$. As illustrated in Figure 2a, at each exposure duration, pleasant, neutral, and unpleasant pictures were rated as different in pleasure, Picture Content $F's_{pic}(2, 141) > 130.01$, $p < .001$, $\eta^2 > .65$ and $F's_{sub}(2, 94) > 79.53$, $p < .001$, $\eta^2 > .63$. An interaction of Picture Content and Exposure Duration, $F_{pic}(14, 987) = 11.23$, $p < .001$, $\eta^2 = .14$, primarily indicated that compared to neutral pictures, unpleasant pictures presented for 250 ms were rated as slightly more unpleasant than when they were presented for 25 ms, as illustrated in Figure 2a, $F_{pic}(1, 96) = 28.8$, $p < .001$, $\eta^2 = .23$. No other differences were significant.

Arousal Rating. The main effect of Picture Content was significant, $F_{pic}(2, 141) = 634.6$, $p < .001$, $\eta^2 = .90$. At each exposure duration, pleasant and unpleasant pictures were rated as more

[1]Analyses conducted using the first 3 s were similar in all major aspects to those reported here for the average of 6 s.

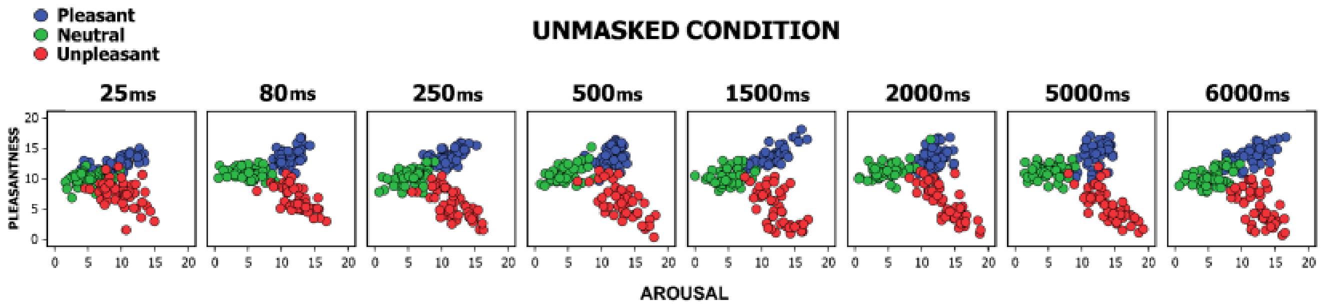

Figure 1. The 2-dimensional affective space defined by mean pleasure (y-axis) and arousal (x-axis) ratings of pleasant, neutral, and unpleasant pictures at each exposure duration (unmasked) in Experiment 1.

arousing than neutral stimuli, Picture Content $F's_{pic}(2, 141) > 73.51$, $p < .001$, $\eta^2 > .51$ and $F's_{sub}(2,94) > 52.3$, $p < .001$, $\eta^2 > .52$, Emotional vs Neutral (Quadratic) $F's_{pic}(1,141) > 147.61$, $p < .001$, $\eta^2 > .51$ and $F's_{sub}(1,47) > 68.06$, $p < .001$, $\eta^2 > .59$. An interaction of Picture Content and Exposure Duration, $F_{pic}(14, 987) = 6.21$, $p < .001$, $\eta^2 = .08$., indicated that

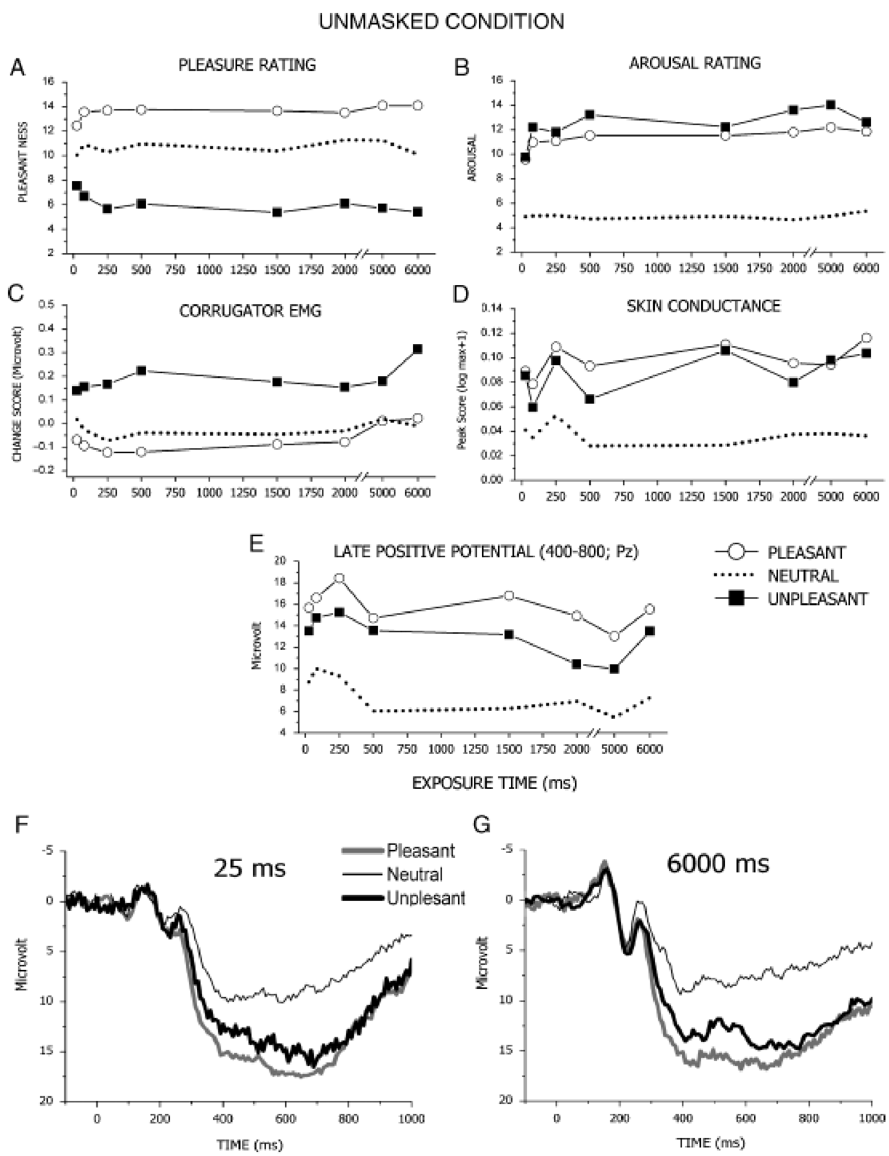

Figure 2. Experiment 1. Mean (A) pleasure ratings, (B) arousal ratings, (C) corrugator EMG changes, (D) skin conductance change, and (E) the late positive potential as a function of hedonic content and exposure duration (25 ms, 80 ms, 250 ms, 500 ms, 1.5 s, 2 s, 5s, and 6s; unmasked). Grand average ERP waveforms at Pz for pleasant, neutral, and unpleasant (unmasked) pictures presented for 25 ms (F) and 6 s (G).

the difference in rated arousal between unpleasant and neutral pictures increased from 25 to 80 ms and from 250 to 500 ms ($F's_{pic}(1,96) > 10.44$, $p < .01$, $\eta^2 > .10$), as illustrated in Figure 2b. Similarly the difference in rated arousal between pleasant and neutral pictures also increased from 25 to 80 ms ($F_{pic}(1,96) = 6.03$, $p = .05$, $\eta^2 > .06$). Overall, unpleasant pictures were rated as slightly more arousing than pleasant pictures in this sample $F_{pic}(1,95) = 22.4$, $p < .001$, $\eta^2 = .19$.

Corrugator EMG

Picture hedonic content affected corrugator EMG activity, $F_{pic}(2,141) = 45.41$, $p < .001$, $\eta^2 = .39$, with unpleasant pictures eliciting larger corrugator EMG activity than either neutral or pleasant stimuli, $F's_{pic}(1,95) > 43.94$, $p < .001$, $\eta^2 > .32$. As illustrated in Figure 2c, this effect was found at all exposure durations, Picture Content $F's_{pic}(2,141) > 4.26$, $p < .001$, $\eta^2 > .06$, and $F's_{sub}(2,94) > 3.30$, $p < .05$, $\eta^2 > .08$. The interaction of Exposure Duration and Picture Content was not significant ($p > .05$).

Skin Conductance

The main effect of Picture Content was significant, $F_{pic}(2,141) = 10.7$, $p < .001$, $\eta^2 = .13$, with pleasant and unpleasant picture viewing eliciting larger skin conductance changes than neutral pictures at each exposure duration except for the shortest (25 ms), Picture Content $F's_{pic}(2,141) > 4.16$, $p < .05$, $\eta^2 > .06$ and $F's_{sub}(2,82) > 4.49$, $p < .05$, $\eta^2 > .10$, Emotional vs Neutral (Quadratic) $F's_{sub}(1,41) > 7.01$, $p < .05$, $\eta^2 > .16$. The interaction of Exposure Duration and Picture Content was not significant ($p > .05$) (see Figure 2d).

Event-related Potentials

Pleasant and unpleasant pictures elicited larger late positive potentials compared to neutral stimuli, Picture Content $F_{pic}(2,141) = 111.3$, $p < .001$, $\eta^2 = .61$, and this effect was observed at each exposure duration (see Figure 2e), Picture Content $F's_{pic}(2,141) > 17.99$, $p < .001$, $\eta^2 > .18$ and $F's_{sub}(2,82) > 20.07$, $p < .001$, $\eta^2 > .35$, Emotional vs Neutral (Quadratic) $F's_{sub}(1,41) > 38.36$, $p < .05$, $\eta^2 > .50$. In this study, pleasant pictures evoked slightly larger late positivity than unpleasant stimuli $F_{pic}(1,95) = 20.7$, $p < .001$, $\eta^2 = .18$. The interaction of Exposure Duration and Picture Content was not significant ($p > .05$).

EXPERIMENT 2

When pictures were presented even for a very brief duration (25 ms), significant differences were obtained in evaluative reports, cortical response, and facial EMG reactions that varied with picture hedonic content. On the other hand, if not followed by a visual masking stimulus, information persistence could have prolonged the effective exposure durations in Experiment 1. Thus, in Experiment 2, we assessed effects of exposure duration alone by following picture offset with a visual pattern mask in order to terminate picture processing. Exposure duration was varied from 25–1000 ms and a 1 s visual pattern mask immediately followed picture offset; the same emotional reactions were assessed as in Experiment 1.

Method

Participants

Participants were 97 (52 female) students of the University of Bologna.

Design and Procedure

Changes from Experiment 1 were that 1) each picture was immediately followed by a 1 s visual pattern mask, and 2) exposure duration was 25, 80, 150, and 1000 ms in one group ($n = 47$), and 40, 50, 250, and 1000 ms in Group 2 ($n = 50$). When pictures were presented for 1000 ms and followed by a mask, similar evaluative (arousal and valence), cortical (LPP), and peripheral responses (SC and corrugator EMG) were found in the two groups of participants (all $p > .05$), hence in the analysis using picture as the random factor the data from the two groups was collapsed. The pattern mask was formed by cutting a set of pictures into small pieces and intermixing them. Pictures and masks were projected from outside of the participant room using two Ektagraphic III E projectors (Kodak) equipped with high-speed M.41010A shutters (Lafayette Instrument Co.). Participants were asked to rate the picture preceding the mask.

Results

Evaluative Judgments

Figure 3 illustrates the affective space formed by plotting each picture by its mean pleasantness and arousal rating, separately for each exposure duration.

Pleasure Rating. The main effect of Picture Content was significant, $F_{pic}(2,141) = 342.72$, $p < .001$, $\eta^2 = .83$, as was the interaction of Picture Content and Exposure Duration, $F_{pic}(12,846) = 66.01$, $p < .001$, $\eta^2 = .48$. As illustrated in Figure 4a, for pictures presented for 25 ms (and masked), ratings of pleasure did not vary as a function of hedonic content, $F_{pic}(2,144) = .27$, $p > .05$; $F_{sub}(2,88) = .8$, $p > .05$. By 40 and 50 ms, however, pleasant, neutral, and unpleasant pictures were each rated as different in rated pleasure, $F_{pic}(2,141) = 12.85$, $p < .001$, $\eta^2 = .15$; $F_{sub}(2,88) = 21.36$, $p < .001$, $\eta^2 = .33$ for 40 ms; $F_{pic}(2,141) = 26.06$, $p < .001$, $\eta^2 = .27$; $F_{sub}(2,88) = 19.99$, $p < .001$, $\eta^2 = .3$, for 50 ms. Moreover, as illustrated in Figure 4a, the difference in rated pleasure between emotional and neutral pictures increased linearly from 50 ms to 250 ms of exposure duration, $p < .01$, and did not significantly differ thereafter.

Arousal Ratings. The main effect of Picture Content was significant, $F_{pic}(2,141) = 243.04$, $p < .001$, $\eta^2 = .77$, as was the interaction of Picture Content and Exposure Duration, $F_{pic}(12,846) = 15.87$, $p < .001$, $\eta^2 = .18$. For pictures that were presented for 25 ms (and masked), arousal ratings did not vary as a function of hedonic content, Picture Content $F_{pic}(2,144) = .01$, $p > .05$; $F_{sub}(2,88) = .34$, $p > .05$. By 40 and 50 ms, however, both pleasant and unpleasant pictures were rated as more arousing than neutral pictures, $F_{pic}(2,141) = 3.26$, $p < .05$, $\eta^2 = .04$; $F_{sub}(2,88) = 7.93$, $p < .001$, $\eta^2 = .15$ for 40 ms; Picture Content $F_{pic}(2,141) = 7.24$, $p < .01$, $\eta^2 = .09$; $F_{sub}(2,88) = 10.63$, $p < .001$, $\eta^2 = .19$ for 50 ms. As illustrated in Figure 4b, the difference in rated arousal between emotional and neutral pictures increased significantly from the 80 ms exposure duration to 150 ms, $F_{pic}(1,142) = 9.68$, $p < .01$, $\eta^2 = .06$, and did not significantly differ thereafter.

Corrugator EMG

Picture Content affected corrugator EMG activity, $F_{pic}(2,141) = 33.49$, $p < .001$, $\eta^2 = .32$, and differed by exposure duration, $F_{pic}(12,846) = 1.82$, $p < .05$, $\eta^2 = .03$. As illustrated in

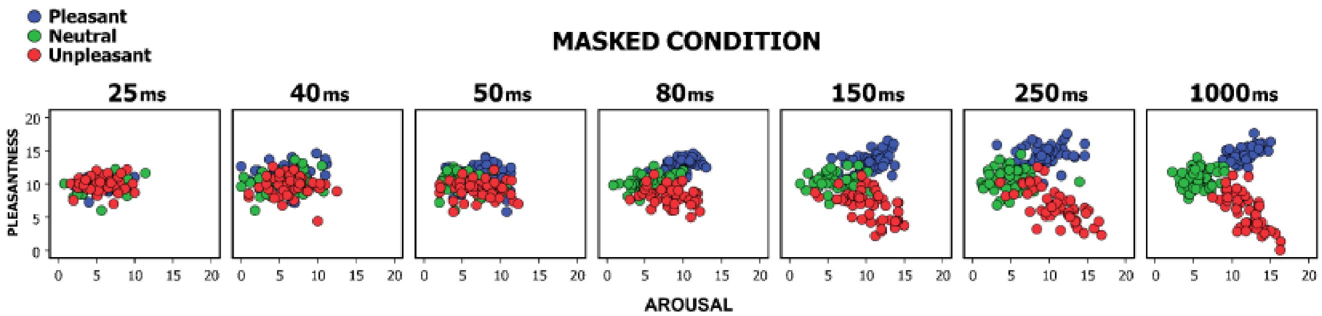

Figure 3. The 2-dimensional affective space defined by mean pleasure (y-axis) and arousal (x-axis) ratings of pleasant, neutral, and unpleasant pictures at each exposure duration (masked) in Experiment 2.

Figure 4c, corrugator activity did not vary as a function of hedonic content for pictures that were presented for 25 ms or for 40 ms, $F_{pic}(2,144) = .7$, $p > .05$; $F_{sub}(2,98) = .72$, $p > .05$. By 50 ms, however, unpleasant pictures elicited larger EMG changes, compared to either neutral ($p < .05$) or pleasant stimuli ($p < .05$), $F_{pic}(2,141) = 3.12$, $p < .05$, $\eta^2 = .08$; $F_{sub}(2,98) = 4.71$, $p < .05$, $\eta^2 = .08$. For longer exposure durations, viewing unpleasant pictures consistently evoked greater corrugator muscle activity than

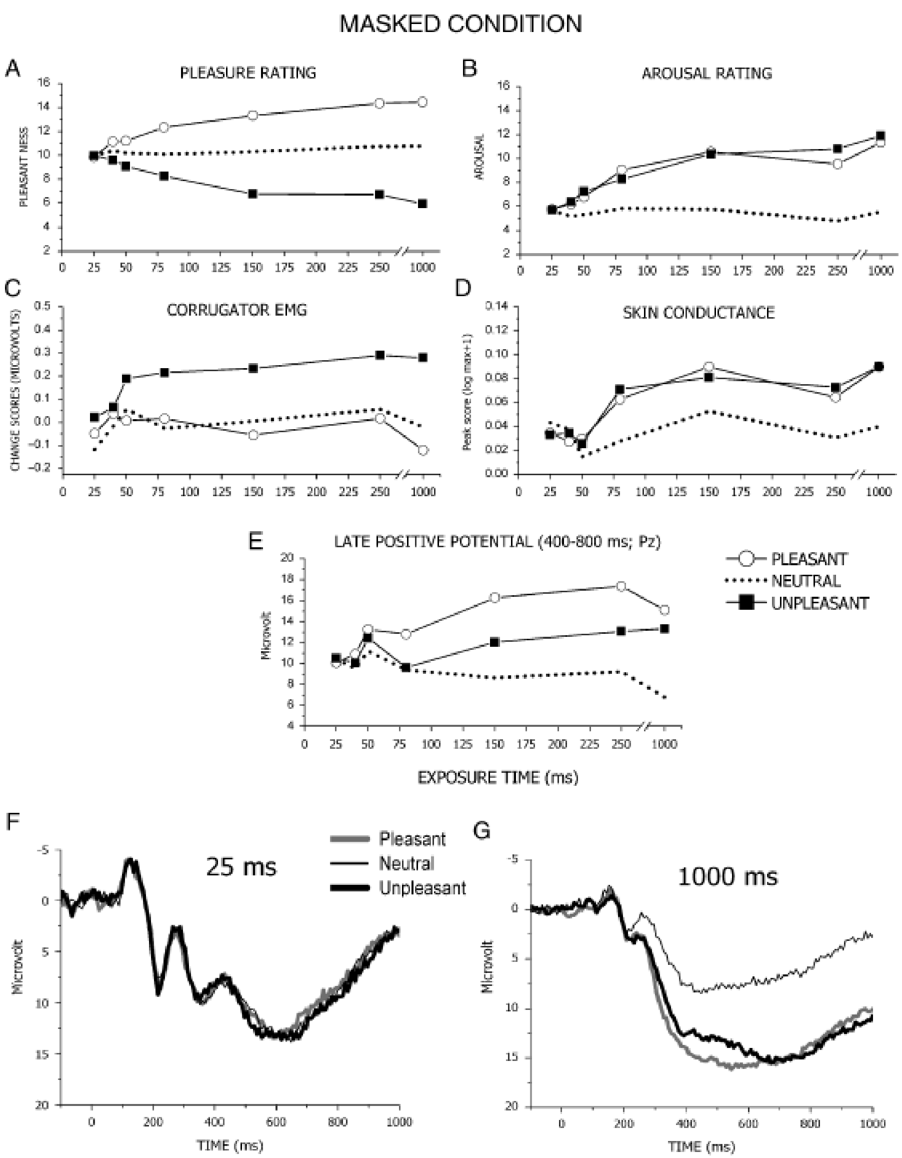

Figure 4. Experiment 2. Mean (A) pleasure ratings, (B) arousal ratings, (C) corrugator EMG changes, (D) skin conductance change, and (E) the late positive potential as a function of hedonic content and exposure duration (25 ms, 40 ms, 50 ms, 80 ms, 150 ms, 250 ms, and 1 s; masked). Grand average ERP waveforms at Pz for pleasant, neutral, and unpleasant (masked) pictures presented for 25 ms (F) and 1 s (G).

pleasant ($p<.05$) or neutral stimuli ($p<.05$), $F's_{pic}(2,141)>5.66$, $p<.01$, $\eta^2>.08$, and $F's_{sub}(2,98)>3.96$, $p<.05$, $\eta^2>.08$.

Skin Conductance

The main effect of Picture Content was significant, $F_{pic}(2, 141)=6.41$, $p<.001$, $\eta^2=.08$. Although the interaction of Exposure Duration and Picture Content did not reach significance, a priori comparisons indicated that skin conductance change was not reliably modulated by hedonic content when exposure duration was less than 80 ms, $F's_{pic}(2,141)<1$, $p>.05$ (see Figure 4d). For all other exposure durations, pleasant and unpleasant pictures elicited larger electrodermal changes than neutral stimuli, $F's_{pic}(2,141)>3.14$, $p<.05$, $\eta^2>.04$ and $F's_{sub}(2,94)>3.63$, $p<.05$, $\eta^2>.07$, Emotional vs Neutral (Quadratic) $F's_{sub}(1, 46)>5.04$, $p<.05$, $\eta^2>.09$.

Event-Related Potentials

The main effect of Picture Content was significant, $F_{pic}(2, 141)=57.58$, $p<.001$, $\eta^2=.45$, as well as the interaction of Picture Content and Exposure Duration $F_{pic}(12,846)=9.62$, $p<.001$, $\eta^2=.12$. The amplitude of the late positive potential did not vary as a function of hedonic content for pictures presented for less than 80, as illustrated in Figure 4e, $F's_{pic}(2,141)<2$, $p>.05$. When exposure duration was increased to 80 ms, Picture Content affected the LPP, $F_{pic}(2,141)=8.5$, $p<.001$, $\eta^2=.11$, $F_{sub}(2,92)=10.01$, $p<.001$, $\eta^2=.18$, with pleasant pictures eliciting larger positivity than neutral or unpleasant pictures, $p_s<.01$. By 150 ms, heightened positivity was obtained when viewing either pleasant or unpleasant, compared to neutral, pictures, $F's_{pic}(2,141)>36.8$, $p<.001$, $\eta^2>.34$, and $F's_{sub}(2, 92)>43.99$, $p<.001$, $\eta^2>.49$, Emotional vs Neutral (Quadratic) $F's_{sub}(1,46)>60.82$, $p<.001$, $\eta^2>.57$ (see Figure 4g).

Individual Differences

Whereas differences in rated pleasure and arousal were obtained for briefly presented masked pictures (i.e., 40 and 50 ms exposure), skin conductance change and the LPP did not show evidence of modulation at these durations. To determine whether those who reliably discriminated in ratings also showed physiological effects, we calculated the difference in rated pleasure for pleasant and unpleasant pictures presented for 40 or 50 ms for each participant, and used a median split to characterize two groups. As illustrated in Figure 5, Discriminators ($N=23$) reliably differentiated between unpleasant and pleasant pictures in rated pleasantness, $F_{sub}(2,44)=64.48$, $p<.001$, $\eta^2=.75$, whereas Non-Discriminators ($N=22$) did not, $F_{sub}(2,42)=.8$, $p>.05$.

A significant interaction of Group and Picture Content was found in arousal ratings $F_{sub}(2,86)=12.1$, $p<.001$, $\eta^2=.24$. indicating that Discriminators rated emotional pictures as more arousing than neutral stimuli, $F_{sub}(2,44)=13.69$, $p<.001$, $\eta^2=.38$, whereas Non-Discriminators did not, $F_{sub}(2,42)=1.8$, $p>.05$. More importantly, as illustrated in Figure 5, Discriminators also showed a significantly larger LPP when viewing masked emotional, compared to neutral, pictures that were presented for 40 or 50 ms, $F_{sub}(2,44)=7.87$, $p<.001$, $\eta^2=.27$, whereas Non-Discriminators did not, $F_{sub}(2,42)=.21$, $p>.05$. Consistent with this, the interaction of Group and Picture Content was significant, $F_{sub}(2,84)=3.68$, $p<.05$, $\eta^2=.08$. Similarly, whereas Discriminators showed larger corrugator EMG activity for unpleasant, compared to pleasant or neutral pictures, $F_{sub}(2,44)=5.40$, $p<.01$, $\eta^2=.19$, Non-Discriminators

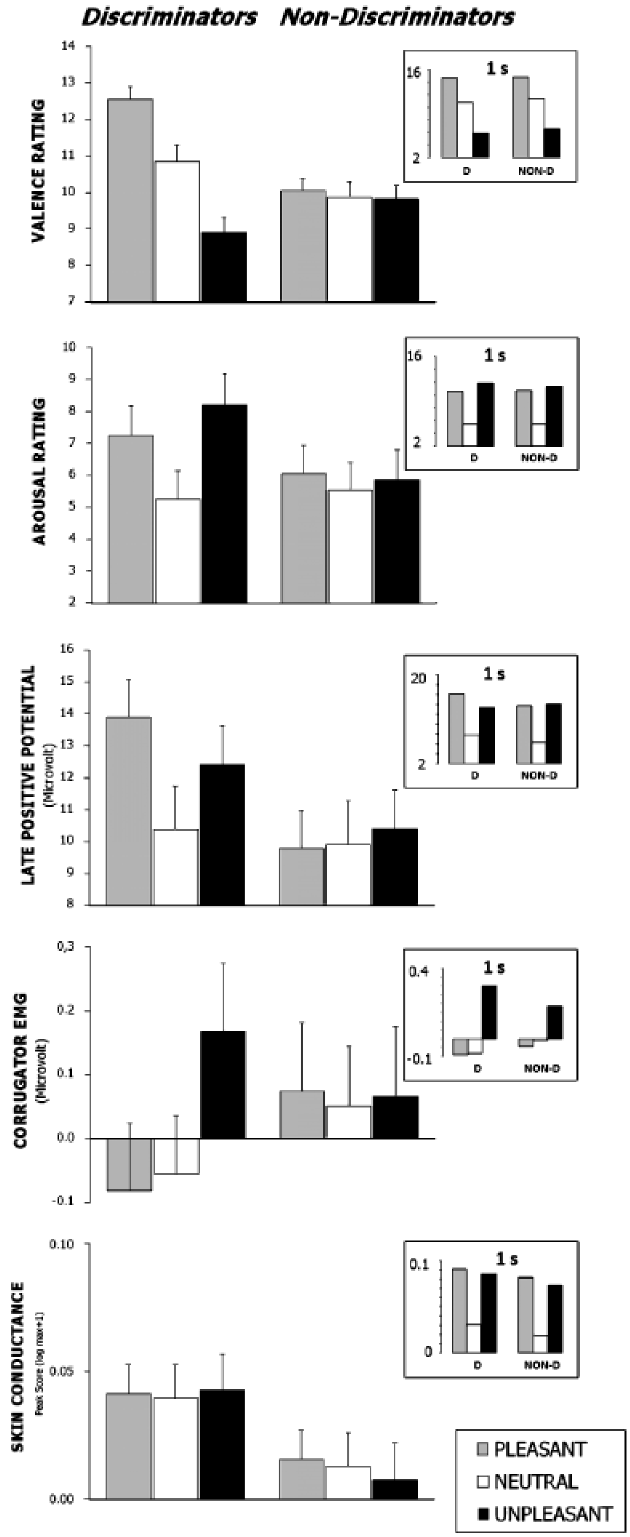

Figure 5. Experiment 2. Mean pleasure ratings, arousal ratings, the amplitude of the late positive potential, corrugator EMG change, and skin conductance and for masked pictures presented for a 40 or 50 ms exposure duration as a function of hedonic content, separately for participants reliably rating pleasant and unpleasant different in rated pleasure (Discriminators) and those who did not reliably discriminate among pleasant and unpleasant pictures (Non-Discriminators) at these exposure durations. Inset illustrates that the two groups did not differ when exposure duration was 1 s (and masked). Error bars represent standard error of the mean.

did not, $F_{sub}(2,42) = .62$, $p > .05$. The interaction of Group and Picture Content was not significant for skin conductance ($p > .05$).

Despite group differences in emotional reactivity following brief (40–50 ms) picture exposures, affective responses for Discriminator and Non-Discrimators were identical when pictures were presented for a longer duration (e.g., 250 ms or 1 s ($p > .05$); see Figure 5).

Discussion

When pictures were not followed by a visual masking stimulus (Experiment 1), emotional engagement was strong and similar in magnitude, regardless of actual exposure duration. Even with very brief exposures, affective pictures elicited evaluative, cortical, and facial changes indicative of emotional engagement. Moreover, there was little evidence that affective reactivity increased with increases in exposure duration. Rather, the pattern of emotional modulation during picture processing was very similar, regardless of exposure duration, when perceptual processing could benefit from short-term information persistence. These data bode well for studies in which brief exposure is desired on the basis of methodological or conceptual issues, as they suggest that in the absence of disruption, very little sensory information is sufficient to prompt the perceptual processes that elicit emotional response. Moreover, these data suggest that, at least with static pictures, affective reactivity is not a function of duration of perceptual processing, but instead seems to rely on the affective information available in the image.

On the other hand, when pictures were immediately followed by a 1 s visual pattern mask (Experiment 2), exposure duration significantly affected emotional engagement. For masked pictures presented for 25 ms, there was no evidence of emotional engagement in any measure. Rather, reliable differences in evaluative, cortical, electrodermal, and facial EMG measures as a function of hedonic content were not apparent across the whole sample until pictures were displayed for about 80 ms. This estimate agrees well with recent studies reporting that accurate identification of natural scenes is strongly reduced when masked pictures are presented for less than 80 ms (e.g., Bacon-Macé et al., 2005; Grill-Spector & Kanwisher, 2005; Rieger, Braun, Bulthoff, & Gegenfurtner, 2005). Similarly, in a recent magnetoencephalography study, recognition of masked faces, as well as the M300, was strongly attenuated for pictures presented for less than 80 ms (Tanskanen, Näsänen, Ojanpää, & Hari, 2007).

For masked pictures presented for slightly shorter exposure durations—40–50 ms—evaluative ratings of pleasure and arousal showed some evidence of affective discrimination, but cortical, facial, and electrodermal changes did not mirror this discrimination at the group level. Rather, only participants who reliably rated pleasant and unpleasant pictures different in hedonic valence following these brief exposures showed significant differences as a function of hedonic content in arousal ratings, the amplitude of the late positive potential, and in corrugator EMG changes. Participants who did not reliably discriminate among picture content in terms of rated pleasure similarly showed no differences as a function of hedonic content in other measures of affective engagement.

At these moderately brief exposure durations, then, marked individual differences were found in which some participants were able to accurately identify hedonic content whereas others were not. Pessoa et al. also reported that only participants able to correctly recognize briefly exposed (33 ms) masked faces showed enhanced amygdala activation when the facial expression depicted fear (e.g., Pessoa, Japee, & Ungerleider, 2005; Pessoa, Japee, Sturman, & Ungerleider, 2006). Taken together, the data suggest that when masked pictures are presented between 25–80 ms in duration, the specific exposure that elicits measurable emotional reactivity varies with individual participants. Previous data reporting that fearful participants react aversively to phobia relevant pictures with very brief (33 ms) masked presentation (e.g., Öhman & Soares, 1994) suggest that fear may be associated with more rapid perception, stronger emotional engagement, or both.

In this study, skin conductance was not affected by picture content when masked pictures were presented for 40–50 ms even for those who reliably rated pleasant and unpleasant pictures as different in hedonic valence (i.e., discriminators). Moreover, in the unmasked condition, reliable arousal modulation of skin conductance was not observed at the shortest exposure duration (25 ms). These findings suggest that this sympathetically mediated response may rely on minimal exposure duration, and that it is attenuated when perceptual information is reduced. Consistent with this interpretation, reducing picture size also prompts a decrease in skin conductance affective modulation (Codispoti & De Cesarei, 2007). Because reliable skin conductance modulation is obtained with an 80 ms exposure, it nonetheless is quite responsive even at brief exposures.

Taken together, the current database represents a resource for researchers who are making decisions regarding exposure duration in the many studies that are currently using affective pictures as cues to elicit emotion in the laboratory. The present findings indicate that even very brief exposure prompts measurable affective reactions when picture processing is not followed by a visual mask, and that affective reactions do not increase (or decrease) with more sustained exposure. When pictures are masked, affective modulation is reliably observed only when pictures are displayed for about 80 ms. At shorter exposure durations (i.e., 40–50 ms), emotional reactivity is highly dependent on the individual participant. Determining the specific mechanism mediating individual differences in perceptual acuity remains a fruitful area for future research.

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