

Affective reactions to briefly presented pictures

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Abstract

Affective reactions to briefly presented pictures were investigated to determine whether fleeting stimuli engage the motivational systems mediating emotional responses. Emotional and neutral pictures were presented for 500 ms; heart rate, skin conductance, corrugator EMG, and the evoked startle reflex were measured. The time course of reflex modulation was similar to that obtained with longer (6 s) presentations, suggesting that picture processing continues in the absence of a sensory stimulus. Affective reactions found with more sustained presentation were also obtained, with more corrugator EMG activity for unpleasant pictures, and greater skin conductance reactivity for emotional pictures. Heart rate modulation, however, appears to rely on the presence of a sensory stimulus. The data also suggest that brief presentations of unpleasant pictures may result in less defensive activation than sustained presentation.

Descriptors: Emotion, Attention, Startle, Reflex modulation, Prepulse inhibition, Affect

Viewing affective pictures elicits a number of physiological reactions in cardiovascular, electrodermal, and somatic systems. For instance, skin conductance responses are larger when viewing emotionally arousing (pleasant or unpleasant) pictures, compared to neutral pictures, whereas corrugator EMG activity and heart rate vary with affective valence, with larger corrugator EMG responses and more deceleratory heart rate responses elicited when viewing unpleasant, compared to pleasant, pictures; the startle reflex is also modulated by the affective content of pictures (see Bradley & Lang, 2000a, for an overview). It is clear that affective pictures are effective cues in activating emotional response.

These affective response patterns have been obtained when participants view pictures for a sustained time period (e.g., 6 s). Here, we investigated whether brief presentations are also able to engage the defensive and appetitive motivational systems that mediate emotional responding (Lang, Bradley, & Cuthbert, 1997). Pictures were presented for 500 ms and skin conductance, heart rate, and corrugator EMG responses were measured for 6 s following picture onset. Predictions are clear: If brief presentations do not activate motivational systems, the modulatory patterns previously obtained will be absent. If brief presentations are sufficient, the identical modulatory patterns will appear.

A particular focus is the pattern of reflex modulation following brief picture presentations, given that affective modulation of the startle reflex is usually observed during active viewing and several seconds after picture onset (see Bradley, Cuthbert, & Lang, 1999, for a review). When acoustic startle probes are presented at different onset delays within a 6-s picture presentation, the blink reflex remains inhibited for up to 3 s after picture onset, and the magnitude and duration of blink inhibition is greater for emotional (pleasant or unpleasant) than for neutral pictures (Bradley, Cuthbert, & Lang, 1993). We have interpreted these unusually extended “prepulse inhibition effects” as reflecting differences in picture encoding, with affectively engaging pictures evidencing “natural selective attention”—drawing more resources during encoding, and for a longer duration of time, than neutral pictures (Bradley & Lang, 2001).

The current study utilized the design of Bradley et al. (1993), in which startle probes are presented at different delays following picture onset. If early blink inhibition reflects differences in picture encoding, we expected to find similar effects following brief presentation, even though a cognitive, rather than a sensory, representation serves as the stimulus. This is consistent with prior research showing that encoding processes continue unimpeded when a visual stimulus is removed, if a second, masking stimulus is not presented (Massaro, 1973). Alternatively, if inhibitory effects on the blink reflex early in the viewing interval reflect operations specifically associated with extracting information from a sensory array, these inhibitory effects should be absent, as the picture is perceptually unavailable after 500 ms.

When viewing a long (6 s) picture presentation, blinks are potentiated for unpleasant, compared to pleasant, pictures beginning around 500 ms after picture onset (Bradley & Lang, 2001), and slightly earlier if an affect-related task is imposed (Vanman, Boehmelt, Dawson, & Schell, 1996). Early affective modulation

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has also been investigated by Globisch, Hamm, Stevens, & Öhman (1999) using phobic subjects and brief (150 ms) pictures of snakes or spiders. Subjects reporting high fear showed significant startle potentiation at 300 ms when viewing fearful, compared to neutral, pictures, whereas low-fear subjects did not. Globisch et al. conclude that fear responses are activated rapidly, with minimal stimulus input. Here, we studied startle modulation in normal subjects after viewing brief presentations of a wide range of both pleasant and unpleasant pictures, assessing the persistence of reactions to cognitive affective representations as compared to response patterns evoked in previous research by a sustained sensory stimulus.

Method

Participants

Fifty-one (23 female) University of Florida introductory psychology students participated as part of a class requirement. Because of equipment failures and/or errors, data were missing for one or more dependent measures for one or more participants. Final sample sizes in each analysis were: skin conductance level, $n = 51$; corrugator EMG, $n = 45$; heart rate, $n = 49$; startle reflexes, $n = 45$.

Materials and Design

The materials and design were identical to that described in Bradley et al. (1993). Fifty-four pictures (18 pleasant, 18 neutral, and 18 unpleasant) were selected from the International Affective Picture System¹ (Center for the Study of Emotion and Attention, 1999). Eleven additional pictures that also varied in pleasantness served as filler stimuli on nonprobed trials (one presented in every block of six pictures). The acoustic startle stimulus consisted of a 50-ms presentation of a 103-dB white noise with instantaneous rise time, presented binaurally over headphones. Each picture was presented for 500 ms, and startle probes were presented either 300, 800, 1,300, 1,800, 2,800, or 4,800 ms after picture onset. The pictures were arranged in nine blocks of six, such that (a) each of the six probe conditions occurred once in each block, and (b) two pictures of each of the three types of valence occurred in each block. Two presentation orders varied the serial position of specific pictures across subjects, and six different timing orders counterbalanced probe-timing condition for specific pictures. The slides were presented using a Kodak Ektagraphic III projector situated adjacent to the experimental room.

After all 54 trials were completed, a yes–no recognition test was conducted to determine whether participants were able to identify the previously seen, briefly presented pictures accurately. In this recognition test, 72 pictures (24 pleasant, 24 neutral, 24 unpleasant) were presented for 500 ms each: 12 pictures of each type of valence had been seen earlier in the experiment; 12 pictures

of each valence were new stimuli that had not been presented in the experiment. The subject was instructed to press one of two buttons on the left or right hand (counterbalanced across subjects), indicating whether the picture had been seen earlier (“yes”) or not (“no”).

Physiological Recording and Data Reduction

The eyeblink component of the startle response was monitored by measuring EMG activity over the orbicularis oculi muscle beneath the left eye. The raw EMG signal was amplified (30,000), and frequencies below 90 Hz and above 250 Hz were filtered using a Coulbourn S75-01 bioamplifier. The raw signal was rectified and integrated using a Coulbourn S76-01 contour following integrator, with an actual time constant of 123 ms. Blink EMG activity was sampled at 1000 Hz for 50 ms prior to the onset of the startle probe, and for 250 ms following probe onset. The startle data were reduced off-line using an interactive MacIntosh program that scored each trial for magnitude in analog to digital units and onset latency in milliseconds, using an algorithm developed by Globisch, Hamm, Schneider, and Vaitl (1993).

The electrocardiogram was amplified with a Coulbourn S75-01 bioamplifier, and heart rate was recorded with a Schmitt trigger that interrupted the computer to measure each R-R interval to the nearest 1 ms. Interbeat intervals were reduced off-line to heart rate in beats per minute in half-second bins.

Skin conductance activity was measured from electrodes placed adjacently on the left hypothenar eminence, using Sensormedics standard electrodes filled with 0.05 M NaCl Unibase paste. The signal was recorded on a Coulbourn S71-22 skin conductance amplifier calibrated to record a range of 0–40 μ S.

Corrugator EMG activity was measured using Sensormedics miniature electrodes placed above the left eye, using the placement recommended by Fridlund and Cacioppo (1986). The raw EMG signal was amplified, and frequencies below 90 Hz and above 1000 Hz were filtered using a Coulbourn S75-01 bioamplifier. The raw signal was amplified by 30,000 and then rectified and integrated using a Coulbourn S76-01 contour following integrator, with a time constant of 500 ms.

Procedure

After filling out a consent form, the sensors were attached, and the subject was instructed that a series of slides would be presented for a very brief period. A fixation point was provided in the center of the screen, and the subject was instructed to comfortably maintain fixation on this point throughout the study. They were told that occasional noises heard over the headphones could be ignored. After all pictures were presented, the 72-picture recognition task was presented.

Data reduction and analysis. Analyses of variance were conducted on startle blink magnitude, the average change score (deviated from a 1-s prepicture baseline) over a 6-s period after picture onset for heart rate and corrugator EMG activity, and the maximum change score (deviated from a 1-s prepicture baseline) between 1 and 4 s post-onset for skin conductance. Significant effects were evaluated at $p < .05$, and Greenhouse-Geisser corrections were used where appropriate.

Results

Startle Reflex

Figure 1 illustrates blink magnitude at different probe delays following brief presentations of pleasant, neutral, and unpleasant

¹The International Affective Picture System (Lang, Bradley, & Cuthbert, 1999) is available on CD-ROM and as photographic slides. These stimulus sets and technical manual can be obtained on request from Margaret M. Bradley or Peter J. Lang, at the NIMH Center for the Study of Emotion and Attention, Box 100165 HSC, University of Florida, Gainesville, FL 32610-0165, USA. The International Affective Picture System identification numbers for unpleasant pictures are 1070, 1090, 1120, 1300, 2120, 3000, 3010, 3100, 3130, 3150, 3530, 6020, 6190, 6200, 6230, 6370, 9040, 9490; for neutral pictures: 2190, 2200, 5500, 7000, 7010, 7020, 7050, 7080, 7090, 7100, 7130, 7150, 7160, 7170, 7180, 7500, 7550, 7700; for pleasant pictures: 1600, 2080, 2250, 4650, 4660, 4680, 7200, 7330, 7350, 8030, 8080, 8200, 8510; 4180, 4210, 4250, 4290, and 4310 for males; 4470, 4490, 4500, 4520, and 4550 for females.

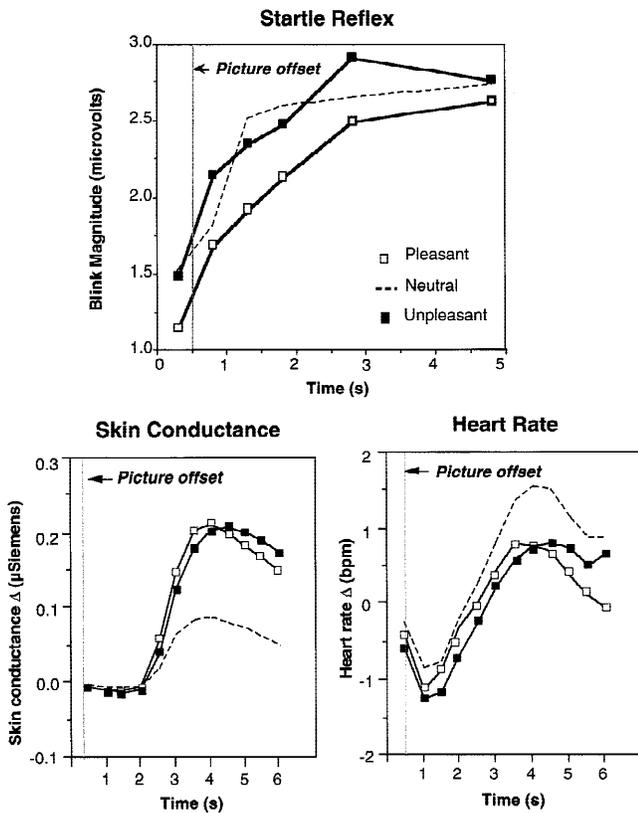


Figure 1. Top panel: Startle blink magnitude for probes delivered at different delays after a 500-ms presentation of pleasant, neutral, or unpleasant pictures. Bottom left panel: Skin conductance change for 6 s following the onset of a 500-ms picture presentation for pleasant, neutral, and unpleasant pictures. Bottom right panel: Heart rate change for 6 s following the onset of a 500-ms picture presentation for pleasant, neutral, and unpleasant pictures.

pictures. Probe delay greatly affected blink magnitude, $F(5,220) = 17.03$. Following Bradley and Lang (2001), pairwise comparisons were conducted on blinks elicited at each probe delay, as well as on blinks at each probe delay and those elicited during the intertrial interval (ITI).

Compared to blinks elicited at the latest probe time (4,800 ms post-onset), blinks elicited at 300, 800, 1,300, and 1,800 ms after picture onset were significantly inhibited, $F_s(1,44) = 47.4, 11.8, 7.2, 5.2$, respectively, whereas those elicited at 2,800 ms after picture onset were not significantly different from those at the latest probe time, $F_s(1,44) < 1$. These data suggest that blinks were relatively inhibited until 2,800 ms after onset. This conclusion was supported by the ITI comparisons: Blinks elicited from 300 to 1,800 ms after picture onset were significantly inhibited, compared to those elicited during ITI, mean = $3.02 \mu\text{V}$; $F(1,44) = 42.7, 25.7, 17.8, 9.4$, for 300, 800, 1,300, and 1,800 ms probes, respectively, whereas those elicited at 2,800 and 4,800 ms after picture onset did not differ from ITI blinks.

The duration of inhibition, defined as the point at which blinks no longer significantly differed from those elicited at all later time points (see Bradley & Lang, 2001) was longer when viewing pleasant (2,800 ms) or unpleasant (2,800 ms), compared to neutral (1,300 ms), pictures. The same pattern was found when compared to ITI blinks, in which blinks ceased being different from ITI

blinks at 4,800 ms for pleasant, 2,800 ms for unpleasant pictures, and at 1,800 ms for neutral stimuli.

Replicating studies using longer picture presentations, the pleasantness of the picture affected blink magnitude, $F(2,88) = 9.85$. Larger startle reflexes were elicited when processing unpleasant, compared to pleasant pictures, $F(1,44) = 12.55$, and inhibited when viewing pleasant, compared to neutral, pictures, $F(1,44) = 13.86$. These effects of picture pleasantness did not depend upon probe position, interaction $F < 1$, and were significant even at the earliest probe time (300 ms), valence $F(2,88) = 4.38$; unpleasant versus pleasant, $F(1,44) = 6.74$; pleasant versus neutral, $F(1,44) = 6.61$. Compared to neutral pictures, however, blinks were not facilitated when viewing unpleasant stimuli at any probe delay.²

Skin Conductance

Replicating effects obtained using a longer viewing interval, picture content affected skin conductance magnitude, $F(2,100) = 16.13$ (see Figure 1, bottom left). Larger increases in skin conductance were elicited when subjects processed emotional pictures (either pleasant or unpleasant) compared to neutral pictures, $F(1,50) = 36.85$ for unpleasant pictures and $F(1,50) = 18.76$ for pleasant pictures. No differences were found in skin conductance magnitude when processing pleasant, compared to unpleasant, pictures.

Corrugator EMG

Corrugator EMG changes varied with picture pleasantness, $F(2,88) = 9.41$, with larger changes occurring when processing unpleasant pictures (mean change = $0.12 \mu\text{V}$, $SD = 0.35$), compared to either pleasant (mean change = $-0.12 \mu\text{V}$, $SD = 0.29$, $F[1,44] = 14.01$) or neutral materials (mean change = $0.01 \mu\text{V}$, $SD = 0.27$, $F[1,50] = 4.92$). Corrugator EMG activity was also significantly lower when processing pleasant, compared to neutral, pictures, $F(1,50) = 6.53$.

Heart Rate

Heart rate response as a function of picture valence differed dramatically from that typically obtained during a 6-s picture presentation (see Figure 1, bottom right). Specifically, although a classic triphasic waveform (Gatchel & Lang, 1973) was obtained, consisting of an initial deceleration, subsequent acceleration, and a secondary deceleration time, $F(11,528) = 22.72$; cubic trend $F(1,48) = 25.23$, average heart rate change did not significantly vary with the affective content of the picture.

Recognition Task

Postexperimental recognition accuracy was quite high for both previously presented (87%) and new pictures (92%), indicating that participants were clearly able to encode (and later recognize) pictures presented for the brief 500 ms duration used in the current study.

Discussion

In most ways, affective reactions were similar for briefly presented (500 ms) pictures as found previously using longer (6 s) presen-

²Unpleasant pictures were divided into a subset of high and low arousal materials to determine whether, compared to neutral pictures, potentiation occurs for highly arousing unpleasant stimuli. Blinks following brief presentation, however, were not significantly potentiated even when viewing highly arousing unpleasant pictures, unlike previous studies using more sustained picture presentation (e.g., Bradley & Lang, 2001).

tation intervals. Skin conductance changes were significantly larger for emotionally arousing (pleasant or unpleasant) pictures, compared to neutral pictures, and corrugator EMG activity was greater following presentation of unpleasant, compared to pleasant, pictures (e.g., Lang, Bradley, Cuthbert, Hamm, 1993). These data are consistent with the idea that a briefly presented picture, in the absence of a masking stimulus, effectively activates emotional responses. On the other hand, heart rate following a brief picture presentation differed substantially from a more sustained presentation: initial deceleration was minimal, and picture valence had no discernible effect. These data suggest that initial heart rate deceleration is associated specifically with sensory detection (Graham, 1992; Lacey and Lacey, 1970), and that heart rate is particularly sensitive to task parameters, as noted previously (Lang, Bradley, & Cuthbert, 1990; Lang et al., 1997).

The development of startle modulation was also similar to that found for more sustained presentations (Bradley et al., 1993): Blinks were generally inhibited for up to 3 s after picture onset (compared to blinks elicited in the ITI), and the duration of the inhibitory period was longer for emotional, compared to neutral, pictures. Finding both of these effects following brief picture presentation suggests that the startle reflex can tap processes related to picture encoding, and do not rely on the presence of a sensory stimulus. Bradley and Lang (2001) interpret the relatively lengthy “prepulse inhibition” period during picture viewing as indicating that complex picture stimuli involve a more extended encoding period than simpler prepulse stimuli (e.g., tones or lights) in which inhibition is usually complete by about a second after stimulus onset (Anthony, 1985). And, consistent with the idea that motivational activation prompts a type of “natural selective attention,” affective pictures draw more heavily on attentional resources at encoding than do neutral pictures. Supporting both of these interpretations, we recently found differential ERP activity as a function of stimulus complexity, with activity rapidly returning to baseline (within about 1 s) when viewing blank slides, whereas picture viewing elicited sustained positivity that was accentuated for emotional, compared to neutral, stimuli (Codispoti, Bradley, Cuthbert, Montebanocci, & Lang, 1998).

Blinks were also larger when viewing unpleasant, compared to pleasant, pictures. Nonetheless, affective modulation differed in interesting ways from that obtained with longer picture presentations. For instance, a number of different studies have found greater blink inhibition early in the viewing interval for emotional, compared to neutral, pictures (Bradley et al., 1993; Bradley & Lang, 2001, Experiment 3; Levenston, Patrick, Bradley, & Lang, 2000). With brief presentation, however, blinks were larger for unpleasant, compared to pleasant, pictures, even at the earliest probe delay. Bradley and Lang (2001) note that specific task parameters—such as presentation duration—may affect the time course of affective modulation. Here, it suggests that brief presentation may accelerate affective processing; alternatively, attentional responses, for example, associated with scanning, could affect modulation found with longer picture presentations.

Second, whereas Globisch et al. (1999) found that blink reflexes were significantly potentiated when viewing unpleasant, compared to neutral, pictures for phobic subjects viewing briefly presented fear material, differences in blink magnitude for unpleasant and neutral pictures were not obtained here. Bradley and Lang (2001) recently proposed a two-process account of startle potentiation, suggesting that blinks elicited when viewing unpleasant pictures reflect the net effect of a facilitatory process (due to aversiveness) and an inhibitory process (due to greater attention). A change in either process can affect blink potentiation for unpleasant pictures. If a brief presentation is considered analogous to a distant (rather than imminent) predator, the defense cascade model (Lang et al., 1997) predicts less intense defensive activation, which leads to vigilance and oriented attention, both of which will decrease defensive startle potentiation.

Taken together, the data indicate that the emotional reactions to affective pictures generally found during sustained perceptual processing also occur when pictures are briefly presented. In indexing emotional content, only the heart rate response appears to depend on sustained sensory input. Results for corrugator EMG activity, skin conductance, and modulation of the startle reflex all suggest that a quick glimpse is sufficient to effectively engage the motivational systems that mediate emotion.

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