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Manipulating affective state using extended picture presentations

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Abstract

Separate, extended series of positive, negative, and neutral pictures were presented to 24 (12 men, 12 women) undergraduates. Each series was presented on a different day, with full counterbalancing of presentation orders. Affective state was measured using (a) orbicularis oculi activity in response to acoustic startle probes during picture presentation, (b) corrugator supercilii activity between and during picture presentation, and (c) changes in self-reports of positive and negative affect. Participants exhibited larger eyeblink reflex magnitudes when viewing negative than when viewing positive pictures. Corrugator activity was also greater during the negative than during the positive picture set, during both picture presentation and the period between pictures. Self-reports of negative affect increased in response to the negative picture set, and self-reports of positive affect were greatest following the positive picture set. These findings suggest that extended picture presentation is an effective method of manipulating affective state and further highlight the utility of startle probe and facial electromyographic measures in providing on-line readouts of affective state.

Descriptors: Affect, Motivation, Acoustic startle, Facial EMG

Motivation and emotion are primary constructs in psychology. Major challenges facing researchers with interest in affect are manipulation and measurement of motivational and emotional states within the laboratory. In most cases, individuals are exposed to situations or stimuli that are intended to generate an affective state, which is measured using self-report following the manipulation. Some techniques include self-oriented imagery (e.g., Larsen & Ketelaar, 1991; Velten, 1968), recalling personal experiences (e.g., Brewer, Doughtie, & Lubin, 1980), music (e.g., Clark & Teasdale, 1985; Mathews & Bradley, 1983), performance feedback (e.g., Isen, Shalker, Clark, & Karp, 1978; Larson & Ketelaar, 1989), and odors (Ehrlichman & Halpern, 1988). This study presents another approach: a 20-min presentation of pictures intended to manipulate separately positive or negative affect. In addition to the standard postmanipulation self-report measure of affective state, acoustic startle eyeblink reflexes and corrugator supercilii activity were used to measure affective state during the presentation.

Schneirla (1959) proposed that approach and withdrawal are fundamental dimensions of behavior common to nearly all species in whom behavior itself is evident. It can be further argued that these approach and withdrawal behaviors are supported by evolutionarily old general motivation systems. Approach behaviors are driven by the appetitive motivation system in response to incentives (cues for consummatory behaviors). Withdrawal behaviors are driven by the aversive motivation system in response to threats. Similar systems have been proposed by a variety of other researchers (e.g., Depue & Iacono, 1989; Gray, 1981; Kagan, Reznick, & Snidman, 1988; Konorski, 1967; Lang, 1995; Rothbart, Derryberry, & Posner, 1994). Activities of the appetitive and aversive motivation system are the basis for general positive and negative affective states, respectively. Following the work of Thayer (1967, 1989), Watson and Tellegen (1985), and Larsen and Diener (1992), terms such as *elated*, *enthusiastic*, *excited*, *euphoric*, *lively*, and *peppy* reflect high activation of the appetitive motivation system, whereas terms such as *annoyed*, *anxious*, *distressed*, *fearful*, *jittery*, and *nervous* reflect high activation of the aversive motivation system. Furthermore, these systems play a major role in affective and anxiety disorders (e.g., Davidson, 1995) and the two primary

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self-report dimensions of personality (e.g., Eysenck's [1967] Extraversion and Neuroticism). Theory and data suggest that these systems are at least partially orthogonal (e.g., Cacioppo & Berntson, 1994; Watson & Tellegen, 1985), although there may well be both individual and stimulus-specific differences in the extent to which inhibition versus coactivation is observed (see Davidson, 1995). We also distinguish these broad motivation systems from more specific, separable, yet highly related emotion systems that can be indexed by terms such as *anger*, *disgust*, *happiness*, and *sadness*. Davidson and colleagues (e.g., Davidson, Ekman, Saron, Senulis, & Friesen, 1990) have proposed that certain commonalities in neural substrates underlie emotions associated with approach and withdrawal respectively. However, they have also suggested that specific neutral patterns are also likely to distinguish among the different discrete emotions, although this project is only just beginning (e.g., George et al., 1995).

There were multiple inspirations behind development of this paradigm for extended manipulation of affective state and its online measurement with psychophysiological procedures. Our primary motivation is an interest in functional neuroimaging of the cortical and subcortical systems related to the appetitive and aversive systems. Cortical electrophysiology studies by Davidson and his colleagues suggest that brain regions associated with these systems are lateralized in anterior cortical zones (for reviews, see Davidson, 1994, 1995). One promising approach for imaging both cortical and subcortical regions is assessment of regional glucose metabolism with positron emission tomography using fluorodeoxyglucose as the radiotracer. An extended picture presentation is a strong candidate for affective state activation given the variety of constraints imposed by this neuroimaging methodology. Successful extended manipulation of positive and negative affect would also allow psychophysiologists to assess relations with slowly moving physiological measures (e.g., skin temperature, cardiovascular reactivity and recovery). Furthermore, this approach would allow researchers to address affective reactions and their sequelae when one is faced with repeated aversive challenges or appetitive opportunities, a condition that is quite different from brief and/or one-time activation or the alternation of aversive and appetitive circumstances. For example, the effectiveness of various strategies for coping with predictable, repeated presentation of aversive stimuli might be assessed using this paradigm. This approach also may provide an opportunity to assess relations between affect and various components of cognition.

For the last decade, Lang and his colleagues (for reviews see, Lang, 1995; Lang, Bradley, & Cuthbert, 1990) have used pictures to manipulate affective state. In most studies, pictures differing in terms of normative valence (unpleasant to pleasant) and arousal (none to high) ratings have been presented in a mixed, quasi-random fashion to assess various subjective, physiological, and cognitive correlates. Pictures are usually shown for 6 s, with a longer interstimulus interval (e.g., 20 s). Using this paradigm, acoustic startle eyeblink reflexes and corrugator supercilii activity repeatedly have been related to systematic variation in the valence and arousal characteristics of pictures. Generally, defensive eyeblink reflexes in response to probes presented 1 or more seconds following picture onset are greater during the presentation of negatively valenced, highly arousing pictures (aversive system activation) than are reflexes during the presentation of neutral, low-arousal pictures. Furthermore, eyeblink reflexes are smaller during the presentation of positively valenced, highly arousing pictures (appetitive system activation) than are reflexes during the presentation of neutral, low-arousal pictures. Similar relations between pictures and corrugator activity have been observed. More negatively valenced pictures are associated with higher levels of corrugator activity, and more positively valenced pictures are associated with lower levels of activity (e.g., Lang, Greenwald, Bradley, & Hamm, 1993).

This mixed-picture paradigm provided the basis for the current study in terms of stimuli and affective state measures. With the aid of the normative ratings collected by Lang and his colleagues (Center for the Study of Emotion and Attention, 1995), 24 pictures were selected for each of three sets of pictures that were expected to be comparably effective for both men and women. With the intent of activating the aversive motivation system and generating negative affect, we selected negatively valenced, highly arousing (*negative*) pictures depicting aversive objects or situations from which one might withdraw (e.g., a snarling dog, a coiled snake, a mutilated human body). With the intent of activating the appetitive motivation system and generating positive affect, we selected positively valenced, highly arousing (*positive*) pictures depicting desirable objects or situations that one might approach (e.g., appetizing food, successful athletic competition, attractive nudes). For a control condition, we selected neutral, low-arousal (*neutral*) pictures depicting objects or situations that, in general, would not activate either the appetitive or aversive motivation system (e.g., a chair, a wicker basket, a mushroom). These selections were used in three 20-min presentations, where each of the 24 pictures were presented for 12 s in both the first and second 10 min, with an average of 14 s between pictures.

Multiple measures of affective state were collected: acoustic startle eyeblink reflex and corrugator supercilii activity during the presentation of the picture sets and self-reports of positive and negative affect before and after picture presentation. Acoustic startle probes were presented at 2.0, 4.5, and 10.5 s following picture onset. The first two probe times parallel those of the mixed-picture paradigm. The 10.5-s probe time is relatively novel and attempts to capture affective state long after the initial perception and interpretation of a picture has occurred. Corrugator activity was collected throughout the 20-min presentation. Activity during three conceptually distinct periods was used to index affective state: the 4 s prior to picture onset, and the first and last 6 s of picture presentation. The two within-picture periods are associated with the early (2.0 s, 4.5 s) and late (10.5 s) acoustic startle probes, respectively. The between-picture period permits assessment of affective state when no picture is being presented.

Given the close ties with the mixed-picture paradigm, it is important to understand the differences that provide challenges to the expected effectiveness of the proposed paradigm. First, in this paradigm, individuals participate in multiple sessions on separate days. A variety of factors with potential to influence affective reactions to pictures and the measures of affective state may differ considerably from one session to the next (e.g., familiarity with the procedure and lab personnel, between-session habituation of the acoustic startle reflex, the person's affective tone based upon events outside of the lab, etc.). Second, the context of picture presentation is considerably different. In the mixed-picture paradigm, an aversive stimulus can occur at nearly any time, and there is variety in the affective tone of the stimuli from one presentation to the next. This degree of uncertainty may produce an elevation of negative affect that pervades the entire presentation (i.e., in preparation for an aversive picture). In the extended-picture paradigm, one would expect little activation of the aversive motivation system during the neutral and positive picture sets. Third, our picture selection criteria, developed to select pictures with the potential to be effective for men and women, resulted in 24 pictures for each set. To satisfy competing criteria, each picture was presented for 12 s in both the first and last 10 min of the presentation. The 12 s of picture presentation is twice as long as that in the typical mixed-picture paradigm. The repetition and longer presentation of pictures may reduce their effectiveness, especially in the last 10 min.

We propose that primary dimensions of positive and negative affect reflect activation of the general appetitive and aversive motivation systems, respectively. Pictures from the International Affective Picture System (Center for the Study of Emotion and Attention, 1995) were used to manipulate affective state for an extended period of time. More specifically, participants viewed 20 min of positive, negative, or neutral pictures on different days, with each participant viewing all three picture sets within a 1-week period. Affective state during each 20-min presentation was assessed by examining the acoustic startle probe eyeblink reflex magnitude and electromyographic (EMG) activity over the corrugator supercilii muscle region. Affective state was also assessed using a self-report measure completed both before and after the presentation of pictures. Following results from the large corpus of data developed with the mixed-picture paradigm, it was predicted that the negative picture set would produce relatively larger eyeblink reflex magnitudes, greater corrugator activity, and higher self-reports of negative affect than would the other picture sets. The positive picture set was expected to produce relatively small eyeblink reflex magnitudes, less corrugator activity, and higher self-reports of positive affect than would the other picture sets. Presentation of the neutral picture set was expected to generate midrange levels for these measures.

Method

Participants

Twenty-four (12 men and 12 women) introductory psychology undergraduates received course extra credit for participation in the study. All participants were right handed, were between 18 and 22 years of age, had no history of brain trauma or disorder, and had no history of psychiatric disorder. Data from two additional individuals (one man and one woman) were excluded from analyses because of an insufficient number of eyeblink reflexes. Data from one additional man were excluded from analyses because of experimenter error.

Design

All participants viewed all three picture sets (within-subject analysis). To control for possible order and session effects (e.g., across session habituation to the startle stimulus), the presentation order of the three picture sets over the three sessions was completely counterbalanced. That is, two men and two women were assigned to each of the six possible orders of picture presentation. The primary independent variable was picture set: negative, neutral, and positive. Additional independent variables were sex and presentation block (i.e., first vs. second half of the 20-min presentation). The dependent variables were eyeblink reflex magnitude, power density of EMG activity over the corrugator supercilii muscle region, and self-reports of positive and negative affect.

Materials

Pictures were selected from Shows 1–4 of the International Affective Picture System (Center for the Study of Emotion and Attention, 1995). The selection of pictures was based upon self-report ratings of valence and arousal published in an International Affective Picture System technical report (Lang, Bradley, & Cuthbert, 1995). Valence ratings were standardized by sex to adjust for sex differences in the distribution of the valence rating. Arousal ratings were similarly standardized by sex. Pictures that met specific range criteria for each group were selected. For example, for the positive picture set, the criteria were a valence rating greater than 0.5 (z score) and an arousal rating greater than 0 (above average). These criteria had to be met for both men and women. For each picture type, the 24 pictures that produced the most similar average ratings for men and women were selected. A list of pictures is available upon request.

Figure 1 displays average self-report valence and arousal ratings (standardized) for all 24 pictures in each picture set. A mixed-design analysis of variance (ANOVA) on valence ratings with sex and picture set as the between-subject variables revealed a main effect for picture set, $F(2,138) = 667.6$, $p < .0001$. Average valence ratings for the positive ($M = 0.73$, $SD = 0.56$), neutral ($M = -0.08$, $SD = 0.22$), and negative ($M = -1.41$, $SD = 0.48$) picture sets differed significantly, $ts(94) > 17.5$, $ps < .001$. There was no main effect for sex, $F(1,138) < 1$, and no Picture Set × Sex interaction, $F(2,138) = 1.67$, $p > .19$.

A similar mixed-design ANOVA on arousal ratings showed a main effect for picture set, $F(2,138) = 455.0$, $p < .001$. Both the negative ($M = 1.30$, $SD = 0.46$) and positive ($M = 0.73$, $SD = 0.56$) picture sets had significantly higher arousal ratings than did the neutral set ($M = -1.39$, $SD = 0.38$), $ts(94) > 21.7$, $ps < .001$, and the average arousal rating for the negative set was higher than that for the positive set, $t(94) = 5.50$, $p < .001$. There was also a significant Picture Set × Sex interaction, $F(2,138) = 4.55$, $p < .02$. Follow-up analyses revealed that women ($M = 1.48$, $SD = 0.44$) had higher average arousal ratings than did men ($M = 1.13$, $SD = 0.41$) for the negative picture set, $t(46) = 2.83$, $p < .01$. There were no significant sex differences for the positive and neutral sets, $|ts(46)| < 1.33$.

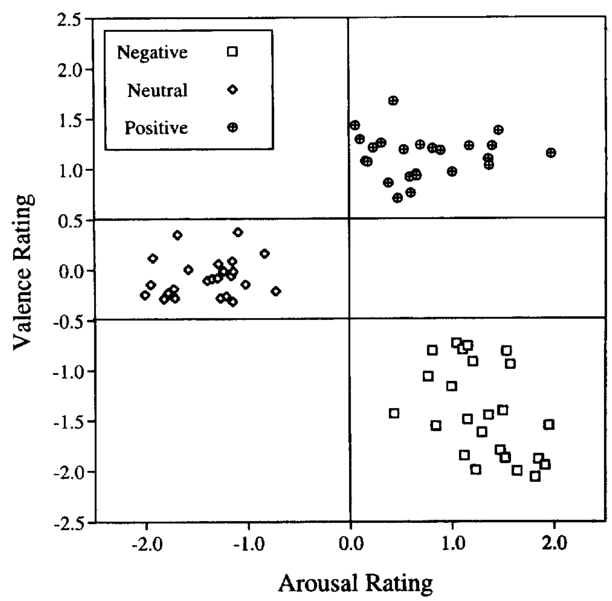

Figure 1. Average valence and arousal ratings (standardized) for each picture presented in this study.

Procedure

Participants volunteered by signing up for an experiment on the psychophysiology of emotion. Potential participants were then contacted by phone and given a brief description of the experiment and screened for handedness and neurological and psychiatric disorder. Potential participants were also informed of the presentation of pleasant and unpleasant pictures. No one declined participation or was excluded based on screening criteria.

Upon arrival, participants were seated in a comfortable arm chair approximately 2 m from a 21-inch (53.3-cm) NEC-6FG multisync color monitor. At the start of the first session, the participants completed informed consent forms, which included information concerning the presentation of unpleasant pictures at some point during the three sessions. Following a brief overview of the procedure, the electrodes were placed and impedances were checked. Participants then completed an affective state inventory. Prior to the 20-min presentation of pictures, participants viewed four neutral pictures and received three startle probes as an introduction and reorientation to the procedure. This practice procedure was the same for all participants and for all sessions.

Participants then viewed the positive, negative, or neutral picture set for 20 min. Picture presentation and acoustic startle probes were controlled by STIM software (Neuro Scan, Inc., Herndon, VA) on a 486 personal computer. Pictures were presented for about 10 of the 20 min; each picture was presented for 12 s with 12–16 s between pictures. In addition, each picture was presented twice: once in the first 10 min (Block 1) and once in the second 10 min (Block 2) of the presentation. Acoustic startle probes were presented on 75% of the trials. Startle stimuli were 95-dB, 50-ms, immediate rise bursts of white noise generated using a Coulbourn S81-02 noise generator and a Coulbourn S84-04 selectable envelope shaped rise/fall audio gate (set to 0), amplified using a Coulbourn S82-24 audio-mixer power amplifier, and delivered through Radio Shack Optimus LV-20 headphones. There were three probe times: 2.0, 4.5, and 10.5 s following picture onset. These were used to assess the effects of motivation system activation throughout the picture presentation. Studies using the mixed-picture paradigm typically show each picture for 6 s (for review, see Lang, 1995). The current paradigm, with the 12-s picture presentation, prompted a desire to present startle probes during the latter portion of a picture presentation. There were six probes at each of these times during the first and second halves of the 20-min presentation. No probes were presented during the between-picture period because of concerns for within-session startle habituation (36 probes over 20 min). A single, quasi-random order of probes and pictures was created for each picture set. For the second presentation of any given picture, the startle probe did not occur at the same time as during the first presentation of that picture. Following the 20-min presentation, participants again completed the affective state inventory.

At the end of the third session, the participants were debriefed.

Data Acquisition and Reduction

EMG activity over the orbicularis oculi and corrugator supercilii muscle regions were collected using two Sensormedics minielectrodes (3 mm diameter) placed directly below the left eye (orbicularis; as done by Vrana, Spence, & Lang, 1988) and two minielectrodes placed above the medial portion of the left eyebrow (corrugator; as suggested by Fridlund & Cacioppo, 1986). A fifth minielectrode was placed in the center of the forehead and used as ground. Impedances for EMG electrode pairs were less than 20,000 ohms. Both raw and integrated EMG activity over the orbicularis oculi and corrugator supercilii muscle regions were recorded. Analysis of EMG activity over the orbicularis oculi muscle region was performed on the integrated signals, whereas analysis of EMG activity over the corrugator supercilii muscle region was performed on the raw signals. Raw signals were amplified 30,000 times using Grass Model 12 amplifiers after passing through bandpass filters set at 1 and 3000 Hz. For the corrugator measure, the output of the Grass amplifier was then digitized and processed. For the eyeblink reflex measure, the EMG activity over the orbicularis oculi muscle region was passed through Rockland bandpass filters set at 90 and 1000 Hz and then rectified and integrated using a Coulbourn S76-01 contour following integrator with the time constant set below 20 ms (lowest marked time constant on the device). Both raw and integrated signals were digitized and stored at 1000 Hz on a 486 personal computer throughout the 20-min presentation using SnapStream software (HEM Data Corp., Springfield, MI) and a 12-bit analog-to-digital board (Analogic Corp., Wakefield, MA). Recording equipment was calibrated both before and after each session, and the units for raw and integrated EMG measures were microvolts.

EMG activity over the orbicularis oculi muscle region in response to acoustic startle probes was reduced to eyeblink reflex magnitudes. First, integrated EMG activity over the orbicularis oculi muscle region in response to each probe was computer scored and reviewed by trained lab personnel. A small percentage of all eyeblink reflexes (2.16%) were excluded because of excessive noise during a 50-ms prestartle baseline period or because the onset of the (integrated EMG) eyeblink reflex began less than 20 ms following the startle probe. Eyeblink reflex magnitudes (in microvolts) were calculated by subtracting the integrated EMG at reflex onset from the maximum integrated EMG between 20 and 120 ms following probe onset. Noise-free trials with no perceptible eyeblink reflex were given a magnitude of zero. Although participants received three probes (one at each probe time) prior to each 20-min presentation, preliminary analyses showed that responses to the first probe of a given probe time were significantly greater than the average response to all other probes at that probe time for each session, regardless of picture set. Therefore, these eyeblink reflex magnitudes were eliminated from further data reduction and analysis. Eyeblink reflex magnitudes were z-transformed within participants because of large individual differences in the distribution of this measure.

Raw EMG activity over the corrugator supercilii muscle region was reduced to average power density ($\mu V^2/Hz$) within a broad EMG band ranging from 45 to 200 Hz. To do this, these raw EMG signals were first extracted through a Hamming window, then fast Hartley transformed (Bracewell, 1984) for all 1-s epochs (with 50% overlap) within each of three recording periods.[1] A 4-s prepicture period was selected to assess affective state when no picture was presented. A period defined by the first 6 s of picture presentation was selected to assess affective state during the traditional time period for picture presentation (i.e., as in the mixed-picture paradigm) and a period where the participant was likely to be effortfully determining the content of the picture. Cohen, Davidson, Senulis, Saron, and Weisman (1992) showed that corrugator

[1]The fast Hartley transform (FHT) is conceptually analogous to the fast Fourier transform (FFT) and provides identical output. The FHT method of spectral analysis is used because it is computationally more efficient.

activity is greater during periods of increased effortful attention in response to auditory stimuli. This increase in activity may also occur in response to visual stimuli, especially in the first seconds following picture onset. A final period defined by the last 6 s of picture presentation was selected to assess activity when initial attention and reaction to the stimulus may have waned and to capture corrugator activity levels during a period associated with the 10.5-s acoustic startle probe. For the two 6-s periods during picture presentation, the 0.5 s before and after the acoustic startle probe was excluded from corrugator data reduction. For each period, power density values were averaged across 12 (of 48) consecutive picture presentations. These average power density values were also z transformed within participants because of considerable individual differences in the distributions.

Self-report measures of positive and negative affect were collected before and after the 20-min picture presentation using a 19-item inventory. Participants responded to each of 19 adjectives by circling a number from 0 to 6 that best represented each participant's current state. The order of adjectives was different for each completion of the inventory. The adjectives used to assess positive and negative affect were drawn from two of Larsen and Diener's (1992) affect circumplex octants: activated pleasant affect and activated unpleasant affect. Positive affect was calculated by summing responses to the following items: elated, enthusiastic, euphoric, excited, lively, and peppy. Negative affect was calculated by summing responses to the following items: annoyed, anxious, distressed, fearful, jittery, and nervous. The seven other terms of the inventory represented discrete emotion states (amused, angry, content, disgusted, happy, sad, surprised) and were not included in the calculation of positive and negative affect scores. Again, because of large between-participant differences in the distribution of these measures, positive and negative affect were z transformed within participants. Changes in positive and negative affect were calculated by subtracting the prepresentation from the postpresentation measure.

Results

General Analytic Strategy

Mixed-design ANOVAs were used to assess the effects of picture set (negative, neutral, positive), block (first versus second half of presentation), probe (2.0, 4.5, 10.5 s following picture onset), and sex. All ANOVA results involving within-subject variables used the Greenhouse–Geisser epsilon correction procedure (Geisser & Greenhouse, 1959). Reported p values reflect this correction. Significant effects involving variables with three levels (e.g., picture set) were followed up using alpha-adjusted t tests to control for experimentwise error during the use of nonorthogonal comparisons. Alpha was set at .033 for these analyses following the modified Dunn–Bonferroni method described by Keppel (1991, pp. 169–170).

Eyeblink Reflex Magnitude

Table 1 displays averaged eyeblink reflex magnitude (standardized within participants) for each of the three probe times crossed with each of the three picture sets. An omnibus, mixed-design ANOVA revealed three main effects. First, there was a main effect for picture set, $F(2,44) = 4.98$, $p < .02$, $\epsilon = 0.924$. Follow-up analyses showed that participants exhibited significantly larger eyeblink reflex magnitudes during the negative than during the positive set, $t(23) = 2.83$, $p < .01$. The difference between the average eyeblink reflex magnitude for the neutral and negative set was not significant, $t(23) = -1.76$, $p = .09$. The difference between the average magnitude for the neutral and positive set was also not significant, $t(23) = 1.71$, $p = .10$.

Table 1. *Means (SD) for Acoustic Startle Eyeblink Reflex Magnitudes (Standardized)*

	Picture set			
Probe time	Negative	Neutral	Positive	All sets
2.0 s	0.14	0.05	−0.33	−0.05
	(0.45)	(0.43)	(0.50)	(0.13)
4.5 s	0.24	−0.04	−0.21	−0.01
	(0.40)	(0.42)	(0.47)	(0.11)
10.5 s	0.36	0.03	−0.13	0.09
	(0.61)	(0.38)	(0.50)	(0.14)
All	0.25	0.02	−0.22	
	(0.43)	(0.34)	(0.46)	

Second, there was a main effect for block, $F(1,22) = 62.68$, $p < .0001$. Eyeblink reflex magnitudes were smaller in the second than in the first half of the picture presentation. Third, there was a significant main effect for probe, $F(2,44) = 4.65$, $p < .02$, $\epsilon = 0.952$. Follow-up analyses showed that the difference between average magnitude in response to probes at 10.5 and 2.0 s was significant, $t(23) = 2.69$, $p < .02$, and the difference between average magnitude in response to probes at 10.5 and 4.5 s was marginally significant, $t(23) = 2.19$, $p < .04$. Results from this omnibus ANOVA revealed no significant main effect for sex, $F(1,22) < 1$, nor were there any significant interactions (Fs < 1.78, $ps > .18$).

Block-specific analyses. One important issue was whether or not differences in affective state would be observed in the first and second blocks of the presentation, especially given the repeated presentation of pictures in the second block. To thoroughly assess this issue, separate mixed-design ANOVAs with picture set as the within-subject variable and sex as the between-subjects variable were performed for the first and second block. Figure 2 displays average reflex magnitudes for the first and second blocks of each picture presentation. Eyeblink reflex magnitudes during the negative set were greater than those during the positive set for both blocks, and magnitudes during the neutral set were more similar to those of the negative set in the first block yet were more similar to those of the positive set in the second block.

For the first block, there was a significant main effect for picture set, $F(2,44) = 4.89$, $p = .02$, $\epsilon = 0.780$. Follow-up analyses showed that participants exhibited significantly larger eyeblink reflexes during the negative and neutral than during the positive set, $ts(23) > 2.44$, $ps < .025$. For the second block, there was also a significant main effect for picture set, $F(2,44) = 4.07$, $p < .025$, $\epsilon = 0.991$. Follow-up analyses showed that participants exhibited significantly larger reflex magnitudes during the negative than during the positive set, $t(23) = 2.86$, $p < .01$. The difference between the average eyeblink reflex magnitude for the negative and neutral set was marginally significant, $t(23) = 1.95$, $p = .065$.

Probe-specific analyses. Another important issue was whether or not differences in affective state would be observed at various

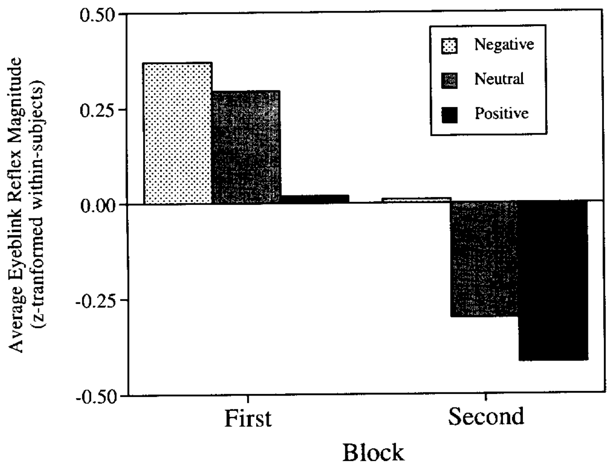

Figure 2. Average eyeblink reflex magnitudes for the first and second block of each picture set. In the first block, each of the 24 pictures in the set was presented for the first time. In the second block, each picture was presented for a second time. Magnitudes were standardized within participants to eliminate between-subject individual differences in the microvolt distribution of these values.

times during the presentation of a picture. To thoroughly assess this issue, separate mixed-design ANOVAs with picture set as the within-subject variable and sex as the between-subjects variable were performed for each of the three acoustic startle probe times. Figure 3 displays average reflex magnitudes for each probe time. At all three probe times, the average reflex magnitude was greater during negative than during positive pictures, with the average magnitude for the neutral pictures in between these extremes.

For the probe at 2.0 s, there was a significant main effect for picture set, $F(2,44) = 4.91$, $p < .02$, $\epsilon = 0.992$. Follow-up analyses showed that participants exhibited significantly larger reflex magnitudes during the negative and neutral sets than during the positive set, $ts(23) > 2.34$, $ps < .03$. The average magnitudes for the neutral and negative sets were not significantly different, $t(23) < 1$. For the probe at 4.5 s, there was also a significant main effect for picture set, $F(2,44) = 4.63$, $p < .02$, $\epsilon = 0.922$. Follow-up analyses showed that participants exhibited significantly larger reflex magnitudes during the negative than during the positive set, $t(23) = 2.77$, $p < .02$; the difference between the average magnitude during the negative and neutral set was marginally significant, $t(23) = 2.20$, $p < .04$. For the probe at 10.5 s, there was also a significant main effect for picture set, $F(2,44) = 4.16$, $p = .03$, $\epsilon = 0.817$. Follow-up analyses showed that the average magnitude for the negative set was significantly greater than that for the positive set, $t(23) = 2.40$, $p < .03$, and the difference between the negative and neutral set was marginally significant, $t(23) = 1.98$, $p = .06$.

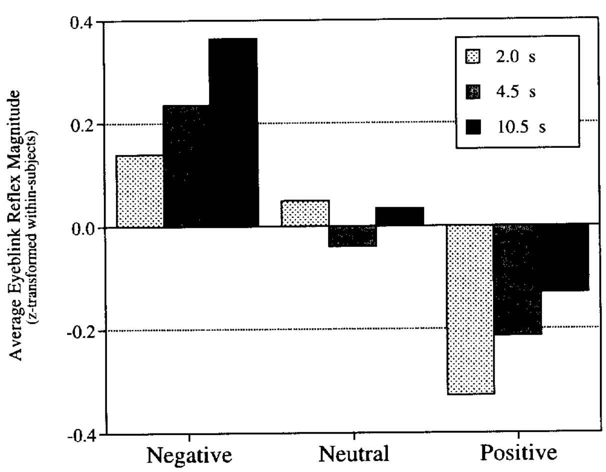

Figure 3. Average eyeblink reflex magnitude (standardized) for the three probe times (2.0, 4.5, and 10.5 s following picture onset) separately for each picture set.

Session analyses. The full counterbalancing of picture set across session allowed for the analysis of picture set influence on the dependent measures while controlling for possible session effects. Full counterbalancing also allowed for the analysis of session effects while controlling for the effects of picture set. A mixed-design ANOVA with sex as the between-subjects variable, session as a within-subject variable, and block as a second within-subject variable revealed a main effect for session, $F(2,44) = 3.93$, $p < .03$, $\epsilon = 0.909$. Follow-up analyses showed that average magnitudes were significantly greater during the first session ($M = 0.23$, $SD = 0.36$) than during the second or third sessions, $ts(23) > 2.07$, $ps < .05$). Average eyeblink reflex magnitudes for the second ($M = -0.15$, $SD = 0.36$) and third ($M = -0.09$, $SD = 0.46$) sessions were not significantly different, $t(23) < 1$. As was observed in the analyses emphasizing picture set, there was also a main effect for block, $F(1,22) = 154.6$, $p < .001$. There was no main effect for sex, $F(1,22) < 1$, and there were no significant interactions ($Fs < 1$).

Corrugator Power Density

Standardized corrugator power density values were calculated for three different periods: the 4 s immediately before picture onset, the first 6 s of picture presentation, and the last 6 s of picture presentation. Averages of this measure are presented in Table 2 for the three periods crossed with the three picture sets. An omnibus, mixed-design ANOVA with sex as the between-subjects variable and period, block, and picture set as the within-subject variables revealed significant main effects for period, $F(2,44) = 22.38$, $p < .0001$, $\epsilon = 0.939$, block, $F(1,22) = 7.51$, $p < .02$, and picture set,

Table 2. *Means (SD) for EMG Activity Over the Corrugator Supercilii Muscle Region (Standardized)*

	Picture set			
Period	Negative	Neutral	Positive	All sets
Prepicture	0.20	−0.36	−0.33	−0.16
	(0.64)	(0.52)	(0.65)	(0.13)
First 6 s	0.66	−0.21	−0.19	0.09
	(0.64)	(0.61)	(0.74)	(0.12)
Last 6 s	0.63	−0.23	−0.19	0.07
	(0.67)	(0.58)	(0.71)	(0.10)
All	0.50	−0.26	−0.24	
	(0.60)	(0.56)	(0.66)	

$F(2,44) = 7.95$, $p < .002$, $\epsilon = 0.961$. Corrugator activity was greater during the first and last 6 s of picture presentation than during the 4 s prior to picture onset, $ts(23) > 5.37$, $ps < .0001$, greater during the first ($M = 0.11$, $SD = 0.21$) versus second ($M = -0.11$, $SD = 0.21$) block, and greater during the negative set than during the positive or neutral sets, $ts(23) > 3.14$, $ps < .005$. The ANOVA also revealed significant interactions of Block × Sex, $F(1,22) = 5.85$, $p < .025$, Period × Block × Sex, $F(2,44) = 5.83$, $p < .01$, $\epsilon = 0.848$, and Period × Block × Picture Set, $F(4,88) = 4.34$, $p < .01$, $\epsilon = 0.827$. The interaction of Period × Block × Picture Set × Sex was not significant, $F(4,88) = 2.42$, $p < .07$, $\epsilon = 0.827$. The nature of these interactions was initially addressed by performing mixed-design ANOVAs for each period.

Prepicture period. The top portion of Figure 4 displays average corrugator activity for the prepicture period. A mixed-design ANOVA with sex as the between-subjects variable and block and picture set as the within-subject variables revealed a significant main effect for picture set, $F(2,44) = 4.46$, $p < .02$, $\epsilon = 0.955$. Follow-up analyses showed that activity during the negative set was significantly greater than activity during the neutral and positive sets, $ts(23) > 2.30$, $ps < .033$. There was also a significant main effect for block, $F(1,22) = 6.91$, $p < .02$, with greater activity during the first than during the second block.

First and second 6-s periods. The middle and bottom portion of Figure 4 displays average corrugator activity for the first and second 6-s picture periods, respectively. Separate mixed-design ANOVAs for each period were run. The results were extremely similar and are reported in conjunction here. There were main effects for picture set, $Fs(2,44) \geq 8.96$, $ps < .001$, $\epsilon s \geq 0.954$. Follow-up analyses showed that activity during the negative set was significantly greater than activity during the neutral and positive sets, $ts(23) \geq 3.30$, $ps < .005$. There were also significant main effects for block, $Fs(1,22) \geq 4.84$, $ps < .04$, with greater activity during the first versus second block. In addition, there were significant interactions of Block × Sex, $Fs(1,22) \geq 6.97$, $ps < .02$, and Block × Picture Set, $Fs(2,44) \geq 3.78$, $ps < .04$, $\epsilon s \geq 0.952$. Follow-up analyses for the Block × Sex interaction revealed that women exhibited significantly greater corrugator activity during the first than during the second block, $ts(23) \geq 3.27$, $ps < .01$. Women also exhibited significantly greater activity than did men during the first block, $ts(22) \geq 2.50$, $ps < .03$. And, in the first 6-s period only, women exhibited less activity than did men during the second block, $t(22) = -2.88$, $p < .01$. Follow-up analyses for the Block × Picture Set interaction revealed that activity during the first block of the negative set was significantly greater than that during the second block, $ts(23) \geq 3.28$, $ps < .005$, whereas activity during the first and second blocks of the positive and neutral sets did not differ significantly, $ts(23) < 1$.

Session analyses. To analyze the influence of session on corrugator activity, a mixed-design ANOVA was performed with sex as the between-subjects variable and period, block, and session as the within-subject variables. There was no main effect for session, $F(2,44) < 1$, and there were no significant interactions involving session, $Fs < 2.49$, $ps > .10$.

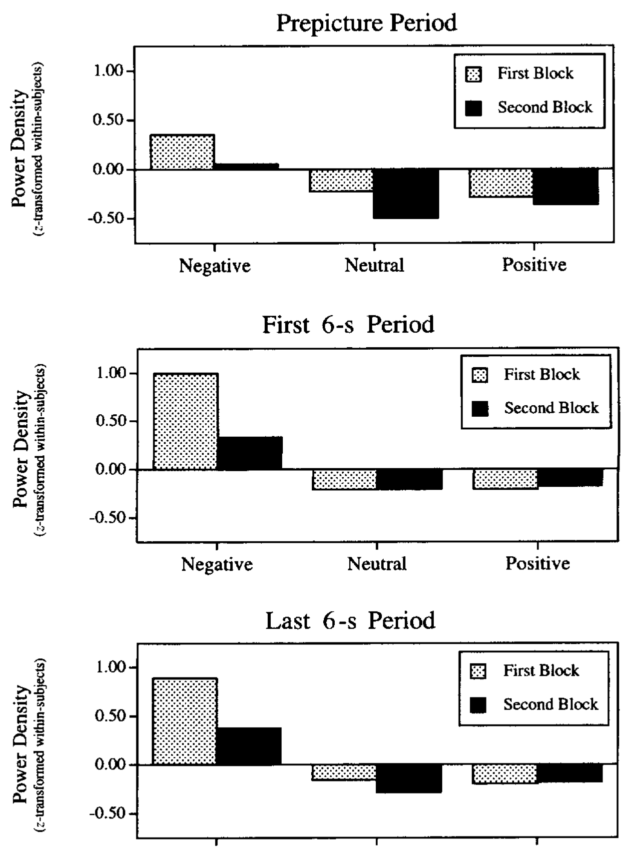

Figure 4. Average amount of corrugator activity during the 4 s prior to picture presentation (top), the first 6 s of picture presentation (middle), and the last 6 s of picture presentation (bottom) separately for each picture set. Power density values ($\mu V^2/Hz$) averaged across 12 trials within each defined period were standardized within participants to eliminate between-subject individual differences in the distribution of these values.

Positive and Negative Affect

Self-reports of positive and negative affect were collected immediately before and after the presentation of pictures for each of the three sessions. The raw mean levels of positive affect and negative affect following positive, negative, and neutral picture sets are presented in Table 3.

As was done with eyeblink reflex magnitudes and corrugator activity, positive and negative affect scores were standardized within participants to control for the large between-participant differences in the distribution of each measure. Separate mixed-design ANOVAs were used to determine whether or not average measures of pos-

Table 3. *Means (SD) for Positive and Negative Affect Following the Presentation of Pictures*

	Picture set		
	Negative	Neutral	Positive
Positive affect	7.9	13.6	17.1
	(7.2)	(11.2)	(10.9)
Negative affect	15.7	6.0	5.6
	(11.2)	(6.1)	(6.5)

itive affect or negative affect differed prior to the presentation of the three picture sets. There were no significant main effects for picture set, $Fs(2,44) \leq 2.32, ps > .11, \epsilon s \geq 0.995$, or sex, $Fs(1,22) < 1$, nor were the Sex × Picture Set interactions significant, $Fs(2,44) < 1$.

To assess the influence of the picture set on positive and negative affect, change scores were calculated by subtracting the prepicture score from the postpicture score. The top portion of Figure 5 displays the average changes in positive affect for each of the three picture sets. A mixed-design ANOVA revealed a significant main effect for picture set, $F(2,44) = 4.97, p < .02, \epsilon = 0.969$, and a significant Picture Set × Sex interaction, $F(2,44) = 5.18, p < .02, \epsilon = 0.969$. There was no main effect for sex, $F(1,22) < 1$. Follow-up analyses for the main effect for picture set showed that positive affect decreased more in response to the negative set than in response to the positive set, $t(23) = -2.68, p < .02$, and that the difference in the change in positive affect in response to the neutral and positive sets was marginally significant, $t(23) = -2.17$, p = .04. Follow-up analyses for the Picture Set × Sex interaction showed that men exhibited a significantly greater decrease in positive affect than did women in response to the neutral set, $t(22) = -2.68, p < .025$. In response to the positive set, women exhibited a significantly greater decrease in positive affect than did men, $t(22) = -2.45, p < .025$. In summary, positive affect generally decreased in response to viewing the picture sets. This decrease was smallest in response to the positive set. In fact, men showed no decrease in positive affect in response to the positive set.

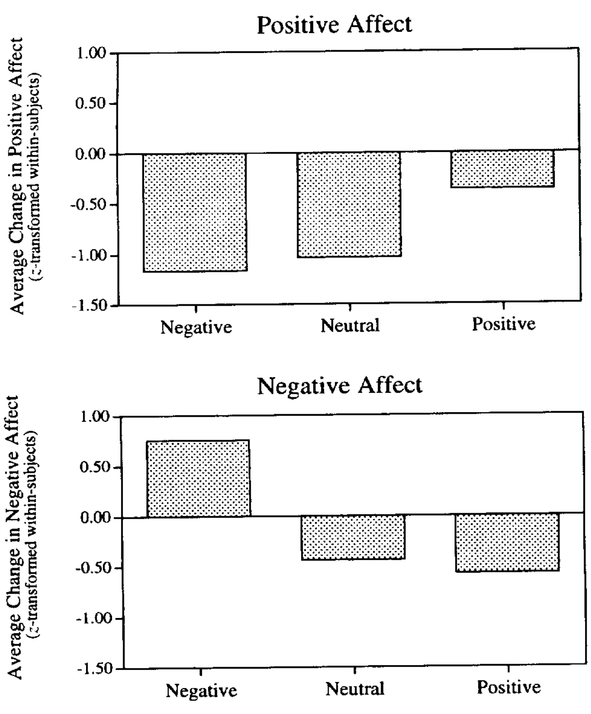

Figure 5. Average change in self-reports of positive (top) and negative (bottom) affect in response to each picture set. Measures of positive and negative affect were obtained before and after each 20-min presentation of pictures. The pre- and postpresentation scores for both positive and negative affect were standardized within participants because of individual differences in the distribution of the scores. The change score was calculated by subtracting the standardized prepresentation score from the standardized postpresentation score.

The bottom portion of Figure 5 displays the average changes in negative affect. A mixed-design ANOVA revealed a significant main effect for picture set, $F(2,44) = 12.03, p < .001, \epsilon = 0.996$, but no main effect for sex, $F(1,22) < 1$, or significant Sex × Picture Set interaction, $F(2,44) = 1.70, p > .19, \epsilon = 0.996$. Follow-up analyses showed that the increase in negative affect in response to the negative set was significantly greater than the decrease in negative affect in response to the positive and neutral sets, $ts(23) > 3.11, ps < .005$. The decrease in negative affect in response to the latter two pictures sets did not differ, $t(23) < 1$.

Session effects. Separate mixed-design ANOVAs were performed with sex as the between-subjects variable and session as the within-subject variable to assess the influence of session on change in positive and negative affect. For both positive affect and negative affect, there were no significant main effects or interactions, $Fs(2,44) < 1.43, ps > .24$.

Discussion

The goal of this study was to manipulate positive and negative affect for an extended period of time by presenting a series of negatively valenced, highly arousing pictures and a series of positively valenced, highly arousing pictures. This method is of interest to us as we attempt to create conditions (meeting numerous constraints) that would permit functional neuroimaging of these affective states in humans using regional glucose metabolism. In addition, we expect this method will be useful in other contexts where extended or repeated affective state manipulation is required. For example, there are many studies where the effect of affect on cognitive function or social behavior is examined (e.g., Blaney, 1986). These studies often use a paradigm where affect is manipulated first. Then its effects on subsequent measures of cognitive or social processes is examined. Such studies are predicated on the questionable assumption that the manipulated affective state persists for the duration of the subsequent task. The methods featured in this experiment can be easily adapted for such studies by inserting the measures of cognitive or social function among the pictures (with appropriate randomization of items or tasks).

One index of affective state was the acoustic startle eyeblink reflex. Analyses of eyeblink reflex data suggested that negative affect can be reliably generated for an extended period of time using the negative picture set, especially when compared with the positive set of pictures intended to generate positive affect. This pattern was apparent for both men and women, at all three probe times and for both the first and second half of the 20-min presentation. Analyses of session effects showed that participants exhibited greater eyeblink reflex magnitudes during the first session than during the second or third session, which were comparable. This effect may be due to simple habituation processes and may be influenced by the presence of greater negative affect during the first session when the procedures and personnel are novel (i.e., potentially anxiety provoking). In any case, it is important that this effect is controlled for (e.g., counterbalancing) in future multisession studies when eyeblink reflex magnitude is used as a dependent variable.

Conclusions based upon eyeblink reflex responses to the neutral picture set are less clear. Over the full 20-min presentation, the average eyeblink reflex magnitude suggested little activation of either the aversive or appetitive motivation system. However, reflex magnitudes during the first half of the neutral and negative sets were similar, and both were greater than magnitudes during the first half of the positive set (Figure 2). Furthermore, during the second half of the presentation, eyeblink reflex magnitudes during the neutral and positive sets were similar, and both were less than magnitudes during the negative set. These data imply a shift from the first to the second half of the picture presentations in the relative aversiveness of the neutral picture set, with the first half associated with more negative affect based upon the larger magnitude eyeblink reflexes observed during this period. These findings also suggest caution in using the neutral picture set as a control condition against which to compare the effects of the positive and negative pictures.

A second physiological index of affective state was corrugator activity during three periods of interest: the 4 s before picture presentation, the first 6 s of picture presentation, and the last 6 s of picture presentation. In general, significant corrugator activity was exhibited only during the negative picture set. This was true for all three periods of interest. In addition, corrugator activity was greater during the first than during the last 10 min of the negative set. This was also true for all three periods of interest. Unlike eyeblink reflex magnitude, there was no effect for session. Most importantly, these findings extend the influence of affective state manipulation outside of picture viewing. That is, corrugator activity was greater during the prepicture period for the negative set than it was for the positive or neutral sets, which suggests that the manipulation of aversive motivation (negative affect) occurred throughout the 20-min presentation of pictures.

Few sex differences were observed in this study. However, during the two picture presentation periods for the negative picture set women exhibited higher levels of corrugator activity than did men during the first 10 min. These data are consistent with the interpretation that corrugator activity reflects negative affect and suggest that women have stronger aversive reactions to the negative pictures than do men. However, this interpretation is not consistent with the analysis of corrugator activity during the prepicture period or with the eyeblink reflex results, where men and women did not differ. A viable alternative explanation is that these sex differences are due to differences in the intensity of facial expressions of emotions such as disgust and fear and that women are expressing considerably more fear and disgust in response to the pictures in the negative set, especially during the first 10 min. This interpretation would be consistent with results of studies reporting that women express more emotion than do men (e.g., Buck, Baron, & Barette, 1982) and of studies showing more facial EMG activity in women than in men (e.g., Dimberg, 1988).

The other measures of affective state were a pre- and post-manipulation self-report inventory. These measures of positive and negative affect differed from the physiological measures by assessing affective state outside of the picture presentation and provide data on the postmanipulation effectiveness of the picture presentation procedure. Consistent with the eyeblink reflex and corrugator data, negative affect increased in response to the negative picture set and decreased to nearly zero in response to the neutral and positive picture sets. Positive affect remained stable in response to the positive picture set for men but decreased slightly for women. For both men and women, positive affect decreased to nearly zero in response to the negative and neutral sets. Although positive affect was relatively greater following the positive picture set, it would be difficult to argue that the positive and negative picture sets had comparable affects on positive and negative affect, respectively. The positive picture set appears to maintain positive affect, not increase it.

The results of this study do provide evidence supporting the use of picture sets for manipulating affective state over extended time periods, especially if relative activation of negative affect is of primary interest. All measures exhibited evidence of greater activation of negative affect in response to the negative set, particularly relative to the positive set: (a) eyeblink reflex magnitudes were larger, (b) corrugator activity was greater, and (c) self-reported negative affect was greater. These measures showing comparable patterns of results reflect partially overlapping but distinctly different aspects of aversive motivation system activation. Future research is required to systematically delineate the specific factors that contribute to changes in these different response systems.

Predictions for this study were derived directly from the mixed-picture paradigm. Comparable results are not surprising yet were not guaranteed given the differences in the paradigms. There were, however, differences in the patterns of eyeblink reflex magnitude and corrugator activity data generated by this extended-presentation paradigm and those patterns of data generated by the mixed-picture paradigm. The primary difference was the low levels of corrugator activity in response to the neutral picture set. Lang et al. (1993) reported that corrugator activity was correlated with picture valence, such that neutral pictures showed moderate amounts of corrugator activity. In this study, only the negative picture set generated significant amounts of corrugator activity. Eyeblink reflex magnitude data were also different, but only in terms of magnitudes during the neutral picture set. Across the entire 20-min presentation, eyeblink reflex magnitude data for the extended and mixed-picture paradigms appears comparable. However, the pattern of eyeblink reflex magnitudes during the first and second blocks of the neutral set were not consistent with our aim of providing a stable control condition. These differences may stem from the fact that the mixed-picture paradigm produces activation of the aversive motivation system simply because negatively valenced, highly arousing pictures may appear at any time. This low to moderate background activation permits a phasic decrease in activation in the presence of appetitive pictures. In this paradigm, with the complete absence of aversive pictures in the neutral and positive sets, one would expect little background activation of the aversive motivation system during these sessions.

Considering the pattern of results across time and measures, the findings from this experiment indicate that pictures of threatening objects and situations presented for a 20-min period successfully generate increased negative affect, especially when compared with responses to positive pictures and less so in comparison with responses to neutral pictures. The creation of a stable control condition will greatly enhance this paradigm. This first effort using extended picture presentations is a step toward providing an alternative method for a relatively enduring manipulation of affective state, one that has the potential for broad use in the laboratory study of affect.

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