

Arousal and attention: Picture size and emotional reactions

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Abstract

Building on the assumption that the motivational relevance of an emotional scene depends on contextual factors such as proximity or stimulus size, the present study examined the effects of picture size on emotional perception using autonomic, facial, and subjective reactions. Affective changes were measured while participants viewed pictures presented in small, medium, and large sizes and varying in affective picture content. Whereas affective modulation of heart rate and Corrugator Supercilii muscle activity were not modulated by picture size, emotional modulation of skin conductance was absent for the smallest stimuli and increased linearly for the medium and largest stimulus sizes. Stimulus size modulated sympathetic changes possibly related to activation of the strategic motivational systems and action preparation. In contrast, responses related to orienting, categorization, and communicative functions did not covary with picture size.

Descriptors: Emotion, Arousal, Attention, Picture size, Skin Conductance, Heart Rate

In natural contexts, objects are viewed from different viewpoints and distances, and the visual system is astonishingly efficient in recognizing them. The retinal size that an object subtends reveals information about its distance from the observer, which might modulate its motivational relevance. The aim of the present study was to examine the effects of picture size on emotional perception using autonomic, facial, and subjective measures.

Previous studies have shown that several factors might affect the intensity of the emotional response, such as stimulus content (Bradley, Codispoti, Cuthbert, & Lang, 2001), previous experience with the eliciting stimulus (Codispoti, Ferrari, & Bradley, 2006, 2007), and individual differences (Cook & Turpin, 1997). Interestingly, a growing body of evidence seems to indicate that changes in media presentation characteristics modulate emotional responses to affective contents (Simons, Detenber, Roedema, & Reiss, 1999). For instance, recent studies evaluated the effects of images presented in color versus grayscale (Bradley et al., 2001), on different presentation media (video glasses vs. projected on screen; Von Leupoldt, Hartle-Bremerich, & Dahme, 2005), and presentation in movie or still image form (Detenber & Reeves, 1996; Simons et al., 1999). However, less is known regarding the effects of stimulus size and distance on emotional modulation. Extensive research has suggested that representation of objects is size invariant (e.g., Biederman & Cooper, 1992). Nevertheless the retinal size of an object plays an important role

in determining the distance from the observer (Cutting & Vishton, 1995; Loftus & Harley, 2005).

From an evolutionary perspective, emotions evolved to adaptively regulate an organism's behavior by helping the individual to evaluate important aspects of his or her environment (environmental dangers, predators, potential mates) and to take quick action to assess, avoid, or approach them depending on whether they constitute an imminent concern or not. The seminal studies of Miller (1944, 1959) have demonstrated that this behavior varies as a function of both stimulus content and distance, with different slopes as a function of distance for positive and negative contents. Interestingly, similar results were found in self-report ratings of valence and arousal (Ito, Cacioppo, & Lang, 1998), suggesting that the "proximity" dimension may be related to the more general "arousal" construct (Lang, Bradley, & Cuthbert, 1997).

More recently, the pattern of psychophysiological and behavioral responses to a threatening stimulus has been described as organized into discrete stages, depending on threat imminence (Fanselow, 1994; Lang et al., 1997). When a threatening stimulus is recognized, a transition is executed, from an initial state (baseline) to orienting of attentional resources, which is followed by explicit action should the threat become too close. These transitions are accompanied by changes in open behavior as well as in different physiological functions, including heart rate (HR), skin conductance (SC), startle reflex, and cortical activity (Lang et al., 1997).

Despite the obvious evolutionary and theoretical importance of the effects of distance and size on emotional modulation, relatively few studies have investigated this issue, possibly because of the observation that the visual system quickly attains size-invariant representations (Graham, 1965; Kolers, Duchnick, & Sundstroem, 1985). However, a study comparing autonomic

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responses in a group of snake phobics to a real snake at different distances showed that SC was directly related to the distance between the snake and the observer (Teghtsoonian & Frost, 1982), suggesting that individual-specific factors may combine with distance in modulating emotional response to a potential menace.

Building on the direct relation between distance and retinal size (Loftus & Harley, 2005), a number of studies have suggested that stimulus size may also play a role in modulating emotional responses. Focusing on cortical activity, a previous study that investigated the effects of picture size on emotional processing using event-related potentials (ERPs) indicated that picture size does not affect the affective modulation of the late positive potential (LPP), considered to reflect attentional capacity invested in the categorization of relevant events (De Cesare & Codispoti, 2006).

As cortical and peripheral responses reflect different processes, the present study assessed the effects of picture size on subjective, facial, and autonomic reactions. Previous studies either examined the effect of size on emotional responses using movies (Reeves, Lang, Kim, & Tatar, 1999) or did not investigate autonomic changes (Detenber & Reeves, 1996). If emotional categorization automatically engages preparation for action regardless of stimulus size, then the effect of size on the emotional modulation of autonomic responses should parallel LPP findings, that is, affective modulation should remain similar across different sizes. Alternatively, as the motivational relevance of a small and possibly distant stimulus is lower compared to an object that is imminent, emotional modulation of autonomic functions reflecting preparation for action can be expected to decrease with stimulus size.

An additional issue of interest concerns attentional capture using stimuli of differing sizes. It is well known that allocating attentional resources to a stimulus elicits an initial HR deceleration, which is part of the orienting reflex (OR; Graham, 1992). There are several reasons to expect that stimulus size may modulate the initial heart rate deceleration. For instance, large images contain more details compared to smaller pictures and, consequently, it could be argued that more attention is needed in order to process all their details fully. Alternatively, because size reduction of the images is associated with lower discriminability, it may be necessary to explicitly allocate more attentional resources in order to categorize the stimulus. By comparing HR deceleration to larger, intermediate, and smaller images, the present study will try to address this issue.

Method

Participants

Fifty participants (25 women) volunteered to take part in the present study. Age ranged from 19 to 25 years ($M = 21.48$, $SD = 1.87$). Due to technical problems, some participants were excluded from analyses of some dependent measures. Final N s were as follows: subjective ratings, $N = 43$; Corrugator Supercilii EMG, $N = 44$; SC change and HR, $N = 50$.

Stimuli and Design

One hundred sixty pictures were selected from various sources, including the International Affective Pictures System (IAPS; Lang, Bradley, & Cuthbert, 2001) and the Internet. Pictures represented contents from seven different categories (each $N = 20$): erotic couples, opposite sex nudes, babies, neutral people, contamination, animal attack, and mutilated bodies. Each picture was resized to three different sizes: large, corresponding

to $20.96^\circ \times 15.66^\circ$ horizontal and vertical degrees of visual angle, medium ($6.99^\circ \times 5.22^\circ$), and small ($2.62^\circ \times 1.96^\circ$). Pictures were normalized to the same average brightness and contrast (155 and 25, respectively, on an absolute scale ranging from 0 to 255), and were pasted on a uniform gray background of the same brightness. Twenty different sequences were built. In each one, 105 of the original stimuli (15 for each category) were presented. To avoid repetition effects, each participant viewed a specific picture only once, in only one of the three sizes. Presentation order was pseudorandomized so that no more than two pictures of the same content or three pictures of the same size were presented subsequently. Across the whole group of participants, each picture was shown in all three sizes.

Pictures were presented on a 19-in. (48.3 cm) monitor using E-Prime software (Schneider, Eschman, & Zuccolotto, 2002). The distance between the monitor and the participant was 100 cm, and a chin rest guaranteed a constant distance within and across participants.

Procedure

On arrival, participants were introduced to the laboratory and warned of the arousing content of some of the images. After having signed an informed consent form, the participant was accompanied to the experimental room and the electrodes were placed. This procedure lasted approximately 10 min. Then the experimenter read the instructions and the experiment began.

Each participant viewed 105 pictures. During each trial, a picture was presented for 6 s in the center of the screen. After a blank screen lasting 4 s, the visual rating scales of valence and arousal were presented. After the ratings, a blank interval lasting between 15 and 18 s was presented (ITI). During the intertrial interval a fixation cross was displayed in the center of the screen.

Physiological Recording and Data Reduction

Activity of the Corrugator Supercilii muscle, skin conductance, and heart rate were recorded. All physiological signals were acquired using a Scientific Solutions Labmaster A/D board controlled by an IBM computer running VPM acquisition software (Cook, 1997). Corrugator Supercilii EMG was acquired by placing two electrodes over the left eyebrow. The raw EMG signal was recorded with two 4-mm Ag/AgCl electrodes, amplified by 10,000 and band-pass filtered between 13 and 1000 Hz using a Coulbourn V75-04 module. The raw signal was rectified and integrated using a Coulbourn V76-23 contour-following integrator with a time constant of 100 ms. The integrated EMG signal was sampled at 200 Hz and stored for successive data reduction. Skin conductance was recorded using two 7-mm Ag/AgCl electrodes filled with the recommended 0.05 mol NaCl Unibase paste, placed on the hypothenar eminence of the left palm. The signal was acquired using a Coulbourn V71-23 module and was calibrated before each session to detect activity in the range of 0–25 μ S and sampled at 20 Hz. For 7 participants, who showed relatively high levels of skin conductance, amplifier gain was set in order to detect activity in the range of 0–49 μ S. Electrocardiogram (EKG) was recorded using two 7-mm Ag/AgCl electrodes placed on the right shoulder and the left lower rib. The ground electrode was placed on the left shoulder. EKG signal was amplified by 5000 and band-pass filtered between 13 and 40 Hz using a Coulbourn V75-04 module. Interbeat intervals were recorded to the nearest millisecond and reduced off-line using VPM software into heart rate in beats per minutes (bpm), in half-second bins (Cook, 1997).

All data were analyzed in half-second bins, and transformed into change scores by subtracting activity during the 1-s interval preceding picture onset. Corrugator Supercilii EMG response was scored as the average amplitude change over the 6-s viewing interval. Skin conductance change was scored as the maximum response occurring between 1 and 4 s from picture onset. SC data were normalized using a logarithmic function (Bradley et al., 2001). HR change score was defined as the maximum deceleration occurring in the first 3 s of picture viewing.

After each picture, participants were requested to rate valence and arousal of their current emotional state. Ratings were collected using the Self-Assessment Manikin (SAM; Lang, 1980), which depicts a graphic figure that varies along two dimensions of pleasure and arousal, on a 9-point scale. SAM ranges from a smiling, happy figure (9) to a frowning, unhappy figure (1) when representing the pleasure dimension; for the arousal dimension, it ranges from an excited, wide-eyed figure (9) to a relaxed, sleepy one (1).

Physiological responses and SAM ratings were averaged across subjects and experimental conditions.¹ Data were analyzed through a repeated-measures ANOVA with the within-subject factors Size (three levels), and Category (seven levels). To deal with sphericity violations that increase the probability of type I error, a Huynh-Feldt correction was applied to the degrees of freedom (Huynh & Feldt, 1970). The eta squared statistic (η^2), indicating the proportion between the variance explained by one experimental factor and the total variance, has been calculated and is reported.

Results

Subjective Ratings

Affective space described by pleasantness and arousal ratings is reported in Table 1 and summarized in Figure 1. The distribution of pictures in the affective space followed the typical boomerang shape that has been observed in previous studies (Bradley, 2000; Ito et al., 1998; Lang et al., 1997).

Arousal. A significant main effect of Category was observed on arousal ratings, $F(6,252) = 59.8, p < .001, \eta^2 = .59$. Pairwise comparisons indicated more intense arousal ratings for erotic scenes and mutilated bodies compared to all other categories, and for mutilation compared to erotic couples, $ps < .05$. Moreover, neutral people were rated as less arousing compared to all other categories, and pictures of contamination were rated as significantly less arousing compared to opposite sex nudes, $ps < .05$. A significant main effect of Size was also observed, $F(2,84) = 122.62, p < .001, \eta^2 = .75$, which was further qualified by a significant linear trend $F(1,42) = 157.39, p < .001, \eta^2 = .79$, indicating progressively lower arousal ratings with smaller picture sizes.

Finally, the Category \times Size interaction was also significant, $F(12,504) = 3.65, p < .001, \eta^2 = .08$. Following this significant interaction, an ANOVA with the factor Category (seven levels)

¹To investigate block effects, data from each subject were split into three blocks of 35 trials each. A repeated-measures ANOVA with the within-subject factors Block (3), Category (7), and Size (3) was conducted on each measure.

A significant Block \times Size effect was observed on Corrugator Supercilii activity, $F(4,192) = 3.42, p < .05, \eta^2 = .067$, indicating significant effects of Size during the first two blocks but not during the last 35 trials. Concerning SC, a significant main effect of Block was observed, $F(2,80) = 29.83, p < .001, \eta^2 = .43$, indicating more pronounced SC changes during Block 1, $p < .05$, and no difference between Blocks 2 and 3. No other main effects or interactions of the factor Block with either Size or Category were observed across measures.

Table 1. Mean Ratings of arousal and Valence, Corrugator Supercilii (in Microvolts) and heart rate (in Beats per Minute) for All Categories and Picture Sizes

Category	Arousal			Valence			Corrugator			Heart Rate						
	Large	Medium	Small	Large	Medium	Small	Large	Medium	Small	Large	Medium	Small	Total			
Erotic couples	5.54 (2.08)	5.33 (2.17)	4.59 (2.17)	5.15 (2.18)	6.84 (1.65)	6.64 (1.71)	6.31 (1.63)	6.6 (1.67)	0.00 (.66)	0.09 (1.06)	0.20 (1.25)	0.09 (1.02)	-3.42 (4.76)	-3.21 (4.51)	-3.23 (5.06)	-3.29 (4.78)
Opp. sex nudes	4.86 (2.09)	4.59 (2.1)	3.82 (1.98)	4.42 (2.1)	6.73 (1.51)	6.63 (1.61)	6.19 (1.58)	6.52 (1.58)	0.06 (1.50)	0.08 (1.08)	0.34 (1.42)	0.16 (1.35)	-2.86 (4.44)	-3.42 (4.92)	-3.74 (4.66)	-3.34 (4.68)
Babies	4.68 (2.24)	4.49 (2.24)	3.74 (1.99)	4.3 (2.2)	7.06 (1.44)	6.88 (1.57)	6.48 (1.31)	6.81 (1.46)	-0.24 (1.23)	-0.12 (1.28)	0.08 (1.32)	-0.09 (1.28)	-3.17 (5.00)	-2.93 (4.51)	-2.95 (4.26)	-3.02 (4.60)
Neutral people	2.37 (1.5)	2.29 (1.55)	1.82 (1.24)	2.16 (1.45)	5.09 (1.02)	4.97 (1.00)	4.73 (1.22)	4.93 (1.09)	0.21 (1.15)	0.18 (1.08)	0.38 (1.85)	0.25 (1.41)	-3.49 (4.74)	-3.06 (4.48)	-3.07 (4.17)	-3.21 (4.47)
Contamination	4.39 (2.22)	3.98 (2.05)	3.24 (1.9)	3.87 (2.11)	2.55 (1.26)	2.82 (1.39)	3.25 (1.39)	2.87 (1.38)	0.48 (1.82)	0.37 (1.37)	0.75 (2.34)	0.54 (1.89)	-4.17 (5.01)	-3.92 (5.10)	-4.01 (4.72)	-4.03 (4.94)
Animal attack	4.68 (2.08)	4.14 (1.95)	3.39 (1.86)	4.08 (2.03)	4.36 (1.9)	4.35 (1.71)	4.41 (1.55)	4.37 (1.72)	0.15 (1.30)	0.17 (1.38)	0.40 (1.52)	0.24 (1.41)	-3.74 (5.05)	-4.16 (5.45)	-3.53 (4.46)	-3.81 (5.00)
Mutilation	6.99 (1.95)	6.33 (2.07)	5.2 (2.33)	6.18 (2.24)	1.93 (1.62)	2.02 (1.52)	2.46 (1.48)	2.14 (1.56)	0.82 (1.94)	0.86 (2.11)	0.89 (2.13)	0.86 (2.06)	-4.43 (4.82)	-4.04 (4.93)	-4.66 (4.89)	-4.38 (4.88)
Total	4.79 (2.41)	4.45 (2.33)	3.69 (2.19)	4.31 (2.35)	4.93 (2.46)	4.89 (2.36)	4.83 (2.06)	4.89 (2.3)	0.21 (1.46)	0.23 (1.41)	0.43 (1.75)	0.29 (1.55)	-3.61 (4.85)	-3.54 (4.87)	-3.60 (4.64)	-3.58 (4.79)

Note. Standard deviations are in parentheses.

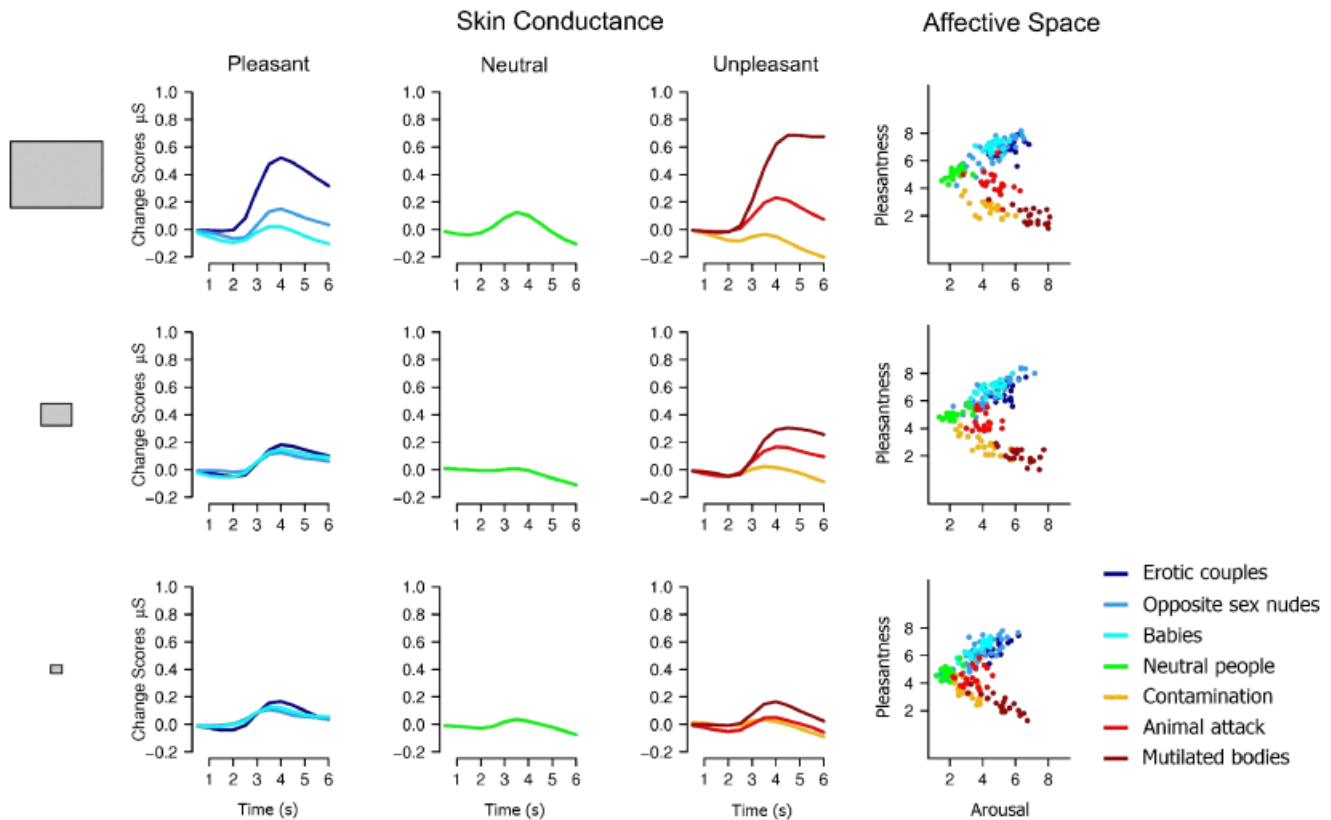


Figure 1. Emotional modulation of skin conductance and subjective ratings. Stimuli differing in size are represented in separate rows, with the largest pictures on the top and the smallest pictures on the bottom. Colors indicate stimulus category. The three panels on the left show the mean SC changes across subjects and pictures, separately for each valence. The panels to the right represent the distribution of pictures in the affective space defined by rated pleasantness and arousal, separately for each stimulus size.

was performed for each size. Results showed a significant Category effect for all picture sizes, $F_s(6,252) > 39.92$, $p < .001$, $\eta^2 > .49$. To examine which picture category was more affected by size reduction in arousal rating, the difference between the largest and smallest size was calculated for each participant and picture category. A less pronounced change with size variation was observed for pictures of neutral people compared to all other categories, $p < .05$. Moreover, a more marked decrease was observed for pictures of mutilation compared to all other contents and for pictures of animal attack compared to neutral people, all $p < .05$.

Valence. A significant main effect of Category was observed on ratings of valence, $F(6,252) = 156.6$, $p < .001$, $\eta^2 = .79$, indicating more pleasant states for pictures depicting positive compared to neutral and negative stimuli. Pairwise comparisons indicated significant differences between all categories, except for erotic scenes, opposite sex nudes, and babies, all $p < .05$. No significant effect of Size was observed.

A significant Category \times Size interaction was observed $F(12,504) = 13.72$, $p < .001$, $\eta^2 = .25$. Following this significant interaction, an ANOVA with the factor Category (seven levels) was performed for each picture size. For all sizes, a significant Category effect was observed, $F(6,252) > 106.89$, $p < .001$, $\eta^2 > .72$. Pleasant (erotic couples, opposite sex nudes, and babies) and neutral pictures decreased in pleasantness as picture size was reduced, whereas unpleasant pictures (contamination, animal attack, and mutilation) showed the opposite pattern. Within pleasant contents, no differences were found. On the other hand, within unpleasant contents, mutilation and contamination

showed larger changes compared to animal attack $p < .05$, which showed no change as a function of picture size.

Physiological Responses

Skin conductance. Figure 1 illustrates skin conductance waveforms as a function of picture content and size. In the largest picture size (top row), highly arousing pictures elicited more pronounced SC changes compared to low arousing and neutral pictures. Interestingly, this emotional modulation was largely reduced in the intermediate picture size and absent in the smallest image size. A significant main effect of Category was obtained, $F(6,294) = 12.15$, $p < .001$, $\eta^2 = .2$, indicating more pronounced SC changes for erotic couples and mutilated bodies compared to all other categories, $p < .01$. Moreover, less pronounced SC changes were observed for neutral pictures and pictures of contamination compared to opposite sex nudes and animal attacks and for pictures of contamination compared to babies, $p < .05$. A significant Size effect was observed, $F(2,98) = 4.06$, $p < .05$, $\eta^2 = .08$, which was further qualified by a significant linear trend, $F(1,49) = 5.86$, $p < .05$, $\eta^2 = .11$, indicating more pronounced SC changes for larger compared to smaller pictures.

Additionally, a significant Category \times Size interaction was obtained, $F(12,588) = 3.32$, $p < .001$, $\eta^2 = .06$, which was further qualified by a significant quadratic \times linear trend, $F(1,49) = 11.32$, $p < .01$, $\eta^2 = .19$. To better describe this effect, separate ANOVAs with the factor Category (seven levels) were conducted for each size. Interestingly, whereas a significant Category effect was observed for large pictures, $F(6,294) = 14.27$,

$p < .001$, $\eta^2 = .23$, it decreased for images in medium size, $F(6,294) = 3.89$, $p < .01$, $\eta^2 = .07$, and did not reach significance for small images, $F(6,294) = 1.92$, n.s. When presented in large size format, pictures of erotic couples and mutilated bodies elicited significantly larger SC changes compared to all other categories ($ps < .05$) and did not significantly differ from each other. Moreover, pictures of babies and contamination elicited significantly less pronounced SC changes compared to opposite sex nudes and animal attack, all $ps < .05$. When presented in medium size, pictures of mutilated bodies elicited larger SC changes compared to opposite sex nudes, neutral people, contamination, and animal attack, whereas pictures of neutral scenes and contamination elicited less pronounced SC changes compared to erotic couples and babies, all $ps < .05$. Finally, separate ANOVAs with the factor Size (three levels) were carried out for each stimulus content to identify the sensitivity of each content to changes in image size. Significant effects of Size were found for erotic couples and mutilation, $F_s(2,88) > 5.89$, $ps < .01$, $\eta^2_s > .1$.

Heart rate. The effects of picture size on the initial heart rate deceleration are reported in Table 1. A significant Category effect was observed, $F(6,294) = 7.08$, $p < .001$, $\eta^2 = .13$.² In particular, pictures of contamination and mutilation elicited more pronounced cardiac decelerations compared to erotic scenes, opposite sex nudes, babies, and neutral people, $ps < .05$. Pictures representing attacking animals elicited larger deceleration compared to those depicting babies and neutral people, all $ps < .05$. Moreover, no main effects or interaction involving the factor picture Size were observed, $F_s < 1$.

Corrugator Supercilii. Results for Corrugator Supercilii EMG are reported in Table 1. Consistent with previous studies, stimulus content modulated Corrugator Supercilii EMG activity, and this emotional modulation appeared equally pronounced for all picture sizes. A significant Category effect was observed, $F(6,258) = 15.77$, $p < .001$, $\eta^2 = .27$. Pairwise comparisons indicated more pronounced EMG activity following presentation of pictures of contamination and mutilation compared to all other categories, and of mutilation compared to contamination. Moreover, attacking animals elicited a more pronounced EMG activity compared to erotic scenes and babies. With regards to the appetitive side, erotic scenes and babies elicited a less pronounced EMG activity compared to neutral people. Finally, pictures of babies elicited the maximum decrease in EMG activity, differing significantly from opposite sex nudes and neutral people, all $ps < .05$. A significant main effect of picture Size was observed, indicating progressively larger EMG activity for smaller sizes, $F(2,86) = 6.71$, $p < .01$, $\eta^2 = .14$. This effect was further qualified by a significant linear trend, $F(1,43) = 8.29$, $p < .01$, $\eta^2 = .16$. No interaction of Category \times Size was observed in this analysis, $F(12,516) = 1.1$.

Discussion

In this study we assessed the effects of picture size on affective perception to evaluate whether a reduction in stimulus size affects emotional responses, providing insight into the functional meaning of physiological changes associated with emotional processing. The data indicated that SC affective modulation was absent for

the smallest pictures and increased linearly with stimulus size. On the other hand, whereas subjective ratings of valence and arousal varied slightly with picture size, with less affective modulation for smaller pictures, affective modulations of heart rate and Corrugator Supercilii activity were not affected by stimulus size.

The present study clearly indicated that picture size reduction is associated with a decrease in skin conductance affective modulation. The magnitude of skin conductance responses, which index general activation of the sympathetic chain (Roth, 1983), covaries strongly with arousal reports (Bradley et al., 2001; Greenwald, Cook, & Lang, 1989; Lang, Greenwald, Bradley, & Hamm, 1993). Roth (1983) suggested that when a relevant stimulus prompts the system for action, sympathetic activation elicits augmented functioning of the sweat glands, which is reflected in skin conductance response. In an evolutionary framework, activity increase of the sweat glands of the palm has been related to the maintenance of optimal hand moisture, to promote grasping efficiency (Roth, 1983). According to this speculation, preparation for action may (or may not) be followed by an overt response, and this includes the increase in sympathetic activity that mediates skin conductance response.

Focusing on cortical activity, several previous studies have shown that the magnitude of the LPP component of the ERP varies with stimulus arousal (Codispoti, Ferrari, De Cesarei, & Cardinale, 2006; Johnston, Miller, & Burleson, 1986; Radilova, 1982; Schupp et al., 2004), with the largest LPPs elicited when viewing the most arousing picture contents, possibly reflecting enhanced attention allocation to relevant events. Interestingly, a previous study, using picture sizes comparable to those used in the present study, found that affective modulation of the amplitude of LPP did not change as a function of picture size (De Cesarei & Codispoti, 2006).³

Although the arousal content of the stimulus similarly affects SC and LPP changes and both responses have been related to orienting and successive sustained attention toward a relevant stimulus (Bradley, 2000; Roth, 1983), a reduction in picture size seems to affect SC and LPP emotional modulation in different ways, suggesting that these two measures index different processes in picture perception. Specifically, the affective modulation of the LPP seems to reflect attentional capacity invested in categorization of relevant events, mostly unaffected by contextual relevance, whereas skin conductance response might be related to action preparation and therefore might be more sensitive to changes in contextual relevance.⁴ Consistent with this interpretation, the same dissociation between SC and LPP was observed in a previous habituation study where the intensity of the stimulus was reduced by repeating the same stimulus several times: The affective modulation of the LPP was preserved after several repetitions,

³In a previous study (De Cesarei & Codispoti, 2006), we presented emotional and neutral pictures using the same range of stimulus sizes as in the present study and a presentation time of 100 ms, and we asked participants to categorize scenes as representing either an animal or a person. Although a significant effect of size on response latency and accuracy was observed, even in the smallest size categorization accuracy exceeded 85%.

⁴Two possible mechanisms might underlie the observed effects of contextual relevance on SC change. In a first scenario, a small stimulus might be categorized, as reflected by subjective and psychophysiological indexes of categorization, but no action preparation would be initiated if its relevance did not exceed a minimum threshold, and therefore no sympathetic activation would be elicited. Alternatively, it is possible that subcortical structures prompt autonomic activation regardless of stimulus size, whereas higher level cortical areas may exert an inhibitory influence on neural structures involved in the regulation of skin conductance changes.

²A separate analysis was conducted on the secondary HR acceleration during the last 3 s of picture viewing and on the average HR change during the whole picture interval. These analyses yielded results that were similar to the initial HR deceleration, showing significant main effects of Category and no main effects or interactions involving factor Size.

whereas SC modulation habituated rapidly with stimulus repetition and was reinstated only when new pictures were presented (Codispoti, Ferrari, & Bradley, 2006, 2007). However, this interpretation remains speculative, and more studies are needed on the functional significance of SC response in affective perception.

Similar to affective modulation of SC, subjective ratings showed that the affective space varied slightly in extension as a function of stimulus size. However, significant differences were observed for all stimulus sizes, and in the smallest size emotional modulation was observed for subjective ratings but not for SC.⁵ Taken together, these results suggest that subjective reports and autonomic responses are modulated differently by factors affecting stimulus relevance.

Emotional modulation of the Corrugator Supercilii muscle activity was not influenced by changes in picture size. The Corrugator Supercilii muscle serves communicative functions related to the pleasantness of the emotional state and has been reported to vary with stimulus valence (Bradley, 2000). Consistent with this, the present study observed emotional modulation of the Corrugator Supercilii activity, which was not affected by changes in stimulus size. Changes in size and distance modulate the motivational relevance of a stimulus (Lang et al., 1997) and may therefore affect more psychophysiological responses related to arousal compared to valence. However, it was observed that across categories Corrugator Supercilii activity was more pronounced for smaller compared to larger pictures, possibly reflecting a facial expression of frowning related to the increased difficulty in understanding the content of small compared to large pictures.

Psychophysiological responses are fractionated across different systems (Lacey, 1967; Lacey & Lacey, 1958), and their pattern as a function of the proximity of a threatening stimulus has been described in the defense-cascade model (Fanselow, 1994; Lang et al., 1997). In this model, different stages of response have been proposed, namely a baseline, an orienting stage, and an overt response stage. During these stages, it has been proposed that SC and cortical activity vary linearly with increasing proximity, whereas HR and startle reflex show an initial decrease related to the orienting of attentional resources, followed by an increase when overt action is initiated.

Consistent with this model, the present study showed a linear increase of SC response as a function of stimulus size, possibly

reflecting higher arousal relating to larger compared to smaller stimuli. Interestingly, no differences in emotional modulation of HR and of ERP signatures of attentional processes as a function of stimulus size were observed either in this study or in previous studies (De Cesarei & Codispoti, 2006; Sánchez-Navarro et al., 2006). However, it should be noted that the defense-cascade model describes the pattern of psychophysiological responses in a natural setting, where a threatening stimulus may become so relevant that an overt active response has to be initiated. In laboratory settings, stimuli are displayed on a computer monitor, and they are unlikely to elicit an overt active response. Thus, it could well be that, despite stimulus size modulated arousal, as reflected by both SC and subjective ratings, for all stimulus sizes HR reflected a pattern of attentional orienting (Graham, 1992) that has been observed for stimuli of intermediate relevance in nonphobic populations (Bradley, 2000; Cook & Turpin, 1997; Lang et al., 1997).

Interestingly, no differences in heart rate changes were found as a function of picture size. This result contrasts with the hypothesis that differences in discriminability or in the number of details would have captured attentional resources differently and that this difference would have been reflected in HR deceleration. It has been suggested that heart rate is an index of a task-specific (tactic) facet of emotional response, and SC reflects a basic (strategic) motivational mechanism related to arousal (Lang, Bradley, & Cuthbert, 1990). Changes in stimulus size, which influence the basic motivational relevance of a stimulus but do not affect task demands, do not require the organism to change its tactical task setting, but rather to adaptively shape its functioning and behavior according to the motivational relevance of the situation.

The present study showed that changes in stimulus size modulated stimulus relevance, as reflected by both subjective and psychophysiological measures. The use of picture sizes ranging from very small to moderately large allowed us to identify a condition in which no affective modulation of skin conductance was observed, even though emotional modulation in HR, Corrugator Supercilii activity, and subjective ratings reflected that a stimulus categorization had been achieved. Taken together, the findings suggest that stimulus size modulates sympathetic changes possibly related to activation of the strategic motivational systems and action preparation.

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⁵Description of the slope of the function relating emotional response to stimulus size is an interesting and informative research goal (e.g., Teghtsoonian & Frost, 1982). Although the present study, which investigated stimulus size from a very small to a standard monitor size, described a linear increase in SC modulation, a recent study found no difference between affective modulation of SC to pictures of either standard monitor size or larger (Sánchez-Navarro, Martínez-Selva, Román, & Torrente, 2006). It could be that the amplitude of SC affective modulation is linearly related to stimulus size until it reaches an asymptotic value that can not be exceeded by further increases in stimulus relevance. However, because differences in experimental design and stimuli do not allow for the combination of results from these two studies, it would be interesting to investigate the effects of stimulus size on affective modulation of SC change, using a consistent design and a consistent stimulus set ranging from very small to very large stimulus sizes.

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