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Emotional reactions in children: Verbal, physiological, and behavioral responses to affective pictures

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Abstract

Many studies have shown a consistent pattern in adults' responses to affective pictures and there is growing evidence of gender differences, as well. Little is known, though, about children's verbal, behavioral, and physiological responses to affective pictures. Two experiments investigated children's responses to pictures. In Experiment 1, children, adolescents, and adults viewed pictures varying in affective content and rated them for pleasure, arousal, and dominance. Results indicated that children and adolescents rated the pictures similarly to adults. In Experiment 2, physiological responses, self-report, and viewing time were measured while children viewed affective pictures. As with adults, children's responses reflected the affective content of the pictures. Gender differences in affective evaluations, corrugator activity, skin conductance, startle modulation, and viewing time indicated that girls were generally more reactive to unpleasant materials.

Descriptors: Children, Startle, Emotion, Pictures, Ratings

Recent studies have investigated emotional reactions using affective pictures to elicit emotional experience in adults (e.g., Greenwald, Cook, & Lang, 1989; Lang, Greenwald, Bradley, & Hamm, 1993). These studies reveal a consistent pattern of verbal, behavioral, and physiological responses associated with the degree to which the pictures are emotionally arousing (see Bradley & Lang, 2000, for an overview). Thus, the corrugator muscle of the face (which draws the brows together in expressions of displeasure) is more active when viewing pictures rated as unpleasant, compared to when viewing pleasant contents. Conversely, increases in zygomatic majoris activity (a muscle involved in smiling) are related to ratings of increased pleasantness. Changes in heart rate are also related to ratings of pleasure, with greater deceleration for unpleasant, relative to pleasant, pictures.

Affective responses to a picture are also apparent in the magnitude of the startle response during picture viewing: the blink response elicited when a sudden noise occurs when looking at an unpleasant stimulus is systematically larger than startle blink reflexes elicited when viewing pleasant pictures (e.g., Lang, 1995; Vrana, Spence, & Lang, 1988; see Bradley, Cuthbert, & Lang, 1999, for an overview). On the other hand, skin conductance is positively correlated with ratings of arousal, increasing for both pleasant and unpleasant pictures compared to low arousal, neutral stimuli. Adults also choose to look at pictures rated high in arousal for a longer period of time than those rated low on arousal, independent of picture pleasantness.

These patterns of autonomic, somatic, and reflex reactions have been found repeatedly when adults look at affective pictures. Gender differences have also been found (e.g., Lang et al., 1993), and a recent study highlights ways in which men and women respond differently to affective pictures (Bradley, Codispoti, & Lang, 2000). Compared to men, women are more reactive to unpleasant materials, rating these pictures as more unpleasant and arousing, and also reacting with more corrugator EMG activity (Bradley et al., 2000). On the other hand, men tend to be more reactive to pleasant pictures, especially erotica, rating these pictures as more pleasant and more arousing than women do, and reacting with significantly more skin conductance activity. In our view, the physiological and behavioral reactions associated with emotion stem from the activation of basic motivational systems controlling appetite or defense, and suggest differences in the ease with which pictorial cues activate these systems in men and women.

Here, we explored emotional reactions in prepubescent boys and girls (i.e., 7–10 years of age). A first goal was simply to determine whether affective pictures elicit similar patterns of reactivity in self-report, physiological, or behavioral responses in children, compared to adults. To the extent that patterns are similar, the picture perception methodology would be appropriate for as-

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sessing questions concerning temperament, development, and other key issues in child psychology. Secondly, we assessed gender differences in these children, testing the hypothesis that differences between males and females in reactions to emotional events are apparent before puberty. In particular, we focused on differences in reactivity of girls and boys to unpleasant pictures, with the hypothesis that girls should be more reactive specifically to these stimuli if these gender differences are present at an early age. Conversely, to the extent that prepubescent girls and boys are more similar to each other than are men and women in reactions to unpleasant pictures, the hormonal changes of adolescence might be implicated in altering later affective responses.

In Experiment 1, we presented 60 pictures selected from the International Affective Picture System[1] (IAPS; Center for the Study of Emotion and Attention [CSEA], 1999; Lang, Bradley, & Cuthbert, 1999) and collected ratings of pleasure, arousal, and dominance from a set of prepubescent, adolescent, and adult participants. The primary goal of Experiment 1 was to acquire normative ratings for different age groups on a subset of IAPS pictures that were judged appropriate for children's viewing by their teachers and principals. The pictures represented a wide range of emotional contents, including babies, animals, amusement parks, sports events, food, candy, nature scenes, household objects, human faces, snakes, spiders, guns, cemeteries, injured humans, and more.

In Experiment 2, we selected a subset of these pictures (based on ratings of pleasure and arousal), and investigated the pattern of responses in verbal, physiological, and behavioral measures while prepubescent children viewed these pictures. As noted above, one goal of Experiment 2 was to determine whether girls, like women, react more strongly to unpleasant stimuli, and whether boys, like men, are more responsive to pleasant pictures. Some data suggest that girls do, in fact, react more strongly to aversive stimuli than boys. Among very young children, for example, studies show that girls display more frequent and intense avoidance and distress to unfamiliar objects and events than boys, and preserve these signs for a longer period of time (Kagan, 1994). In a study of empathy, Strayer (1993) found that girls were more likely than boys to report feeling sad or scared in response to videos showing children in sad or scary scenarios. These differences may be due to different gender roles and expectations for males and females at different developmental stages (Brody, 1993, 1999).

A second goal in Experiment 2 was to determine whether prepubescent children, regardless of gender, respond to affective pictures with patterns of reactivity previously found in adults. The simplest hypothesis is that children will respond similarly, as affective response is assumed to be activated by basic motivational systems of appetite and defense that are phylogenetically old and ontogenetically early. Some data support this view. For instance, even 5-month-old infants show affective modulation of the blink reflex, with larger blinks elicited when the infant was looking at a picture of an angry, compared to a smiling or neutral face (Balaban, 1995).

The pictures used in this research were screened in advance by teachers and other elementary school personnel. Their decisions concerning suitability for viewing by young children resulted in the elimination of the IAPS pictures judged most arousing, unpleasant, and pleasant by adults. This constraint raised the possibility that children might not respond similarly to adults because of the weak emotionality of the picture stimuli. To evaluate this hypothesis, in Experiment 2, a group of adults viewed the same set of IAPS pictures as the children. We evaluated the pattern of reactivity in adults primarily to determine the extent to which the current set of pictures, selected to be most appropriate for children, elicits a pattern of reactivity similar to that previously found in adults with more affectively intense materials.

EXPERIMENT 1

Method

Participants

There were 64 (35 girls) children ranging in age from 7 to 11 years. There were 62 (25 girls) adolescents (12–14-year-olds). Children and adolescents were recruited from P. K. Yonge Laboratory School at the University of Florida, Gainesville, FL. A group of 20 (10 women) college undergraduates, 18–23 years old, was recruited from Introductory Psychology classes at the University of Florida.

Materials

Pictures were selected from the IAPS (CSEA, 1999; Lang et al., 1999). Based on previous normative studies with college student and elderly populations, an attempt was made to select pictures that cover a wide range of affective content. All slides were in color with high figure/ground contrast to facilitate discrimination of relevant features. Representatives of the school district reviewed the pictures for age appropriateness. All participants saw the same picture set.[2]

Procedures

Each participant rated the set of 60 pictures using the Self-Assessment Manikin (SAM; Bradley & Lang, 1994; Lang, 1980), which measures the pleasure, arousal, and dominance associated with viewing each picture. For pleasure, words like happy, pleased, or good, and unhappy, scared, angry, bad, or sad were used in the instructions to describe the endpoints. For arousal, words like calm, relaxed, bored, or sleepy and excited, nervous, or wide-awake described the endpoints. For dominance, endpoint descriptors included feeling important, being a leader, and feeling unimportant or bullied.

The unlabeled dimensions were represented pictorially on a 9-point scale. Order of the dimensions on a page was randomized across trials. Figure 1 shows the SAM figure with pleasure, arousal, and dominance scales on the top, middle, and bottom rows, respectively. The pleasure scale shows SAM smiling at one extreme and frowning at the other. A sleeping figure at the calm end of the scale and a figure jumping at the other represent arousal. The dominance scale represents submission as a small figure and dominance with a large figure. Participants were run in groups of 8 to 25. Sessions were conducted in similar rooms (a classroom) under the same lighting conditions for each group.

[1]The IAPS (CSEA, 1999) is available on CD-ROM and as photographic slides. These stimulus sets and technical manual (which includes children's ratings) 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.

[2]The following pictures from the IAPS were used in Experiment 1: 1040, 1120, 1280, 1300, 1710, 1750, 1920, 1930, 2070, 2120, 2130, 2190, 2280, 2320, 2650, 2660, 2780, 2810, 2890, 2920, 3230, 3280, 3500, 3530, 5020, 5030, 5450, 5480, 5910, 5950, 6230, 6300, 6370, 7000, 7010, 7030, 7040, 7080, 7090, 7100, 7130, 7150, 7170, 7250, 7330, 7380, 7390, 7400, 7410, 7430, 7510, 8260, 8490, 8510, 8620, 9050, 9421, 9450, 9461, 9480.

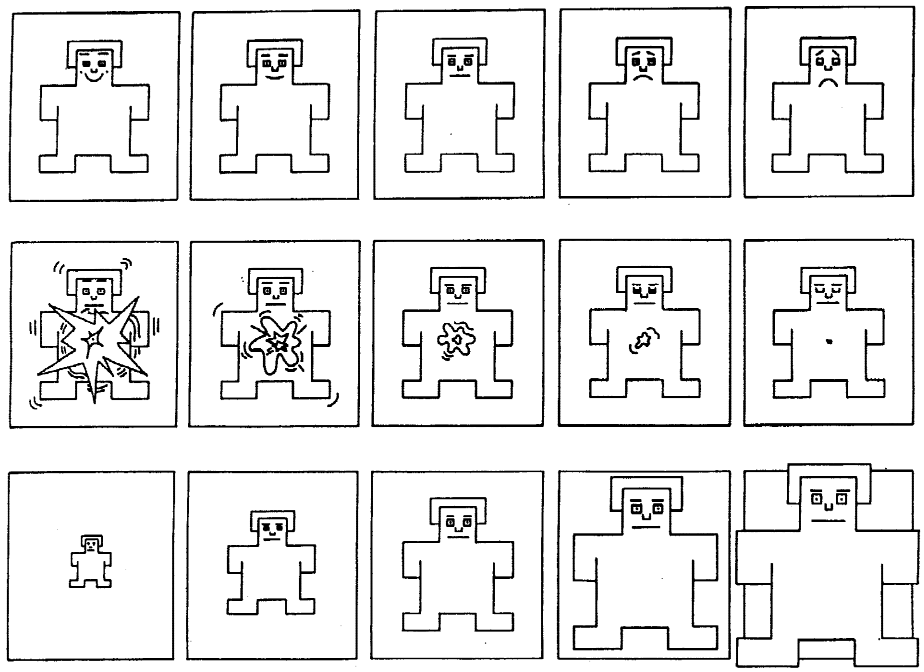

Figure 1. The paper-and-pencil version of the Self-Assessment Manikin (SAM; Lang, 1980). The affective dimensions of pleasure, arousal, and dominance are graphically represented by the top, middle, and bottom rows, respectively.

Participants were instructed to make a mark on the page for each dimension. A mark could be made on or between the figures. Participants viewed a signal/preparation slide for 5 s, then viewed each content picture for 6 s, immediately after which the ratings were made, following the procedure described in Lang, Bradley, and Cuthbert (1997). The rating period was 20 s for children and 15 s for adults, allowing ample time for ratings.

Results

Mean pleasure, arousal, and dominance ratings were computed for each picture. Figure 2 illustrates the location of each picture in a two-dimensional affective space defined by the mean pleasure and arousal ratings of each picture for each age group. Looking at Figure 2, it can be seen that the pictures elicited ratings across the range of each scale. Pearson correlations on the mean pleasure and arousal ratings for each picture were computed and no age group differences in the correlations between the dimensions were found. As expected from previous studies, the pleasure and arousal dimensions were linearly independent for adults, $r(58) = -.10$, $p > .05$, and similar relationships were found for children, $r(58) = -.09$, $p > .05$, and adolescents, $r(58) = -.11$, $p > .05$. As previously found, pleasure and dominance tended to be linearly related for adults, $r(58) = .73$, $p < .01$, and this was also true for children, $r(58) = .91$, $p < .01$, and adolescents, $r(58) = .95$, $p < .01$. The arousal and dominance dimensions were also linearly related in children, $r(58) = -.39$, $p < .01$, adolescents, $r(58) = -.31$, $p < .02$; and adults, $r(58) = -.40$, $p < .01$.

Rather than a linear relationship, the relationship between pleasure and arousal ratings for children, adolescents, and adults was quadratic, $r(58) = .64$ for children, $r(58) = .68$ for adolescents, $r(58) = .55$ for adults, indicating that, as ratings of pleasantness or unpleasantness increased, so did arousal ratings. This quadratic relationship between pleasure and arousal gives affective space its boomerang-shaped form, which is apparent in the plots depicted in Figure 2.

Correlations between adult and child ratings are shown in Table 1. The strong positive correlations indicate that all age groups rated the pictures similarly. Given the high correlations between the ratings and the similarity of the relationships between the affective dimensions the conclusion is that children, adolescents, and adults used the scales in similar ways and demonstrate the ability to use affective dimensions to organize their verbal emotional responses.

EXPERIMENT 2

Method

Participants

Participants included 30 children (15 girls) 7 to 10 years of age and 30 undergraduates (15 women) from the University of Florida. Children were recruited from Alachua County, Florida through a random sample of names drawn from the school district rolls, and received 10 dollars for their participation. The undergraduates were students in an Introductory Psychology course who fulfilled a class requirement with their participation. One subject, a seven-year-old boy, withdrew from the experiment and another seven-year-old boy was dropped from the final analysis because he did not stay on task, as determined by observation.

Apparatus and Response Measurement

The timing, stimulus control, and data acquisition of experimental events was controlled by a Northgate 486 computer (Industry, CA) running VPM data acquisition and experimental control software (Cook, 1997). A Gerbrands electronic shutter controlled slide duration. Slides were projected onto a white matte screen approxi-

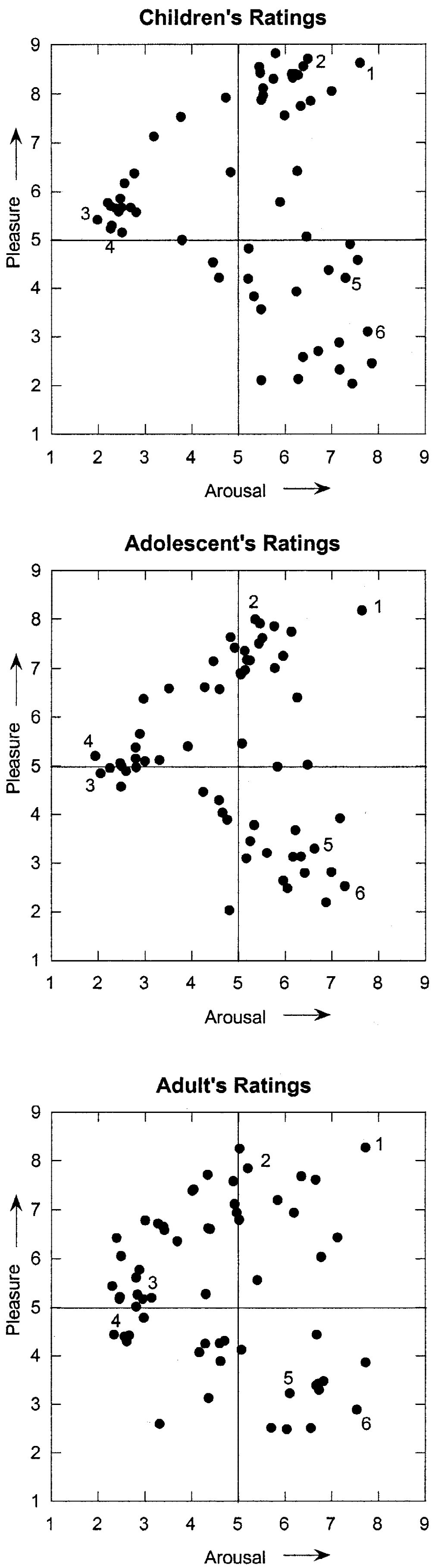

Table 1. *Correlation of Children's and Adolescents' Pleasure and Arousal Ratings with Ratings of Adults*

Group	Pleasure	Arousal	Dominance
Children	.95	.88	.83
Adolescents	.96	.91	.86

Note. All $p < .001$.

mately 2 m in front of the participants by a Kodak (Rochester, NY) Ektagraphic III slide projector. Startle stimuli were 95 dB (Quest model 1700 precision impulse sound level meter) bursts (50 ms) of white noise produced by a Coulbourn Noise Generator and presented binaurally through Telephonics (Farmingdale, NY) headphones.

The startle eyeblink reflex was measured by recording electromyographic (EMG) activity over the orbicularis oculi region under the left eye with Ag/AgCl surface electrodes (see Lang, Bradley, & Cuthbert, 1990). The raw EMG signal was amplified (×30,000) using a Coulbourn Bioamplifier (Allentown, PA), and bandpass filtered between 90 Hz and 250 Hz and digitally sampled at 20 Hz. The amplified and filtered signal was rectified and integrated using a Coulbourn Contour-Following Integrator with a time constant of 125 ms. This signal was digitally sampled at 1000 Hz from 50 ms before startle probe onset until 250 ms after probe onset.

Corrugator EMG activity was measured by recording over the left corrugator muscle region with Ag/AgCl surface electrodes. The raw EMG signal was amplified (×30,000) using a Coulbourn Bioamplifier, and bandpass filtered with a low cutoff of 90 Hz and a high cutoff of 1000 Hz. The amplified and filtered signal was rectified and integrated using a Coulbourn Contour-Following Integrator with a time constant of 500 ms and digitally sampled at 20 Hz.

Heart rate was measured from sensors attached to the left forearm and right collarbone of participants, amplified by a Coulbourn amplifier. A Schmitt trigger detected R-waves and sent a signal to the computer. Interbeat intervals were recorded as the time (in milliseconds) between R-waves. Heart rate was then calculated off-line following Graham (1980).

Skin conductance was transduced with Ag/AgCl electrodes filled with a 0.05 Molar Unibase cream electrolyte (Fowles et al., 1981) affixed to the hypothenar eminence of the left palm. A Coulbourn skin conductance coupler maintained a constant 0.5 V across electrodes. The analog signal was digitally sampled at 20 Hz.

Viewing time was counted to the nearest millisecond and recorded by an IBM XT computer. The same computer presented the computerized version of the SAM (Cook, Atkinson, & Lang, 1987) using VPM software and recorded valence, arousal, and dominance ratings. Ratings were on a scale from 0 to 20, and a joystick was used to manipulate the SAM figure.

Stimulus Materials

Stimuli were selected from a set of 60 pictures previously rated on the dimensions of pleasure, arousal, and dominance (Experi-

Figure 2. Mean pleasure and arousal ratings of the affective pictures in Experiment 1 by age group. The numbers indicate where the following pictures are for each age group: (1) Roller coaster, (2) Baby, (3) Fork, (4) Iron, (5) Pit bull, and (6) Aimed gun.

Table 2. *Mean Pleasure and Arousal Ratings (and Standard Deviations) from Experiments 1 and 2*

	Children			Adults		
	Boys	Girls	Mean	Men	Women	Mean
Pleasure ratings						
Experiment 1						
Pleasant	8.3 (.3)	8.6 (.3)	8.4 (.3)	7.3 (.6)	7.7 (.7)	7.4 (.9)
Neutral	5.9 (.2)	5.7 (.5)	2.4 (.3)	4.9 (.6)	5.0 (.4)	5.0 (.5)
Unpleasant	3.8 (1.0)	2.8 (1.2)	3.4 (1.3)	3.0 (.8)	2.1 (.8)	3.3 (1.2)
Experiment 2						
Pleasant	17.3 (2.8)	19.2 (1.0)	18.3 (1.6)	15.9 (3.9)	16.0 (1.7)	15.9 (1.6)
Neutral	9.9 (2.4)	11.4 (1.6)	10.7 (2.0)	10.6 (1.8)	10.5 (1.3)	10.5 (1.1)
Unpleasant	5.4 (4.1)	2.4 (1.8)	3.9 (2.8)	5.0 (2.8)	3.4 (2.4)	4.2 (1.5)
Arousal Ratings						
Experiment 1						
Pleasant	5.7 (.8)	6.5 (.9)	6.2 (.8)	4.6 (1.4)	5.6 (1.7)	5.1 (1.6)
Neutral	3.0 (.3)	5.7 (.2)	2.4 (.3)	2.6 (.5)	2.8 (.3)	2.7 (.4)
Unpleasant	7.0 (.8)	6.9 (1.0)	7.0 (.9)	5.5 (1.1)	7.2 (.9)	6.4 (1.3)
Experiment 2						
Pleasant	14.7 (5.4)	16.0 (5.0)	15.4 (1.7)	12.5 (1.8)	11.2 (3.2)	11.8 (2.5)
Neutral	7.0 (3.4)	7.7 (4.6)	7.4 (1.9)	5.3 (3.0)	6.2 (2.9)	5.8 (1.5)
Unpleasant	9.5 (5.0)	11.9 (7.1)	10.7 (2.3)	14.7 (3.6)	15.4 (1.8)	15.0 (1.2)

Note. The rating scale was from 0 (low) to 9 (high) for Experiment 1 and from 0 (low) to 20 (high) for Experiment 2.

ment 1). Stimuli were selected on the basis of their ratings to find a set of stimuli to which children would respond. Twenty-seven of the original pictures were selected, nine that were high on both pleasure and arousal (pleasant), nine that were low on pleasure, but high on arousal (unpleasant), and nine that were in the center of the pleasure scale and low in arousal (neutral).[3]

Procedure

Participants came to the laboratory and were seated in a comfortable waiting room where the procedure was explained and informed consent obtained. Participants were then seated in a reclining chair in a small (3.0 × 2.4 m) sound-attenuated room. Sensors and headphones were placed on the participants. Parents were allowed in the room during this part of the procedure if the child or parent requested.

Parents, if present, were then asked to return to the waiting room. The lights were dimmed and participants were instructed to watch the slides the entire time they were on the screen (6 s) and to keep their movements to a minimum. The experimenter left the room, and subjects were given 2 min to adjust to the new light level before the first slide was presented. Each participant saw 27 slides in one of three possible slide orders. Orders were randomly generated with the constraints that each of three groups of nine pictures was presented in the first, second, and last block across the three orders, and each group of three pictures (nine groups) contained a pleasant, unpleasant, and neutral picture. Intertrial intervals varied from 12 to 30 s. A startle probe was delivered randomly between 2.8 and 5.5 s into the viewing period of each picture. Six startle probes were delivered between slides, the first one delivered before the first slide was presented.

Following the picture trials, the sensors were removed and the participants were given an opportunity to stretch. Participants were then instructed on how to use a joystick to control the amount of time they viewed a slide, and the SAM rating procedure. There were two neutral practice slides presented to ensure that each participant understood that he or she could view each slide for as long as he or she wished (up to 30 s maximum) before making his or her ratings. The pictures were then presented in the same order as before, and pleasure, arousal, and dominance ratings were made for each picture. At the end of the procedure, participants were debriefed and received their compensation.

Physiological Data Reduction and Analysis

Average values for each half-second of data collection were computed. EMG activity, skin conductance, and heart rate during picture viewing were converted to change scores from a 1-s baseline immediately preceding picture onset. The average change over the viewing period was averaged within subject across all slides of a given valence and used in statistical analyses for each measure.

Startle responses were scored off-line using a program written by the second author, which incorporated the peak scoring algorithm developed by Globisch, Hamm, Schneider, and Vaitl (1993), and scored, for each blink, the magnitude of change from baseline, in analog-to-digital units (A/D units).

Results

Following the recommendation of Keselman (1997), multivariate analysis of variance (MANOVA) was used to determine the significance of all repeated measures effects. F statistics were computed from Pillai's Trace.

Affective Ratings

Children rated pleasant, neutral, and unpleasant pictures different in terms of pleasure, $F(2,27) = 193.60$, $p < .001$ (see Table 2), as expected, with ratings for each content different from the other by post-hoc t test. An interaction of gender and picture content, $F(2,27) = 4.39$, $p = .02$, however, indicated differences for boys and girls. Girls rated aversive pictures more unpleasant than did

[3]The following pictures from the IAPS were used in Experiment 2: 1120, 1280, 1300, 1710, 1750, 1920, 2190, 2280, 2320, 2920, 3100, 3500, 3530, 5480, 6230, 6300, 6370, 7000, 7010, 7090, 7100, 7130, 7150, 7330, 7410, 8490, 8510.

boys, $t(28) = 2.52$, $p = .02$. Girls also rated both pleasant and neutral pictures more pleasurable than did boys, $t(28) = 2.51$, $p = .02$ and $t(28) = 2.08$, $p < .05$, respectively.

Children also rated the picture contents differently in arousal, $F(2,27) = 30.24$, $p < .001$. Pleasant pictures were rated as more arousing than either unpleasant pictures, $t(29) = 2.81$, $p = .009$, or neutral pictures, $t(29) = 7.99$, $p < .001$, whereas, surprisingly, neutral and unpleasant pictures did not differ in rated arousal. There was no gender difference in arousal ratings.

As can be seen in Table 2, adults showed the expected differences in pleasure ratings, $F(2,27) = 161.63$, $p < .001$. Pleasant pictures were rated as more pleasant than neutral and unpleasant pictures, $t(29) = 14.41$, $p < .001$, and $t(29) = 17.96$, $p < .001$, respectively. Unpleasant pictures were also rated less pleasant then neutral pictures, $t(29) = 13.28$, $p < .001$. Adults also showed the expected differences in arousal ratings between picture contents, $F(2,27) = 80.03$, $p < .001$ (see Table 2), with pleasant and unpleasant pictures rated as more arousing than neutral pictures, $t(29) = 10.07$, $p < .001$, and $t(29) = 12.35$, $p < .001$, respectively. Unpleasant pictures were also rated as more arousing than pleasant pictures, $t(29) = 4.92$, $p < .001$. There were no gender differences for adults.

Comparison to Experiment 1. The correlations between the ratings of pleasure obtained in Experiment 1 and the ratings obtained in Experiment 2 were very high for both children and adults (all rs $> .90$, $p < .001$). The correlation in arousal ratings for Experiment 1 and Experiment 2 was .86 for men and .91 for women, but the correlation between arousal ratings in the two studies was somewhat lower for children (.77 for girls; .60 for boys, $p < .001$ for both boys and girls).

Whereas Experiment 1 did not find a linear relationship between pleasure and arousal for children, girls and boys in Experiment 2 showed a positive correlation between pleasure and arousal ratings, $r(25) = .73$, $p < .001$, for boys, $r(25) = .44$, $p < .05$, for girls, indicating that, in the subset used in the present study, pleasant pictures were rated more arousing than unpleasant pictures by children. This contrasts with Experiment 1, in which there was a clear pattern of unpleasant pictures being rated as more arousing than pleasant pictures (see Table 2).

Physiological Responses

Corrugator EMG activity. As can be seen in Figure 3, corrugator EMG change varied when viewing different types of pictures for children, $F(2,27) = 10.21$, $p < .001$. Consistent with the pattern of differential activity typically obtained in this facial muscle, there was more corrugator EMG activity when viewing unpleasant, compared to pleasant, pictures, $t(29) = 4.30$, $p < .001$. In addition, corrugator activity was decreased when viewing pleasant, compared to neutral, pictures, $t(29) = 3.38$, $p < .01$.

An interaction between gender and picture content for children, $F(2,27) = 3.63$, $p = .04$, however, indicated differences in facial EMG activity for girls and boys. Greater corrugator EMG activity was elicited when viewing unpleasant, compared to pleasant, pictures for both boys, $t(14) = 2.71$, $p < .02$, and girls, $t(14) = 4.02$, $p = .001$, but this difference was larger for girls, compared to boys, linear Content $\times$ Gender $F(1,28) = 7.36$, $p = .01$. In addition, whereas girls showed a reduction in corrugator EMG activity when viewing pleasant, compared to neutral pictures, $t(14) = 3.67$, $p = .003$, boys did not show this effect.

For adults, corrugator EMG activity varied with picture content $F(2,27) = 8.23$, $p < .01$, with less activity when viewing pleasant, compared to neutral, pictures, $t(29) = 3.92$, $p < .001$, but no significant increase in corrugator EMG when viewing unpleasant, compared to neutral, pictures. As can be seen in Table 3, there were no gender differences.

Skin conductance. Across all picture contents, girls showed larger changes in skin conductance levels, compared to boys, $F(1,28) = 5.22$, $p = .03$ (see Figure 3). Although the interaction of gender and content was not significant, our a priori hypothesis of greater reactivity when viewing unpleasant pictures for girls was supported by a difference in skin conductance magnitude when viewing unpleasant pictures, $t(28) = 2.46$, $p < .03$, but not when viewing pleasant pictures.

For adults, skin conductance varied with picture content, $F(2,27) = 5.70$, $p < .01$, with larger changes when viewing unpleasant pictures, compared to pleasant, $t(28) = 3.62$, $p < .01$, or neutral pictures, $t(28) = 2.45$, $p = .02$. There were no gender effects.

Heart rate. Heart rate change varied when viewing different picture contents for children, although the overall effect was marginal, $F(2,27) = 3.16$, $p = .06$. Greater heart rate deceleration occurred when viewing unpleasant, relative to pleasant, pictures, $t(28) = 2.58$, $p < .02$. There were no gender differences.

Heart rate change did not vary as a function of picture content for adults.

Blink modulation. As illustrated in Figure 3, the pattern of blink modulation varied for boys and girls, as suggested by a marginally significant overall interaction between picture content and gender, $F(2,27) = 2.96$, $p = .07$, and an effect in the linear component of this interaction, linear Content $\times$ Gender, $F(1,28) = 6.03$, $p = .02$. Girls and boys primarily differed in the pattern of blink modulation when viewing pleasant and unpleasant pictures, with girls showing the expected increase in blink magnitude when viewing unpleasant, compared to pleasant, pictures, $t(14) = 1.78$, $p < .05$, one-tailed, whereas boys tended to show the opposite pattern, $t(14) = 1.69$, $p < .06$, one-tailed. When boys' and girls' blink magnitude while viewing unpleasant pictures was directly compared, the difference was marginally significant, $t(28) = 1.98$, $p < .07$. No other comparisons were close to significant.

For adults, there was also an interaction between picture content and gender, $F(2,27) = 4.19$, $p = .03$. For men, picture content did not reach significance. For women, on the other hand, an effect of picture content, $F(2,13) = 16.59$, $p < .001$, indicated that blinks were smaller when viewing neutral pictures, compared to when viewing unpleasant, $t(14) = 3.39$, $p < .01$, or pleasant pictures, $t(14) = 2.54$, $p = .02$.

Viewing time. Girls and boys differed in the amount of time that they voluntarily chose to view the pictures, with girls spending more time viewing these stimuli than boys, $F(1,27) = 8.09$, $p < .01$. On average, boys looked at pleasant pictures for 4.00 s (SD = 1.00), neutral pictures for 3.74 s (1.57), and unpleasant pictures for 4.43 s (2.29). Girls looked at pleasant, neutral, and unpleasant pictures for 6.32 s (2.39), 5.50 s (2.46), and 5.38 s (1.64), respectively. Although gender did not interact significantly with picture content, analyses showed that this effect was most pronounced for pleasant and neutral pictures, with girls viewing these contents longer than did boys, $t(28) = 3.73$, $p < .01$ and $t(28) = 2.31$, $p < .03$, respectively.

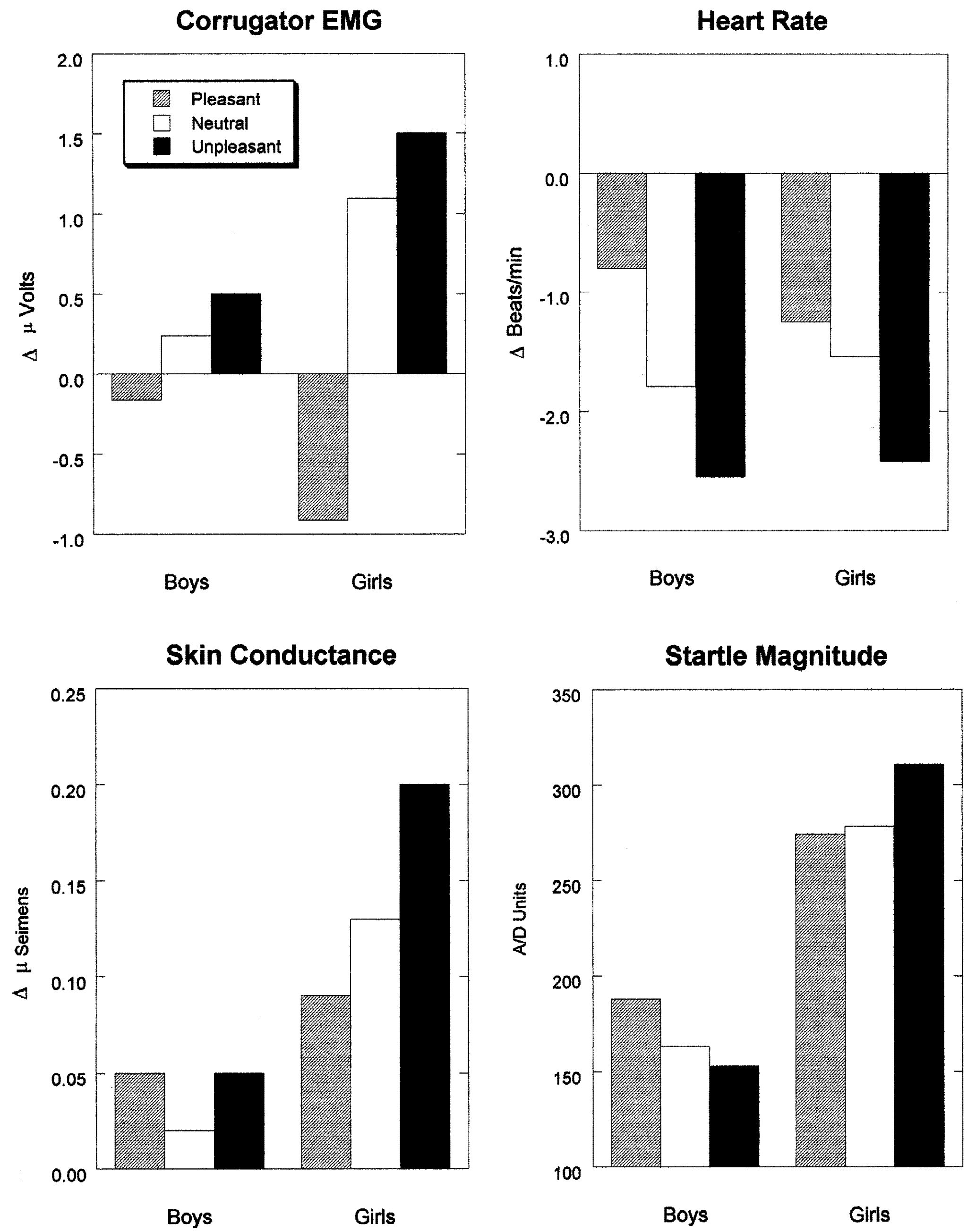

Figure 3. Children's physiological responses to affective pictures.

For adults, viewing time varied with picture content, $F(2,27) = 5.56$, $p = .03$, with longer viewing times for unpleasant, compared to either pleasant, $t(28) = 2.55$, $p < .02$, or neutral pictures, $t(28) = 3.03$, $p < .01$.

Discussion

Children's Responses to Affective Pictures

Experiment 1 demonstrated that children's and adolescents' affective evaluations of pictures, in terms of pleasure, arousal, and dominance, were similar to those of adults. Additionally, Experiment 1 demonstrated that children are able to use the paper-and-pencil version of the SAM (Lang, 1980) to make dimensional ratings of pleasure and arousal in ways similar to adults. Thus, paper-and-pencil SAM can be used to study differences in affective evaluations in children who differ in critical psychological, social, or clinical ways. In both experiments, children rated emotional pictures as more arousing than neutral pictures, as expected. However, children in Experiment 2 rated the pleasant pictures as more arousing than unpleasant, whereas the opposite pattern was found in Experiment 1. The group setting in Experiment 1 might have allowed the reactions of some children to affect the ratings of others, and perhaps differentially for unpleasant pictures. Or, sampling error is a possibility; further studies are needed to determine the reliability of children's evaluative responses to affective stimuli.

Table 3. *Physiological Responses for Adults During Picture Viewing: Experiment 2*

Responses	Mean	Women	Men
Corrugator EMG change (μV)			
Pleasant	−.07 (.51)	−.15 (.66)	.02 (.35)
Neutral	.36 (.60)	.28 (.25)	.43 (.82)
Unpleasant	.39 (.57)	.43 (.40)	.35 (.71)
Average skin conductance change (μSeimens)			
Pleasant	.06 (.13)	.10 (.16)	.03 (.07)
Neutral	.08 (.15)	.11 (.20)	.05 (.08)
Unpleasant	.15 (.22)	.23 (.27)	.08 (.11)
Heart rate change (bpm)			
Pleasant	−1.51 (1.86)	−1.33 (1.18)	−1.68 (2.39)
Neutral	−1.00 (1.56)	−1.02 (1.73)	−.98 (1.44)
Unpleasant	−1.11 (1.96)	−.85 (2.12)	−1.36 (1.82)
Blink magnitude (ADU)			
Pleasant	190 (129)	185 (112)	196 (147)
Neutral	196 (171)	159 (116)	233 (211)
Unpleasant	219 (173)	203 (146)	235 (201)
Viewing time (s)			
Pleasant	5.0 (2.1)	4.8 (2.1)	5.2 (2.2)
Neutral	4.7 (2.5)	4.8 (3.1)	4.6 (2.0)
Unpleasant	5.6 (2.7)	5.2 (2.6)	6.0 (2.9)

Experiment 2 demonstrated that physiological reactions were related to the content of affective pictures for children. Both corrugator EMG activity and heart rate were significantly different as a function of picture content, with greater corrugator EMG activity and more cardiac deceleration when viewing unpleasant, compared to pleasant, pictures. Consistent with gender effects found in adults, however, girls were more reactive to unpleasant pictures. Thus, girls showed more differentiation in corrugator EMG activity when viewing unpleasant and pleasant pictures, rated pictures with aversive content as more unpleasant, and tended to show larger blink reflexes when viewing unpleasant, compared to pleasant, pictures. Relatedly, girls were not only generally more reactive in skin conductance during picture viewing than boys, but specifically more so when viewing unpleasant pictures. Although boys reacted with equivalent cardiac deceleration when viewing unpleasant pictures as did girls, they responded with smaller changes in skin conductance and corrugator EMG activity, and, if anything, tended to show an opposite pattern of startle modulation, with smaller, rather than larger, blinks elicited when viewing unpleasant, compared to pleasant, pictures.

Taken together, these gender differences in emotional reactivity are consistent with the idea that pictures, as affective cues, differentially activate the defensive motivational system for boys and girls. As we have elucidated more fully elsewhere (e.g., Lang et al., 1997), defense is considered to be a staged response that proceeds from oriented attention to defensive action. Drawing on work by Timberlake (1993), Fanselow (1994), Masterson and Crawford (1982), and other animal theorists, defense is viewed as a procedure for dealing with threatening stimuli as they vary from a distant threat to an imminent attack.

According to the defense cascade hypothesis (see Bradley & Lang, 2000; Lang et al., 1997), oriented attention predominates in the initial stages of defense, when a threat is detected, but not imminent. As the threat becomes more imminent, defensive action (e.g., fight, flight) ensues. Importantly, the defense cascade hypothesis posits that physiological responses do not all change in parallel with increased defensive activation. Rather, different measures are sensitive to different aspects of a phased shift from attention/vigilance to action. In the early stages of defense, selective attention to the threatening stimulus is indexed by typical measures of orienting, including sustained heart rate deceleration and modest skin conductance activity; facial displays of fear are also appropriate at initial stages of defense. As the threat becomes imminent, defensive responding increases, with greater sympathetic activity (i.e., increased skin conductance reactivity), behavioral freezing, and priming of defensive reflexes, such as the startle blink. The defense cascade hypothesis proposes that heart rate acceleration occurs late in the defense sequence, when this cardiac activity promotes the distribution of blood to muscles for action. In the context of picture perception, in which a threatening stimulus is never actually nociceptive, this high level of defense rarely occurs, except when highly aversive pictures are viewed by phobic subjects (Hamm, Cuthbert, Globisch, & Vaitl, 1997).

From the viewpoint of the defense cascade hypothesis, the increased conductance and potentiated startle reflexes for girls suggest that these children are "further along" in the defense cascade than are boys—that is, for girls, unpleasant pictures more strongly activate defensive mobilization. On the other hand, boys respond with not only cardiac deceleration, but tend to show reflex inhibition when viewing unpleasant pictures. This pattern of responding—cardiac deceleration and relative inhibition of the startle reflex—was found by Cuthbert, Bradley, and Lang (1996) when adults viewed unpleasant, but not highly arousing, pictures, and suggests an early stage of defensive activation, in which oriented attention dominates. The fact that both boys and girls show cardiac deceleration when viewing unpleasant pictures is consistent with the notion that, although unpleasant pictures activate the defensive motivational system for children, this activation is not strong enough to prompt action in this aesthetic, picture-viewing context, even for girls.

The enhanced reactivity, specifically to unpleasant pictures, for girls, compared to boys, is very similar to the differences found previously for women, compared to men (Bradley et al., 2000; Greenwald et al., 1989; Lang et al., 1993). They are also consistent with findings that, for mature women (e.g., 50+; see Bradley & Lang, 2000), unpleasant pictures are generally rated as more highly arousing than pleasant pictures. Taken together, these data support the hypothesis that gender differences are stable across the lifespan, at least from the age of 7, and are consistent with other evidence that females are more fearful than males across the lifespan (Kagan, 1994; Rose & Ditto, 1983) and across cultures (Ollendick, Yang, Dong, Xia, & Lin, 1995). Among nonhuman mammals, females show more frequent and intense signs of fear (retreat, freezing, alarm calls) especially during threat (Blanchard, Shepherd, Carobrez, & Blanchard, 1991; Crepau & Newman, 1991). There are numerous hypotheses for why females may be more reactive to threatening stimuli than males, including obviously those related to strength and size.

Adults' Affective Responses

As noted in the introduction, initial screenings by teachers and principals resulted in elimination of the most highly arousing unpleasant and pleasant pictures that are typically used in studies of affective perception in adults (Cuthbert et al., 1996; Lang et al., 1993; Simons & Zelson, 1985). Indeed, there were significant differences in the mean arousal ratings for pleasant and unpleasant pictures used in the current study, and the high arousal pictures used by Cuthbert et al. (1996; e.g., 4.87 versus 6.93, $t(12) = -5.66$,

$p < .001$, for pleasant pictures; 6.59 versus 7.07, $t(12) = -1.79$, $p < .05$, for unpleasant pictures), with the pictures used here rated lower in arousal.

Consistent with this, affective reactions of adults were not strong in this study. The physiological and behavioral measures did not show the patterns previously found when adults viewed more emotionally arousing materials. There were no differences in heart rate among picture contents, suggesting a lack of differential orienting. Although skin conductance, corrugator EMG activity, and viewing time varied with picture content, the patterns were somewhat different than those typically obtained. Whereas corrugator EMG is usually increased when viewing unpleasant pictures and decreased when viewing pleasant pictures, in the current study there was only a significant reduction in corrugator EMG activity when viewing pleasant pictures.

In addition, whereas skin conductance is usually greater when viewing emotional (i.e., pleasant or unpleasant), compared to neutral, pictures, increased skin conductance was only obtained when viewing unpleasant pictures. Similarly, whereas viewing time is usually longer for emotional, compared to neutral, pictures, longer viewing times were only obtained here when viewing unpleasant pictures. The typical pattern of affective startle modulation also was not obtained with these relatively low arousal pictures. Rather, men showed no significant differentiation in the blink reflex, and women showed an unusual pattern, with the smallest reflexes elicited when viewing neutral materials. Taken together, the data are consistent with the hypothesis that low to moderately arousing pictures do not strongly or reliably activate emotional reactions in adults. They further suggest that the activation prompted by these moderate stimuli was below the threshold for evoking gender differences previously obtained in adults.

Conclusion

The data are consistent with the notion that boys, more so than girls, react with interest and attention to moderately arousing aversive stimuli, such as images of war, violence, and aggression, whereas girls respond more defensively. It would clearly be useful to increase the intensity of both the pleasant and unpleasant pictures that are shown to children, if this can be done in an ethical, culturally condoned manner. Given the numerous sexual and violent materials to which children are normally exposed via print, video, and web media, it is important to determine how children perceive and respond to these affective stimuli, and whether boys respond with attention, but not aversion, to unpleasant, arousing images.

More generally, this investigation suggests that affective modulation of the blink reflex in the context of picture perception may be useful in studying children's emotional responses. Affective modulation of the startle reflex has been shown to be sensitive to temperamental differences (Cook, Hawk, Davis, & Stevenson, 1991) and can differentiate clinical populations (Patrick, Bradley, & Lang, 1993), as well as differences in defense thresholds in clinical populations (Levenston, Patrick, Bradley, & Lang, in press) among adults. Additionally, the startle probe has been used to investigate the time course of affective picture processing (Bradley, Cuthbert, & Lang, 1993) and the development of anticipatory anxiety (Grillon, Ameli, Woods, Merikangas, & Davis, 1991). As the current study also demonstrates, however, it is critical to use a variety of physiological, self-report, and behavioral measures to obtain a clear picture of how the defensive and appetitive systems may be differentially engaged in boys and girls, and how patterns of response change with the intensity of emotional arousal.

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