Blood pressure changes highlight gender differences in emotional reactivity to arousing pictures

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Abstract

The current study was aimed at investigating the effects of gender on the magnitude and patterning of blood pressure responses to specific pleasant and unpleasant, arousing visual stimuli. Systolic and diastolic blood pressure (SBP and DBP), as well as heart rate (HR) and skin conductance (SCR) responses were investigated during picture viewing in 21 female and 25 male students. The pattern of SCR and HR reactivity across emotional categories was found to be similar for men and women. Gender was found to be an effective moderator of BP responses specifically to sexual stimulus content, which prompted greater reactivity in men than in women. These findings extend prior research on gender differences in autonomic responding to emotional visual stimuli and suggest that BP changes might reflect sexual peripheral arousal more than other autonomic measures.

Keywords: Gender differences; Blood pressure; Heart rate; Skin Conductance; Emotional pictures; Erotic stimuli

1. Introduction

In Western countries, stereotypic beliefs about gender differences in emotional expression and experience are widely shared and are acquired as early as preschool age (Birnbaum, 1983). Women are expected to smile more, to share their feelings more often, to express more positive emotions, but also more powerless emotions, such as fear, sadness, shame and guilt, and with greater intensity. On the other hand, men are believed to inhibit their emotions, both positive and negative, except for powerful emotions, such as anger and pride (Brody and Hall, 1993; Heesacker et al., 1999; Timmers et al., 2003).

This gender role stereotype, though, has received only partial support from empirical findings, especially when specific emotional events and detailed social situations are considered (LaFrance and Banaji, 1992; Feldman Barrett et al., 1998; Hess et al., 2000).

The most consistent results on gender differences regard the expressiveness, or the “outward display” of the emotion (Kring and Gordon, 1998; Hutson-Comeaux and Kelly, 2002). Smiling behavior is observed more frequently in women than in men, and aggressive/anger overt reactions are more typical for men (Brody and Hall, 1993; Hess et al., 2000; Neumann and Waldstein, 2001). Other studies indicate that women are superior to men at facially expressing most of the basic emotions, including fear, sadness, disgust and surprise (Fujita et al., 1980; Tucker and Riggio, 1988; Kring and Gordon, 1998). However, since emotional expressivity per se is strongly influenced by voluntary control and modulation, as well as by social and cultural display rules (Ekman and Friesen, 1975; Ekman, 1992; Kring and Gordon, 1998; Bradley et al., 2001b), the general emotion stereotype could ultimately be the source of the sex-related differences (Hess et al., 2000).

Research investigating the relationship between emotional expression and physiology indicate that diminished physiological reactivity is associated with a more expressive behavior (externalizing style), whereas enhanced reactivity is associated with inhibition of emotional expression (internalizing style) (Buck, 1984). On the ground of this
evidence, men are found to be more often internalizers, women externalizers (Manstead, 1991). On the other hand, Brody (1999) suggested that women might be better defined as generalizers, since they tend to express emotions in many modalities of emotional expression.

Indeed, it is reasonable to hypothesize that gender differences in emotional physiology are not extended to all affective contexts, but emerge more strongly under specific stimulus conditions, especially the ones that differentially challenge men and women, being more salient to one gender than the other. From an evolutionary point of view, men and women have been engaged in dealing with different adaptive problems, in order to achieve different biological and social goals. Thus, men might be more inclined to engage in competitive behaviors and in maximizing their sexual success, whereas women might invest more resources in motherhood and in developing enduring relationships (Troisi, 2001). Moreover, it is possible that gender differences in psychophysiological reactivity, if present, may be revealed only by physiological measures that are less influenced by voluntary control (e.g. autonomic versus EMG measures), and thus less affected by subjective evaluations and display rules (Bradley et al., 2001b). Lastly, it can be speculated that, due to constitutional factors, across genders emotional reactivity is represented by the selective activation of different response systems. In this respect, there is a lack of systematic investigation of gender differences in physiological responses to emotional stimuli.

In a recent study, Bradley et al. (2001b) investigated emotional responding in men and women by means of physiological, expressive and subjective indices. Results indicated that compared with men, women rated unpleasant pictures as more arousing and unpleasant, also reacting with larger changes in corrugator EMG activity and greater cardiac deceleration, irrespective of specific content. On the other side, men rated erotic materials as more arousing and pleasant, also reacting with larger changes in corrugator EMG activity and greater cardiac deceleration, irrespective of specific content. The pattern of autonomic and somatic modulation was found to be largely comparable, with both genders being more reactive to highly arousing stimuli. Different results had been previously reported by Kring and Gordon (1998), who found that women were overall more facially expressive than men in response to emotional films, with no differences in reports of experienced emotion. Moreover, men were found to display greater skin conductance responses than women during fear and anger, whereas women showed greater reactivity during sadness and disgust. Thus, it cannot be concluded that women are, in general, more emotional than men, or that they are specifically more reactive to unpleasant events. On the other hand, no gender differences in cardiovascular reactivity have been reported by Neumann and Waldstein (2001) across different emotional recall tasks differing in affective valence and arousal, indicating largely comparable response patterns in men and women. However, as suggested by the authors, some physiological differences between genders might have been identified by using a larger sample of emotional contents.

Some explanations for discrepancies in the literature may be the different nature (emotional perception versus emotional imagery) and duration (seconds versus minutes) of the employed tasks, as well as the adopted theoretical perspective (specific emotion versus dimensional approach).

Far more consistent and converging evidence emerge across studies investigating gender differences in cardiovascular reactivity to stressful events. In particular, one crucial measure, that also has potentially pathogenic implications, is blood pressure (BP). Stress research has demonstrated larger blood pressure responses in men under physical (Allen et al., 1993; Daida et al., 1996), cognitive (Allen et al., 1993; Lawler et al., 1995; Rose et al., 2004) and psychosocial (Morris-Prather et al., 1996; Fichera and Andreassi, 2000) stress. An exaggerated cardiovascular reactivity to stressors might play a role in the higher incidence of coronary heart disease (CHD) in men. Epidemiological evidence indeed indicates that the male gender is an established risk factor for cardiovascular disease and hypertension (Johnson, 1977; Kannel, 1987; Hall, 1990; Anastos et al., 1991; Smith et al., 2000). Although much focus has been placed on constitutional differences such as potential buffering effect of estrogens and/or on the role of androgens in blood pressure control (Reckelhoff, 2001; Leinwand, 2003), little is known about the underlying mechanisms associated with gender differences in cardiovascular disease and blood pressure regulation.

The importance of blood pressure, as compared with other cardiovascular parameters, in highlighting gender differences to stress has been documented by a large number of studies. On the other hand, little attention has been devoted to gender differences in blood pressure reactivity under nonstressful emotional conditions. Aversive, challenging, or engaging laboratory tasks, such as mental arithmetic, mirror tracer, public speaking, shock avoidance, or aerobic exercise have been usually employed. Even when defined as passive, standard stressful tasks usually imply by definition long-lasting aversive conditions, such as cold pressor test, loud noise stimulation or viewing accident/surgery films (Levenson, 1979; Sherwood et al., 1990), so that research is clearly biased in favour of prolonged negative emotional states.

The primary interest that guided the design of this study was the potential role of blood pressure in enhancing gender differences in emotional responding. It was hypothesized that BP, better than other autonomic measures, would be helpful in determining the emotional conditions under which gender differences are especially large. We investigated whether male “superiority” in BP reactivity to stress would
extend also to nonstressful emotional tasks, and possibly to pleasant arousing contents. The affective picture paradigm has been employed in the present study since research has demonstrated that it's able to elicit a broad range of emotional reactions, varying in intensity and in pleasantness, without engaging subjects in physiologically active tasks (e.g. Bradley, 2000). In the context of affective picture perception, a number of physiological measures have been proved to covary significantly with subjective reports of valence (e.g. heart rate and corrugator EMG activity) or arousal (e.g. skin conductance and slow cortical responses) (Lang et al., 1993; Bradley, 2000). However, in prior research on autonomic responding to emotional pictures, BP measures have largely been neglected. To our knowledge, no studies have compared blood pressure responses during picture viewing in men and women. Indeed, besides gender-related differences, no data are available to date on blood pressure responses to specific categories of pleasant and unpleasant pictures.

In the present study, specific emotional picture contents, both pleasant and unpleasant, were selected from the standardized set of International Affective Picture System (IAPS, Center for the Study of Emotion and Attention [CSEA-NIMH], 1999) in order to expose men and women to various semantic categories depicting emotional events commonly displayed by media in everyday life. Only highly arousing contents were selected for the pleasant and unpleasant picture categories, since these have been observed to induce the most remarkable psychophysiological changes (see Bradley et al., 2001a). Thus, for each valence, the categories were selected to fall within the same quadrant of the affective space (positive/high arousal or negative/high arousal).

In addition to blood pressure changes, other commonly employed autonomic measures (i.e. heart rate and skin conductance) were recorded during picture viewing in order to investigate gender differences in general autonomic responding and to test the possible specificity of blood pressure measures in indexing differential responding in men and women. In particular, skin conductance responses to pictures were considered as an indicator of subject’s physiological arousal level. It has been demonstrated that these measures reliably covary with rated arousal, although interest or attentional demands also tend to affect the subjective dimension (Lang et al., 1993). Furthermore, in a second experimental session, gender differences in viewing time were investigated as a behavioral index of interest by measuring the amount of time that men and women voluntarily chose to view the pictures.

2. Method

2.1. Participants

Twenty-five male and 21 female undergraduates (mean age = 23.5, S.D. = 2.9) were recruited from psychology courses at the University of Padova, receiving course credit for participating in the study. All participants were normotensive (resting SBP < 140 mmHg and DBP < 90 mmHg) and reported no history of hypertension, or cardiovascular disease, or use of medications. All subjects provided written informed consent to the study.

Due to technical problems, data from some participants and measures were unavailable. Final Ns were thus as follows: heart rate, n = 46; blood pressure, n = 43 (m = 23); skin conductance, n = 44 (m = 24).

2.2. Stimuli

Twenty digitized pictures1 were selected from the International Affective Picture System (IAPS, Center for the Study of Emotion and Attention [CSEA-NIMH], 1999). Five separate picture contents were considered, including two pleasant (“sport”: scenes of extreme sports/adventure; “erotic couples”: heterosexual couples engaged in sexual intercourses), two unpleasant (“threat”: aimed weapons; “blood”: injuries and mutilations) and one “neutral” (household objects). Four exemplars were thus included in each category. Pictures were selected such that average a priori ratings of arousal (Lang et al., 1999) were comparably high across the emotional categories, as reported in Table 1. Such ratings were scored on 9-point graphic scales (Self-Assessment Manikin, SAM; Lang, 1980) with 1 indicating lowest pleasantness and lowest arousal and 9 indicating highest pleasantness and highest arousal. There were no significant differences among the emotional categories for normative ratings of arousal (F[3, 12] = 0.05, p < 0.9).

Each picture was presented for 6 s on a 19-in. monitor. A variable inter-trial-interval (ITI, 15–20 s) was employed. Across subjects, pictures were presented in three different orders. Stimulus control was accomplished by using an IBM-compatible computer Pentium II running MEL 2.0 software (Micro Experimental Laboratory; Psychology Software Tools Inc., Pittsburgh, PA).

2.3. Physiological recording

Beat-to-beat systolic (SBP), diastolic (DBP) and mean arterial pressure (MAP) were measured continuously through an Ohmeda Finapres 2300 Blood Pressure Monitor, using a finger-cuff positioned on the middle phalange of the third finger of the left hand. The hand was kept at heart level.

Electrocardiogram (ECG) was recorded using Ag/AgCl surface electrodes placed on the subject’s chest in a modified Lead II configuration. The signal was recorded with a time constant of 30 ms and a low pass filter set at 100 Hz.

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1 The IAPS picture numbers were as follows: (a) erotic couples, 4659, 4664, 4800, 4810; (b) sport, 8030, 8080, 8180, 8490; (c) neutral, 7006, 7009, 7090, 7233; (d) threat, 6230, 6250, 6550, 6560; (e) blood, 3000, 3053, 3150, 3400.

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Skin conductance response (SCR) was recorded with Ag/AgCl electrodes attached to the palmar surface of the middle phalanges of the first and second fingers of the non-dominant hand. A Coulbourn S71-22 skin conductance coupler provided a 0.5 V constant voltage across electrodes.

ECG and SCR were amplified and filtered on a d/150 d/160 Digitimer LtD amplifier system, fed into an A/D board (NB MIO 16L-25; sampling rate: 500 Hz for ECG and 20 Hz for SCR), and stored on a Macintosh Quadra 700 computer. Data acquisition and analyses were implemented by LabVIEW 3 software (National Instruments, Austin, TX), according to Angrilli (1995).

2.4. Procedure

Upon arrival, participants were given general information about the experiment, and their written informed consent was obtained. Subjects were then seated in a comfortable chair in a dimly lit room and physiological sensors were attached. Prior to picture viewing, subjects rested for 10 min, the last 3 min of which were considered as resting period. Next, the pictures were shown. Participants were instructed to view each picture for its entire duration. Three practice pictures were presented to the participants to allow adjustment to the experimental setting.

Blood pressure, heart rate and skin conductance were recorded continuously for 3 s before picture onset (baseline) and for 6 s during picture viewing.

In a second experimental session, subjects were allowed to view the pictures as long as they wanted to, but had to press a key to stop picture presentation. The time interval between picture onset and offset was recorded as an index of viewing time (VT). At the end of the study, participants were debriefed and thanked.

2.5. Data reduction and analysis

A digital trigger detecting R-waves was applied to the ECG signal to obtain interbeat intervals. Interbeat intervals were then converted to heart rate in half-second bins, as described by Graham (1978). Beat-to-beat SBP, DBP and MAP measures obtained from Finapres system were recorded every second and stored through serial port on an IBM-compatible computer Pentium II.

Males and females were first compared on resting levels of SBP, DBP, and HR, considering the mean activity across the last 3 min of the adaptation period. Next, men and women were compared on their reactivity to picture viewing using change scores from baseline. For HR and BP, change scores between the 6-s picture period and the last 2 s of baseline were analyzed. For skin conductance, the maximum change occurring between 1 and 4 s after picture onset was considered. For viewing time, the time interval between picture onset and the key press was recorded in milliseconds by using an IBM-compatible computer Pentium II running MEL 2.0 software (Psychology Software Tools Inc., Pittsburgh, PA).

A two-way (gender × category) repeated measures analysis of variance (ANOVA) was performed on mean heart rate change scores, skin conductance responses and viewing times. In order to reduce Type I error, a two-way (gender × category) repeated-measures multivariate analysis of variance (MANOVA) was applied to the change scores of the three blood pressure measures. Follow-up univariate analyses of variance (ANOVAs) were used for relative means when significant effects were found. The uncorrected p-values for effects within variables having more than two levels are reported together with the Greenhouse-Geisser epsilon (ε). Post-hoc means comparisons (Newman-Keuls) were employed to further examine significant effects (using a p < 0.05 criterion for significance).

3. Results

3.1. Resting HR and BP levels

Males demonstrated significantly greater BP levels at rest than women (Wilks’s lambda = 0.58, F[2, 40] = 14.23, p < 0.0001). Post-hoc ANOVAs revealed significant differences between men and women for both SBP and DBP (F[1, 41] = 21.82 and 24.79, respectively, p < 0.0001). There was no significant difference in basal HR levels between genders (t[44] = −1.33, p < 0.19), although women tended to have higher HR at rest than men (M = 74.26 and 70.28 bpm, respectively).

3.2. Skin conductance

No significant main or interactive effects of gender were found for this measure. The magnitude of skin conductance change across the different emotional contents was similar for men and women, (F[4, 168] = 11.88, p < 0.00001, e = 0.50). Post-hoc tests indicated that erotic stimuli produced the largest changes (Fig. 1). In addition, subjects were more reactive to threat and blood stimuli than to sport scenes, which, in turn, induced larger changes than neutral contents (see Table 2).
The gender main effect for this measure only approached significance ($F[1, 44] = 3.62, p < 0.06$). Overall larger heart rate decreases were displayed by women ($M = -2.06$ bpm) as compared with men ($M = -0.84$ bpm). The gender \times category interaction was not significant. The significant category main effect ($F[4, 176] = 3.34, p < 0.011, \varepsilon = 0.85$) indicated that, independent of gender, HR responded differently to the different emotional contents (Fig. 2). As expected, each category elicited HR decrease, with the greatest deceleration obtained during the viewing of blood stimuli, as revealed by post-hoc tests. No significant differences were found among the other categories (see Table 2).

### 3.4. Blood pressure

Results indicated overall a significant multivariate main effect of category condition (Wilk’s lambda = 0.41, $F[12, 30] = 3.54, p < 0.002$). Follow-up ANOVAs revealed that the category effect was significant for SBP ($F[4, 164] = 3.22, p < 0.014, \varepsilon = 0.87$), DBP ($F[4, 164] = 5.81, p < 0.0002, \varepsilon = 0.95$), and MAP ($F[4, 164] = 5.05, p < 0.0007, \varepsilon = 0.88$). Post-hoc analyses showed that large increases in all the three BP measures were produced when viewing erotic scenes as compared to all the other contents. No significant differences were found among BP changes induced by the other emotional categories (see Table 2).

Interestingly, the multivariate gender \times category interaction effect was significant (Wilk’s lambda = 0.46, $F[12, 30] = 2.93, p < 0.008$). As indicated by follow-up ANOVAs, significant gender \times category interactions were obtained for SBP ($F[4, 164] = 3.03, p < 0.019, \varepsilon = 0.87$), DBP ($F[4, 164] = 2.94, p < 0.022, \varepsilon = 0.95$) and MAP ($F[4, 164] = 3.7, p < 0.006, \varepsilon = 0.88$). Post-hoc comparisons revealed that men demonstrated a significantly larger increase in BP responses than women did when viewing erotic pictures. Moreover, men responded with significantly greater DBP and MAP changes to erotic stimuli compared to all the other contents (for SBP changes, compared to threat and neutral stimuli), whereas women showed no differentiation among the five categories in any of the BP measures.

The gender main effect was not significant (Wilk’s lambda = 0.88, $F[3, 39] = 1.78, p = 0.17$). As a result of the

### Table 2

Results of separate pairwise analyses between specific picture categories, separately for skin conductance, heart rate, and blood pressure measures

<table>
<thead>
<tr>
<th>Category</th>
<th>Dependent measures</th>
<th>SCR</th>
<th>HR</th>
<th>SBP</th>
<th>DBP</th>
<th>MAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erotic couples</td>
<td></td>
<td>a</td>
<td>b</td>
<td>a</td>
<td>a</td>
<td>a</td>
</tr>
<tr>
<td>Sport</td>
<td></td>
<td>c</td>
<td>b</td>
<td>b</td>
<td>b</td>
<td>b</td>
</tr>
<tr>
<td>Threat</td>
<td></td>
<td>b</td>
<td>b</td>
<td>b</td>
<td>b</td>
<td>b</td>
</tr>
<tr>
<td>Blood</td>
<td></td>
<td>b</td>
<td>a</td>
<td>b</td>
<td>b</td>
<td>b</td>
</tr>
<tr>
<td>Neutral</td>
<td></td>
<td>d</td>
<td>b</td>
<td>b</td>
<td>b</td>
<td>b</td>
</tr>
</tbody>
</table>

Note: within each dependent measure, letter sets indicate the results of pairwise comparisons. Categories that share at least one letter do not significantly differ. SCR, skin conductance responses; HR, heart rate; SBP, systolic blood pressure; DBP, diastolic blood pressure; MAP, mean arterial pressure.

Fig. 1. Mean skin conductance responses during picture viewing as a function of emotional content. Error bars represent standard errors of the mean.

Fig. 2. Mean heart rate changes from baseline during picture viewing as a function of emotional content. Error bars represent standard errors of the mean.

Fig. 3. Mean systolic blood pressure changes from baseline in men and women during picture viewing as a function of emotional content. Error bars represent standard errors of the mean.
multivariate analysis not reaching significance, follow-up ANOVAs were not conducted.

Figs. 3 and 4 depict mean SPB and DBP changes, respectively, during picture viewing for each gender.

3.5. Viewing time

There were no significant main or interactive effects of gender for this measure. The category main effect ($F[4, 176] = 14.31; p < 0.00001, \epsilon = 0.64$) showed that all the emotional categories were viewed longer than the neutral, with no significant differences among affective pictures.

4. Discussion

The present study was, to our knowledge, the first to examine the influence of gender on blood pressure changes during visual affective processing. The study extended prior research on gender differences in autonomic responding to emotional visual stimuli. Indeed, in the literature, the investigation of blood pressure responses elicited by the viewing of emotional pictures has largely been neglected, irrespective of gender-related issues.

It was hypothesized that this cardiovascular measure, that plays a significant role in indexing males’ higher reactivity during stress-induced adjustments, might be able to reveal sex differences in emotional responding even under nonstressful conditions, and, possibly, under pleasant high-arousal conditions. Standardized emotional pictures were selected to represent motivationally relevant situations commonly displayed by media in everyday life. Moreover, all the chosen emotional categories were comparably high in terms of mean subjective emotional intensity.

There were two main findings of the study. First, gender differences in autonomic emotional reactivity were evident only when considering blood pressure measures. Second, men displayed higher BP increases than women specifically when confronted with erotic pictures.

Largely comparable cardiac and electrodermal response patterns were elicited in men and women when viewing emotional pictures. Skin conductance responses differed as a function of picture content in both sexes, with erotic stimuli producing the highest and neutral pictures the lowest responses. The lack of a gender-related effect suggests that the different contents induced a similar arousal response in men and in women. Similarly, heart rate changes corresponding to difference in picture content were found, reflecting larger deceleration in response to blood stimuli in either gender. Taken together, these results are in line with previous studies (Bradley et al., 2001a; Buodo et al., 2002; Schupp et al., 2004) demonstrating that erotica and mutilations are contents that prompt highest affective engagement, strongly activating appetitive and defensive motivational systems underlying emotional experience, in both men and women.

Bradley et al. (2001b) did demonstrate greater electrodermal reactivity to sexual visual stimuli in men than in women. However, this effect was obtained when showing pictures depicting opposite-sex nudes, whereas only a trend in the same direction was found for erotic couples. Our results indicate that blood pressure show greater sensitivity in revealing gender differences in emotional reactivity to stimuli openly depicting sexual intercourses, whereas the other autonomic measures failed to reliably capture any gender difference in emotional reactivity. Evidence was presented indicating that men responded to erotic stimuli with reliable and larger increases in both systolic and diastolic BP, whereas women displayed only a slight increase in SBP, which was found not to differ from BP changes to the other emotional contents. BP responses during affective processing of erotic material were thus specifically modulated by gender.

In contrast to the deceleratory heart rate response, typical of affective picture processing and indicative of attentional engagement (e.g. Bradley, 2000), BP changes to erotic stimuli seem to reflect mainly peripheral activation related to sexual arousal, although further characterization of the central and peripheral determinants of BP responding is needed. Indeed, some studies indicate that BP, systolic in particular, provides a good estimation of extragenital autonomic arousal (Carmichael et al., 1994; Exton et al., 2000). On a different perspective, but consistent with this view, some empirical data suggest that blood pressure responses are indicative of the degree of engagement, effort, and energization (Wright et al., 1992; Jacob et al., 1999) or of behavioral approach, under appetitive conditions (Tomaka and Palacios-Esquibel, 1997).

Evolutionary and sociobiological theories indicate differential reproductive goals and investment of resources in males and females, who consequently developed differential strategies for reproductive success and, presumably, different emotional reactions to events related to reproduction (Troisi, 2001). Since males have less parental investment, and have to deal with paternity uncertainty, their
optimal reproductive strategy would be trying to inseminate as many females as possible, being easily and frequently sexually aroused. On the other hand, females, who have more parental investment, would become sexually aroused only when the best resources are available, being much more selective in their choice of mate (Trivers, 1972; Murmen and Stockton, 1997; Troisi, 2001). It has often been assumed that women are less responsive to sexual stimuli and have a milder sex drive than men (Murmen and Stockton, 1997; Baumeister, 2000). Lower correlations between measures of self-reported sexual arousal and physiological response have been documented in women than in men (Rosen and Beck, 1988). In fact, female sex drive and sexual responses are more easily influenced by cultural, social and situational factors, whereas male sexuality is heavily dependent on biological and physical processes (Baumeister, 2000). Accordingly, men show greater motivation to seek out photographs with explicit erotic content, receiving more social reinforcements for expressing their sexuality, whereas women do not usually indicate interest in sex and are not expected by society to express their sexual needs (Murmen and Stockton, 1997).

Consistent with these findings, it has been recently demonstrated that men and women process identical visual sexual stimuli differently, with men showing greater activation in the amygdala and hypothalamus, indicating greater appetitive motivation and faster detection and responding to these cues (Hamann et al., 2004). Different cognitive styles or neural pathways have been hypothesized in males and females during the processing of sexual stimuli, this difference being functional to males’ greater motivation to maximize their mating opportunities (Hamann et al., 2004). Whether such differential activation reflects constitutional (i.e. genetic) or sociocultural influences, or both, is a matter of debate that future research might try to clarify.

Even irrespective of gender, no data are available to date on BP changes to specific pleasant and unpleasant picture contents. To the best of our knowledge, there is only one published study in which BP responses elicited by standardized emotional pictures were recorded (Globisch et al., 1999). However, BP was measured in animal fearful subjects and controls (both males and females) during the viewing of fear-relevant, generally pleasant and neutral pictures. Little attention was devoted in that study to BP changes to pleasant stimuli and significant content effects in control subjects were found only when low and high arousal contents were separately analyzed, with highly arousing pictures prompting an increase in BP relative to neutral ones. In this respect, the results of the present experiment are in agreement with Globisch et al. (1999)’s findings, as in their study high-arousal pleasant pictures indeed consisted of erotic scenes, although no explicit mention of this was made in their article. As indicated by the highly significant category effects obtained for BP in the present study, it can be suggested that, independent of gender, sexual stimuli are able to prompt large BP increases, possibly by means of sympathetic vasomotor excitation. However, as revealed by the significant gender \times category interaction, BP increases to erotic pictures are largely due to males’ reactivity. Consistent with previous research on cardiovascular reactions to stressful stimuli, one implication of the current data is that men and women’s cardiovascular responses may have to be analyzed separately also when using emotional perceptual tasks, at least when sexual pictures are included as pleasant high-arousal stimuli.

As largely acknowledged in the literature (e.g. Stoney et al., 1987), in the present study higher resting SBP and DBP were found in men, whereas in women resting HR only tended to be higher. Men, thus, displayed blood pressure values that were higher at rest and nevertheless had stronger reactivity (to erotic stimuli) than did women. Similar gender differences have been observed in previous research under ambulatory (Shapiro et al., 1996) and stressful conditions (Steptoe et al., 1996; Morris-Prather et al., 1996).

It is possible that different underlying hemodynamic mechanisms, mediating the respective BP changes, exist in men and women. Several investigations report that males show BP increases mainly through increased vascular reactivity (namely, increases in total peripheral resistance, TPR), whereas females display BP increases through greater myocardial reactivity (greater increases in HR and cardiac output, CO) than males (Stoney et al., 1987; Girdler et al., 1990). In the present work, women did show a trend toward greater HR decreases than men to emotional stimuli, irrespective of content. Given that cardiac deceleration is the usual response during visual affective processing, this finding suggests that females displayed overall more responsiveness in HR compared with men. Future studies, through the use of impedance cardiography, that allows estimation of CO and TPR, might examine whether the hemodynamic mechanisms regulating BP and HR responses during affective picture processing are different for males and females.

One of the limitations of the present investigation is that neither subjective sexual arousal nor generalized emotional arousal was directly measured, therefore it was not possible to rule out the possibility that self-report ratings of affective arousal contributed to the differential BP reactivity to sexual stimuli in men and women. The different picture contents were selected as balanced for average normative arousal ratings, but were not matched for a priori arousal in men and women. Exposing participants to highly and equally arousing categories of emotional visual stimuli was among the main concerns of our experiment, in order to use motivationally relevant experimental conditions. Furthermore, as erotic stimuli, we decided to use pictures depicting heterosexual couples engaged in sexually explicit activities, avoiding pictures differing in content and/or in perceptual characteristics for men and women, in order to compare responses to identical stimuli in the two genders. However, as indicated by previous studies (Bradley et al., 2001b; Costa et al., 2003), sexual stimuli are often evaluated as more
arousing by men than by women, even though this gender difference is not always large (Murnen and Stockton, 1997). When considering normative arousal ratings separately for males and females, the erotic pictures we selected did receive higher scores by men than by women \( (M = 7.45 \text{ and } 6.29, \text{ respectively}) \). Nevertheless, the data obtained from electrodermal activity, a clear indicator of physiological arousal, and from free viewing time, a measure that shows a strong association with experienced arousal (e.g. Winton et al., 1984; Lang et al., 1993), indeed indicate that the four emotional categories elicited the same level of arousal in men and women. In both genders sexual stimuli elicited comparably higher skin conductance responses, as compared with the other emotional categories, and were viewed as long as the other contents (except neutral pictures). Hamann et al. (2004) demonstrated significantly greater activation in the amygdala and hypothalamus in males than in females when viewing identical sexually arousing pictures, even though females reported ratings of greater arousal than males. Taken together, these findings indicate that subjective arousal is not sufficient to fully account for gender differences in physiological activation to visual sexual stimuli. It has been suggested that sexual arousal might be a specific form of generalized arousal characterized by unique psycho-physiological processes (Rosen and Beck, 1988; Koukounas and McCabe, 1997). In this respect, given the multidimensional nature of the sexual response, at both psychological and physiological levels, sexual stimuli might be considered as a peculiar type of emotional content that is processed differently from other types of motivationally relevant appetitive information, and for which there is not a clearcut relationship between emotional arousal and physiological activation (Hamann et al., 2004).

A further limitation of the present study is that differential BP reactivity to sexual stimuli in men and women was found in the context of the affective picture perception paradigm, therefore it is uncertain the extent to which these findings may be generalized to other emotional nonstressful tasks. The issue of gender-related differences in emotional BP reactivity to erotic material might be addressed in future studies employing different emotional tasks, and/or stimuli of different nature.

In summary, no data existed in the literature as to whether gender may influence blood pressure responses during affective picture perception. Accordingly, a primary goal of the current study was to examine the effects of gender upon the BP responses to specific visual emotional contents. Our prediction regarding the role of BP in enhancing gender differences in emotional responding was supported. However, gender was found to be an effective moderator of BP responses specifically to sexual stimulus content. This finding suggests that BP changes might reflect sexual peripheral arousal and not generalized emotional arousal, more than other autonomic measures.

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