



## Gender differences in response to pictures of nudes: a magnetoencephalographic study

Marco Costa<sup>a,\*</sup>, Christoph Braun<sup>b</sup>, Niels Birbaumer<sup>b,c</sup>

<sup>a</sup> *Department of Psychology, University of Bologna, Bologna, Italy*

<sup>b</sup> *Institute of Medical Psychology and Behavioral Neurobiology, University of Tübingen, Tübingen, Germany*

<sup>c</sup> *Center for Cognitive Neuroscience, University of Trento, Trento, Italy*

Received 12 March 2001; accepted 23 January 2003

### Abstract

The magnetic equivalent of the contingent negative variation (CMV) and visual evoked magnetic fields (VEF) in anticipation of pictures of opposite-sex nude, same-sex nude, and neutral photographs has been recorded with whole-head MEG in 12 males and 12 females. Subjective ratings of valence indicated a strong gender effect. While females rated both male and female nudes as neutral, males rated male nudes similar to neutrals but female nudes received higher scores of pleasantness. Gender differences were also found for ratings of picture-induced arousal. While females rated male and female nudes as equally arousing, males attributed more arousal to opposite-sex nudes. The CMV instead revealed, for both male and female participants, higher amplitudes for opposite-sex nudes. VEF in response to nudes revealed two components with mean latencies of 126 and 203 ms. The amplitude of the first component was stronger in males than in females, and only in males the magnetic activity was increased in response to male and female nudes compared to neutral pictures. For the second component the mean magnetic activity was higher in response to nudes than to neutral contents for both male and female participants. The results are discussed in terms of an evolutionary view of sexual selection, which predicts a greater response in male subjects to stimuli relevant for mate choice.

© 2003 Elsevier Science B.V. All rights reserved.

*Keywords:* MEG; Physical attractiveness; Visual evoked magnetic field; Contingent negative variation; Sexual arousal

\* Corresponding author.

*E-mail address:* [costa@psibo.unibo.it](mailto:costa@psibo.unibo.it) (M. Costa).

## 1. Introduction

The aim of this study was to investigate brain responses to pictures of nudes by recording the magnetic equivalent of contingent negative variation (CNV) and visual evoked magnetic fields (VEF) and determine their relationship to subjective ratings of valence and arousal. In previous studies using event-related potentials as correlates of affective picture processing, pictures of nudes were not considered in isolation but usually inserted in groups of pleasant highly arousing stimuli. Most of these studies reported an enhanced late positive potential evoked by motivational content compared to neutral slides. The onset of this component is in the latency range of 300 ms and reaches its maximum at about 1 s after picture presentation, and is sustained for most of the picture presentation period (Cuthbert et al., 2000; Palomba et al., 1997; Johnston et al., 1986; Carretié et al., 1996). Pictures of adult nude persons in a society with bodies covered by clothes represent stimuli with a particularly biological value. The assumption that they would be perceived a priori as pleasant is questionable. Photographs of nudes with an explicit erotic content tend to be perceived as neutral or slightly unpleasant by females independent of the sex of the depicted figures. In contrast, heterosexual males perceive opposite-sex nudes as pleasant and highly arousing and same-sex nudes as neutral and only slightly arousing. This gender difference becomes larger using pornographic versus erotic stimuli and is much larger for college age participants compared to older populations (Murnen and Stockton, 1997; Costa and Ricci Bitti, 1999a). Similar results have been found with other measures of sexual interest such as viewing time (Quinsey et al., 1996). In this study we intended to verify whether this gender difference is reflected in specific brain activities assessed by evoked magnetic fields, or whether brain responses are dissociated from subjective reports.

Three studies have measured CNV to differentially study brain responses to photographs depicting nudes. An increased anticipatory CNV was expected to preferred sexual stimuli. First, Costell et al. (1972) recorded the CNV in the interval between paired exposure of male nudes, female nudes, and sexually neutral slides and found that in 18 out of the 24 participants CNV amplitude was greater in response to opposite-sex stimuli than to either same-sex or neutral slides. Furthermore, only females demonstrated a greater response to same-sex than to neutral pictures. No subjective data of attractiveness and sexual interest were collected. Twenty years later Howard et al. (1992) replicated results of Costell et al. (1972) in a sample of males introducing a “match/mismatch” CNV paradigm in which S2 was either identical or different from S1 although belonging to the same stimulus category (male nude, female nude or neutral) as S1. Subjects were required to indicate a same/different judgment by pressing a button at S2 offset. With this paradigm requesting all subjects to perform the same task it was possible to control for variations in levels of attention which could have accounted for the results of the Costell et al. (1972) study. Howard et al. (1994) applied the same paradigm in self-declared homosexuals and in male child sex offenders. The results showed that in male and female homosexuals CNV amplitude was not different between same-sex and opposite-sex pictures of nudes. Furthermore, “non-pedophiles” showed

significantly larger CNVs to female adults than to female children, but “pedophiles” did not.

In the present study the same “match/mismatch” paradigm used by Howard et al. (1992, 1994) was adopted with a single modification. While, in previous studies, trials belonging to one category of stimuli (female nudes, male nudes, neutrals) were recorded in a blocked design, in this study the order of presentation was completely randomized trying to avoid effects of enhanced attention or distraction caused by sequences of matched and unmatched pairs. Cortical activation was recorded by magnetoencephalography (MEG) with better temporal and spatial resolution than EEG (Williamson et al., 1991). Previous studies of magnetic evoked responses to affective pictures focused mainly on emotional face expressions (Streit et al., 1999; Swithenby et al., 1998). Following Watanabe et al. (1999) two components can be expected in the magnetic evoked response to affective stimuli. The mean latency for the first component was 131 ms in response to full faces with opened and closed eyes and 145 ms in response to eyes alone. Mean latency for the second component was 179 ms in response to faces and 208 ms in responses to eyes alone. According to Watanabe et al. (1999) the second component is more sensitive to the difference between neutral stimuli and pictures of faces. Comparability with previous results for electrical CNV was assured by the work of Hultin et al. (1996) which showed a correlation of  $r = 0.76$  between the amplitude of magnetically and electrically recorded CNV.

For the present study we hypothesized that cultural norms affect subjective ratings of valence of opposite sex nudes more than brain activity. We assumed an increased anticipatory brain response to opposite sex persons for both genders but not necessarily for subjective valence. In line with previous researches (Mercer and Kohn, 1979; Costa and Ricci Bitti, 1999a,b) we expected that male participants express more polarized ratings of valence than females.

## 2. Method

### 2.1. Participants

Twelve male (mean age: 24.7; S.D.: 3.8 years) and 12 female (mean age: 22.3; S.D.: 2.9 years) university students participated in the study. All subjects had normal or corrected-to-normal vision. They were paid 10 € for a 90 min session. They were informed that the study concerned the response to visual affective stimuli among them pictures of nudes. All subjects gave informed consent. Three male and four female participants were excluded from CMV analysis due to excessive number of eye movement artifacts (exceeding 30% of all trials). For the same reason two male and three female participants did not enter VEF analysis.

## 2.2. Stimuli

Thirty neutral photographs were chosen from the International Affective Picture System (IAPS, Center for the Study of Emotion and Attention, 1994) and 30 pictures of nude females and males were selected from *Playboy* and *Playgirl*, respectively, in order to compose 60 picture pairs including 20 neutral stimuli, 20 female nudes, and 20 male nudes. In 50% of pairs the first and second picture matched, i.e. were identical, and in the other 50% pictures were different although belonging to the same category. Pictures of nudes represented whole body nude models aged 18–30 depicted in frontal view, with visible genitals, and in explicit provocative erotic pose. Neutral pictures depicted household objects such as a towel, an hairdryer, a book, a spoon or buildings or abstract patterns, and did not include human faces or bodies.

## 2.3. Procedure

A “match/mismatch” paradigm was used in which the subject had to indicate whether or not S2 differed from S1. Subjects indicated “same” and “different” by raising, respectively, their right or left forefinger after S2 offset (Howard et al., 1994). Response assignment was counterbalanced across subjects. S1 and S2 belonged both to one of the following categories: neutral, female nude, and male nude. The duration of S1 and S2 was 1 and 2 s, respectively, the interstimulus interval (offset S1 to onset S2) was 3.5 s, and the inter-trial interval varied randomly between 5 and 15 s. Picture pairs were presented in a quasi-random order, with the constraint that not more than two pairs of a given category were presented consecutively.

Subjects sat in a comfortable chair adjustable in height and were instructed to gaze at the red cross near the center of the screen and to refrain from blinking or moving their eyes except during the interval between trials.

## 2.4. MEG recording

The magnetic field recorded by MEG is mainly due to intracellular currents parallel to the head surface. Radial currents oriented towards the center of the head or in opposite direction do not contribute to the magnetic field. In contrast to EEG, magnetic fields are largely unaffected by the electrical properties of the different tissues surrounding the brain (cerebrospinal fluid, skull and scalp). Neuromagnetic fields are extremely weak, being typically of about 100 femtotesla (fT) ( $100 \times 10^{-15}$  T) (Williamson and Kaufman, 1987).

All data acquisition was carried out at the MEG Center of the University of Tübingen using a CTF-Omega whole head MEG. The system contains 151 gradiometers, covering the upper part of the head. Data were low-pass filtered at 104 Hz and digitized using a sampling rate of 312.5 Hz. Eye movement artifacts were controlled by recording horizontal and vertical electro-oculogram. Head position was determined prior and after the recording by activating small coils positioned at the nasion and the left and right preauricular points. Error tolerance for sensor locations was less than 5 mm.

Subjects viewed images that were projected onto a screen inside the magnetically shielded room using a video projector. Each image was  $384 \times 384$  pixels in height and width and subtended a visual field of  $15^\circ \times 15^\circ$ . All images were created using a 16 color scale and were processed such that mean luminance and variation of luminances were within narrow ranges.

### 2.5. Subjective measures

Valence and arousal of 10 pictures of each category selected randomly from the 30 picture set presented during MEG recordings were rated by each subject using a paper-and-pencil version of the Self-Assessment Manikin (Bradley and Lang, 1994). Subjective ratings for valence were scored on an 11 point scale ranging from  $-5$  (extremely unpleasant) to  $5$  (extremely pleasant) with  $0$  indicating neutral valence. Arousal was also scored on an 11 point scale ranging from  $0$  (totally unexciting) to  $10$  (extremely exciting). Presentation order was randomized.

### 2.6. Data analysis

Epochs of magnetic fields activity ranging from 500 ms before S1 onset to 500 ms after S2 offset were stored for off-line analysis of evoked magnetic fields. Selective averaging of trials was done for each condition. Each average was based on a minimum of 15 epochs. Epochs were rejected if they contained eye artifacts ( $\pm 70 \mu\text{V}$ ) or magnetic artifacts ( $\pm 1 \text{ pT}$ ). Contaminated trials exceeding 30% caused the exclusion of the subject from further analysis. Because of the large inter-individual as well as intra-individual differences in the amplitude of the magnetic homologous of the CNV—the magnetic contingent variation (CMV)—(Hultin et al., 1996) the seven channels with the largest magnetic activity, corresponding to regions of maximal magnetic activity within a window of 1.5–3.5 s post S1 stimulation, were selected for each subject and for each category. Contingent magnetic variation was computed as the mean amplitude in the interval ranging from 1.5 to 3.5 s after S1 onset.

VEF's were analyzed in a window ranging from 200 ms before to 600 ms after slide onset. For each subject artifact-free epochs of S1 were separately averaged for each magnetic channel and for each picture category, i.e. neutrals, pictures of male and female nudes. Only evoked responses to S1 entered the averaging procedure. Evoked responses to S2 were discarded because subjects knew its category in advance. All occipital and temporal channels were averaged separately for the left and right hemisphere. The distinction between hemispheres was motivated by the symmetrical distribution of dipole fields across both hemispheres obtained in our study. Since the polarity of the magnetic activity indicates the direction of magnetic flux, but not the amount of brain activity, MEG-data were rectified by calculating the squared amplitude of the magnetic field. As in Swithenby et al. (1998) occipital and temporal channels were selected on the basis of main magnetic activities.

A visual inspection of the spatio-temporal pattern of evoked magnetic fields revealed the presence of two main components (termed M1 and M2) which

confirmed results found by Watanabe et al. (1999) for human face perception. The first component had a mean peak latency of 126 ms whereas the second one revealed a peak at 203 ms (Fig. 3). Visual evoked magnetic activity was parameterized by calculating the mean squared amplitude of the magnetic fields, in an interval ranging from 100 to 140 ms for M1 and from 180 to 220 ms for M2.

Single dipole source modeling based on a least-square fit was used to characterize the topography of the evoked responses and to yield rough estimates of the brain areas, which were involved in affective picture processing. Source analysis was carried out separately for M1 and M2 components. Only sources accounting for > 85% of the field variance were accepted.

## *2.7. Statistical analysis*

Valence and arousal ratings were analyzed by a three-way ANOVA inserting PARTICIPANT GENDER as between-subject factor. PICTURE CONTENT (three levels: “Neutral”, “Male Nude”, and “Female Nude”) and PICTURES within each category (10 levels) constituted the within-subject factors.

For both valence and arousal the gender difference for the variability of SAM ratings for pictures of male and female nudes was statistically tested. The standard deviation (S.D.) for each of the ten “Male Nudes” and the ten “Female Nudes”, distinguishing between male and female participants, was computed. S.D. data were submitted to a two-way ANOVA with GENDER and PICTURE CONTENT (two levels: “Male Nudes” and “Female Nudes”) as grouping variables.

The magnetic equivalent of CMV was analyzed by a two-way ANOVA with PARTICIPANT GENDER as between-subject factor and PICTURE CONTENT as within-subject factor. VEFs were analyzed separately for the first and second component by means of a four-way ANOVA involving PARTICIPANT GENDER as between-subject factor and PICTURE CONTENT, HEMISPHERE, and REGION (two levels: occipital and temporal) as within-subject factors. VEF variability for female and male participants was statistically tested computing the S.D., distinguishing between females and males, of VEF data in response to pictures of female and male nudes considering separately occipital, temporal and parietal channels of left and right hemisphere. S.D. data were then submitted to a two-way ANOVA including GENDER and PICTURE CONTENT (two levels: “Male Nudes” and “Female Nudes”) as grouping variables.

Source localization results, specified in Cartesian coordinates referring to a coordinate system with an origin in the center of the head and axes along the axial, coronal and sagittal planes were compared by a MANOVA. The MANOVA involved the factors COMPONENTS (two levels: M1 and M2) and the factor LOCATION with three levels (“X”, “Y”, “Z”). Pairwise comparisons (Tukey test) were performed to follow-up main effects if appropriate. Greenhouse–Geisser adjustments were applied to degrees of freedom on variables with more than two levels.

### 3. Results

#### 3.1. Valence and arousal rating

The mean valence ratings for female and male participants are illustrated in Fig. 1(top). The interaction between PARTICIPANT GENDER and PICTURE CONTENT was significant:  $F(2, 44) = 25.21$ ,  $P < 0.001$ ,  $\varepsilon = 0.93$ . Post-hoc comparison evidenced that for females both “Male Nudes” ( $P < 0.76$ ) and “Female Nudes” ( $P < 0.69$ ) were not significantly different from valence rating assigned to “Neutrals”. Furthermore “Male Nudes” were not rated significantly more pleasant than “Female Nudes” ( $P < 0.07$ ). For male participants “Male Nudes” were rated similar to “Neutrals” ( $P < 0.88$ ), whereas “Female Nudes” received a higher evaluation as compared to both “Male Nudes” ( $P < 0.001$ ) and “Neutrals” ( $P < 0.001$ ).

The variability in valence rating for pictures of nudes was significantly higher for female participants (Mean S.D. = 2.09) in comparison to males ones (Mean S.D. = 1.53):  $F(1, 36) = 25.95$ ,  $P < 0.001$ . The variability was not significantly different between “Male Nudes” and “Female Nudes”.

The interaction between PARTICIPANT GENDER and PICTURE CONTENT was significant for Arousal:  $F(2, 44) = 49.10$ ,  $P < 0.001$ ,  $\varepsilon = 0.98$ , and is illustrated in Fig. 1(bottom). The post-hoc comparison revealed higher ratings for “Male Nudes” in comparison to “Neutrals” ( $P < 0.001$ ) in female participants. The difference between “Male Nudes” and “Female Nudes” was, however, not significant ( $P < 0.17$ ). In male participants “Male Nudes” were evaluated more arousing than “Neutrals” ( $P < 0.02$ ) and “Female Nudes” received a significant higher evaluation in comparison to “Male Nudes” ( $P < 0.001$ ).

The variability for arousal ratings, as for valence, was significantly higher for female participants (Mean S.D. = 2.81) than for male participants (Mean S.D. = 1.81):  $F(1, 36) = 47.74$ ,  $P < 0.001$ . The variability did not differ between “Male Nudes” and “Female Nudes”.

#### 3.2. CMV

The main effect of PICTURE CONTENT was significant:  $F(2, 30) = 3.28$ ,  $P < 0.05$ ,  $\varepsilon = 0.85$ . Mean CMV amplitudes in response to the three picture categories were: 107.88 fT for “Neutrals”, 136.91 fT for “Male Nudes”, and 141.46 fT for “Female Nudes”. The post-hoc test evidenced a significant difference for “Female Nudes” in comparison to “Neutrals” ( $P < 0.03$ ), whereas the difference between “Male Nudes” and “Neutrals” approached significance ( $P < 0.06$ ). The comparison between “Male” and “Female Nudes” was not significant ( $P < 0.76$ ). Grand-averages of CMV for female and male participants are represented in Fig. 2.

The interaction between PARTICIPANT GENDER and PICTURE CONTENT was also significant:  $F(2, 30) = 3.88$ ,  $P < 0.03$ ,  $\varepsilon = 0.85$ . Mean CMV amplitudes for female participants were: 102.10 fT for “Neutrals”, 160.68 fT for “Male Nudes”, and 128.22 fT for “Female Nudes”, whereas mean CMV amplitudes for male participants were:

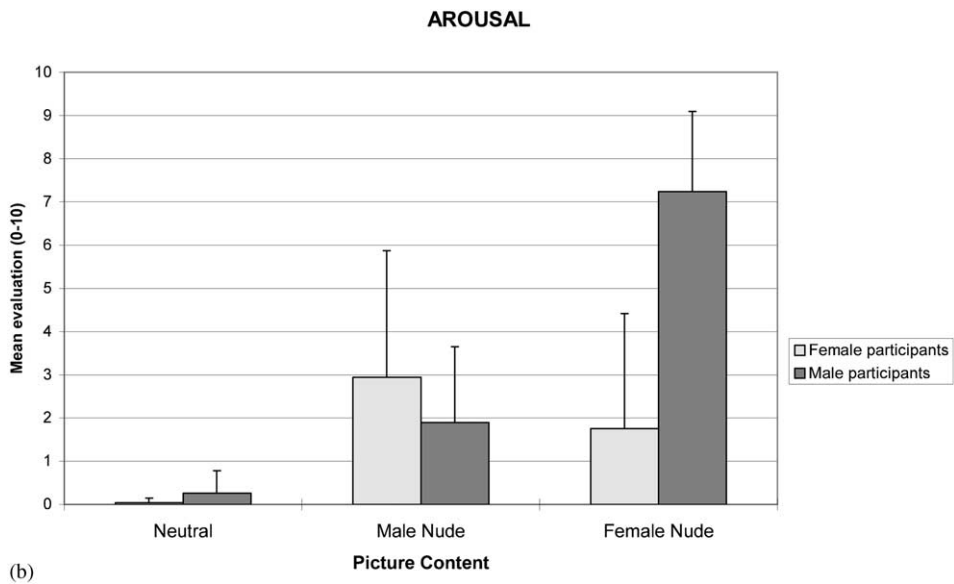
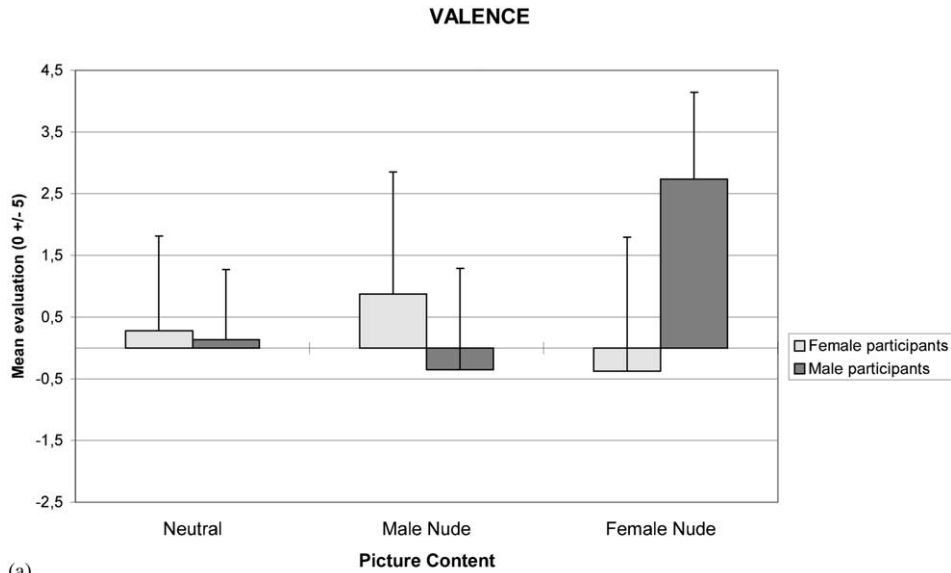


Fig. 1. Valence (top) and arousal (bottom) ratings for male and female participants in response to female nudes, male nudes, and neutrals.

113.67 fT for “Neutrals”, 113.14 for “Male Nudes”, and 154.70 fT for “Female Nudes”. Post-hoc analyses revealed that for females the CMV amplitude in response to “Male Nudes” was significantly higher ( $P < 0.01$ ) than in response to “Neutrals”,

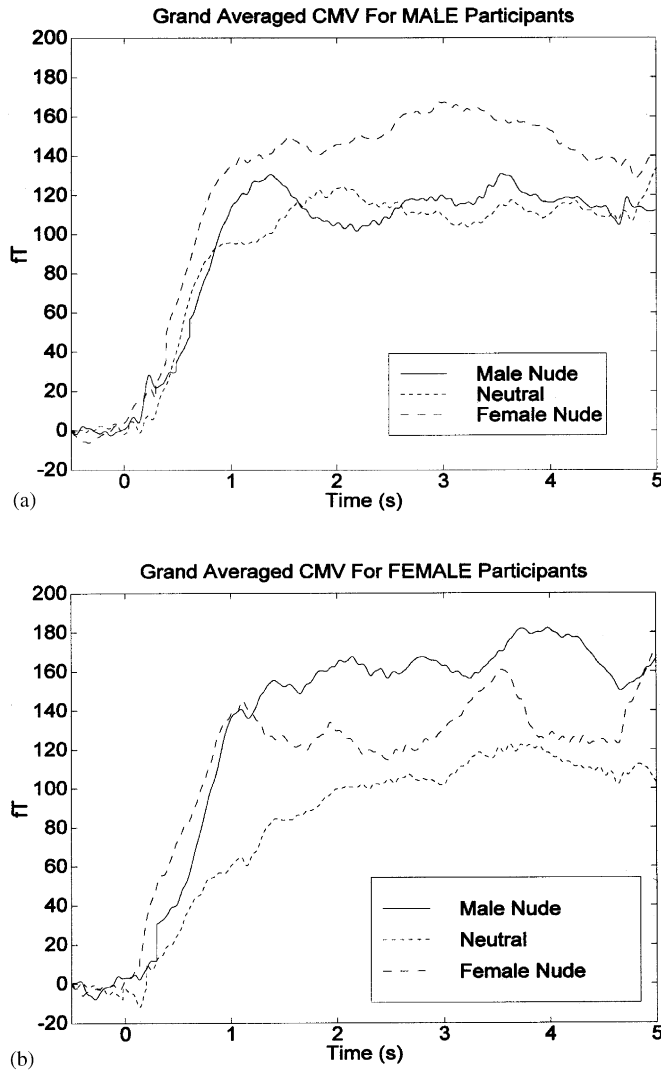


Fig. 2. Grand-averages of CMV for male (top) and female (bottom) participants in response to the three stimulus categories (“Neutral”, “Female Nudes” and “Male Nudes”).

whereas the difference between “Neutrals” and “Female Nudes” did not reach significance ( $P < 0.26$ ). Considering males, the CMV amplitude in response to “Female Nudes” when compared to “Neutrals” was significantly larger ( $P < 0.02$ ), whereas the difference between “Neutrals” and “Male Nudes” was not significant ( $P < 0.58$ ). In summary, considering “Neutrals” as control condition, CMV increases were significant only in response to opposite sex pictures.

### 3.3. Visual evoked magnetic fields

#### 3.3.1. First component

Averaged magnetic brain responses for male and female participants, considering all occipital and temporal channels, are depicted in Fig. 3. The main effect of PARTICIPANT GENDER was significant:  $F(1, 17) = 5.19, P < 0.03$ . The mean magnetic activity was higher for male participants than for female participants. The main effect of PICTURE CONTENT was also significant:  $F(2, 34) = 4.99, P < 0.03, \varepsilon = 0.70$ ,

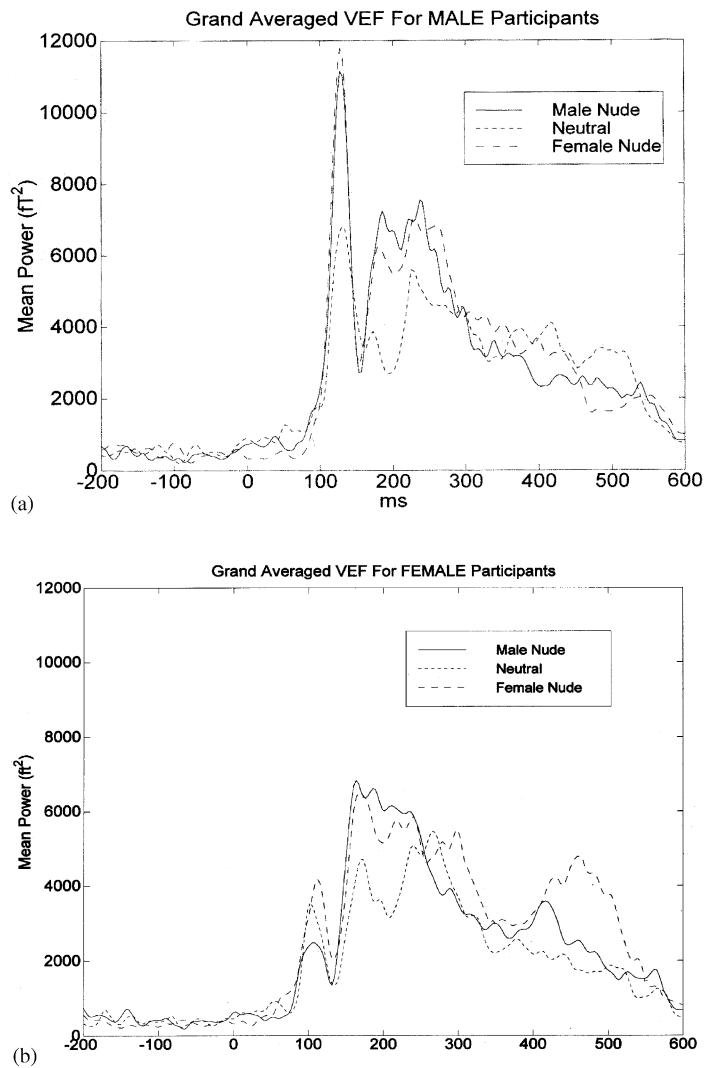


Fig. 3. Grand-averaged visual evoked magnetic fields (VEF) for male (top) and female (bottom) participants in response to the three stimulus categories.

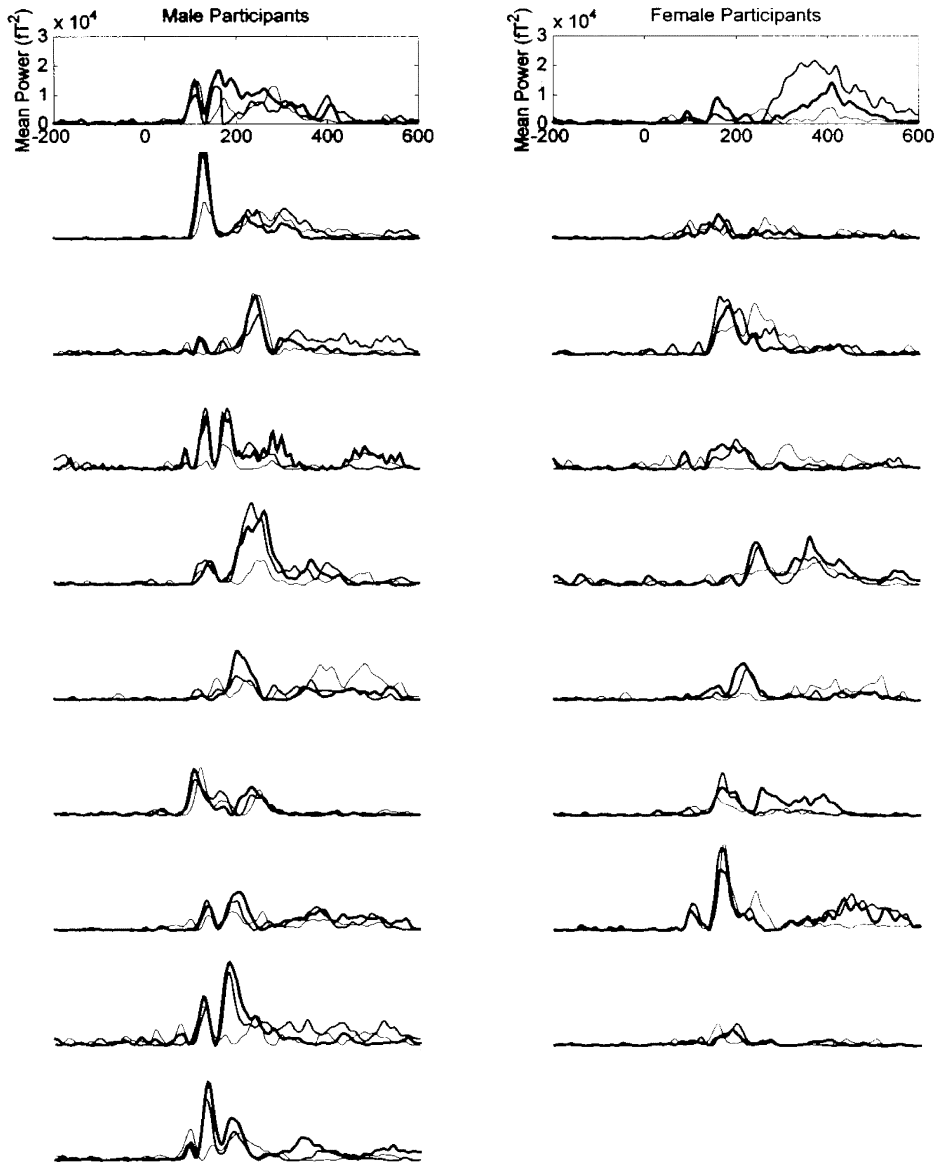


Fig. 4. Individual averaged visual evoked magnetic fields (VEF) for male (left column) and female (right column) participants in response to “Male Nude” (thicker line), “Neutral” (thinner line), and “Female Nude” (middle thickness line) pictures.

and post-hoc analyses evidenced a greater amplitude for “Male Nudes” ( $P < 0.03$ ) and “Female Nudes” ( $P < 0.009$ ) as compared to “Neutrals”. The Left and Right hemisphere activity did not differ significantly, whereas REGION was critical:  $F(1, 17) = 8.36$ ,  $P < 0.01$ . The evoked magnetic activity was larger in occipital than in

temporal areas. Finally the interaction between PARTICIPANT GENDER and PICTURE CONTENT was significant:  $F(2, 34) = 3.41$ ,  $P < 0.04$ ,  $\epsilon = 0.79$  (Fig. 5, top). The difference between pictures of nudes and “Neutrals” was significant only for male participants ( $P < 0.04$  for “Male Nudes” and  $P < 0.009$  for “Female Nudes”). For

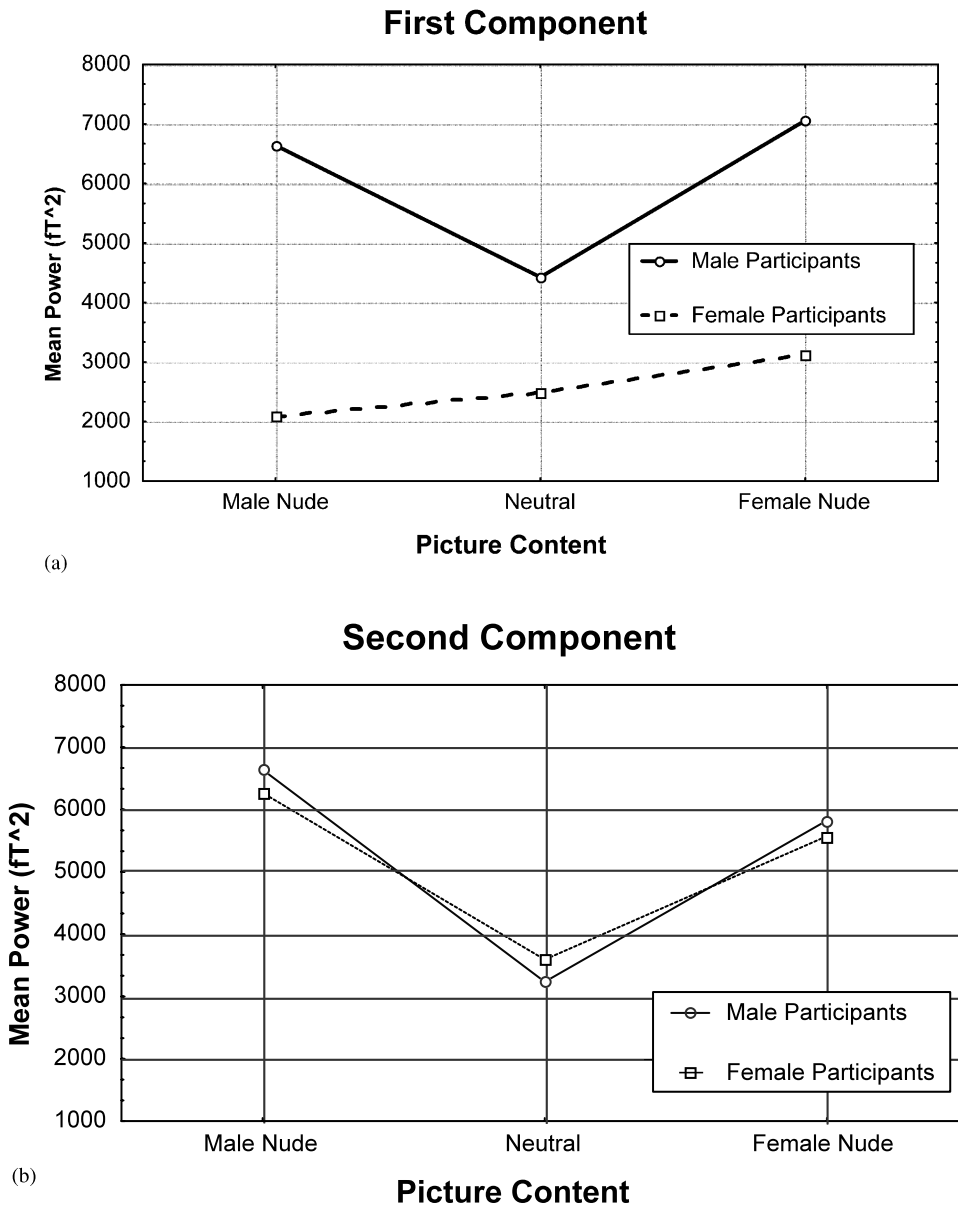


Fig. 5. Interaction between PARTICIPANT GENDER and PICTURE CONTENT for the first component (top) and the second component (bottom) of the VEF.

female participants the activity evoked by “Male” and “Female Nudes” did not differ. Variability in response to pictures of nudes for male and female participants was not significantly different ( $P < 0.18$ ). Individually averaged VEF for all male and female participants that entered this analysis are shown in Fig. 4.

### 3.3.2. *Second component*

The PARTICIPANT GENDER did not influence the second component ( $P < 0.94$ ). The main effect of PICTURE CONTENT was significant:  $F(2, 34) = 9.96$ ,  $P < 0.0005$ ,  $\varepsilon = 0.85$  (Fig. 5, bottom). The magnetic activity was higher for “Male Nudes” ( $P < 0.0005$ ) and for “Female Nudes” ( $P < 0.007$ ) in comparison to “Neutrals”. The main effect of HEMISPHERE was significant:  $F(1, 17) = 4.52$ ,  $P < 0.04$ . The activity was higher in the right than in the left hemisphere. The interaction between HEMISPHERE and PICTURE CONTENT was also significant:  $F(2, 34) = 3.35$ ,  $P < 0.04$ . Post-hoc analysis revealed that the higher right hemisphere activation occurred only for “Male Nudes” ( $P < 0.0004$ ), and “Female Nudes” ( $P < 0.009$ ), whereas for “Neutral” pictures HEMISPHERE was not critical ( $P < 0.99$ ). As for the first component variability between female and male participants was not significantly different ( $P < 0.48$ ).

### 3.3.3. *Topography of M1 and M2*

A significant effect of the MANOVA (Rao's  $R[3, 104] = 5.22$ ,  $P < 0.002$ ) indicated a difference in topography between the first and second component. In particular, analysis of specific effects showed a significant difference in antero-posterior direction ( $F([1, 106] = 13.47$ ,  $P < 0.003$ ) with the first component being more occipital than the second one. No significant difference emerged for axial and sagittal directions. Large variability of dipole source localization indicate that the modeled activity is generated by extended sources in the ventral occipito-temporal regions for both components, with sources of M1 being more occipital than those of M2.

## 4. Discussion

The gender effect that was found for the first component of the magnetic evoked potential could be linked to expectations of sexual selection theory regarding gender differences in response to erotic stimuli (Buss, 1989; Symons, 1979). The absence of an emotional modulation in the first component in female subjects mirrored the subjective data in which females expressed only a slight increase of arousal for both male and female nudes. With regard to valence pictures showing opposite-sex nudes received a much more positive evaluation by male participants than by female ones. Male subjects rated opposite-sex pictures highly arousing and pleasant in comparison to same-sex pictures and expressed more polarized judgments as female subjects. An exact replication of these data using the same stimuli depicting nudes was obtained in an Italian sample (Costa and Ricci Bitti, 1999a) by using viewing time as a measure of sexual interest. Females typically explore photographs of nude males

and females for the same time whereas males devote much more time to the exploration of opposite-sex than same-sex nudes (Costa and Ricci Bitti, 1999b; Quinsey et al., 1996). Also in Oliver-Rodriguez et al. (1999) the magnitude of the difference between male and female faces was larger for male than for female participants when evaluating pictures of faces differing in attractiveness. This finding is in accordance with the evolutionary theory of mate preferences by Symons (1979) which states that differences between male and female mate preferences are explicable in terms of differential parental investment. Since human males have a higher potential reproduction rate than human females they emphasize physical attractiveness in mate choice. Human females, to the contrary, are more selective in their choice of sexual partners and attach more importance to social status, earning potential and security than males. More recently, Buss (1989) has confirmed this theory collecting data from 33 countries located on six continents and five islands. Baumeister (2000) has proposed that female sex drive is more prone to respond to sociocultural and situational factors than the male one, which is suggested to be more rigid. A possible explanation for this gender difference is that women have a less intensive sex drive than men and that this difference allows the female sexual behavior and preference to be more easily modified by environmental and cultural factors. Women report spontaneous sexual desire less often than men and think about sex less often than men (Beck et al., 1991; Eysenck, 1971; Knoth et al., 1988; Laumann et al., 1994). Women have fewer sexual fantasies involving fewer partners and less variety of activity (Ellis and Symons, 1990; Leitenberg and Henning, 1995). They also report less enjoyment of erotica and pornography, the type of stimuli adopted in the present research. They rather enjoy more artistic well designed pictures of nudes, pictures of partially naked and pictures of nudes that evoke tenderness and without an explicit sexual content (see, e.g. Reed and Reed, 1972; Schmidt and Sigusch, 1970; Sigusch et al., 1970; Sigusch and Schmidt, 1973). They desire less frequent sex and fewer sexual practices than men (Ard, 1977; Bergström-Walan and Nielsen, 1990; Julien et al., 1992; Laumann et al., 1994). Women initiate sex less frequently and refuse it more often (Byers and Heinlein, 1989; Clark and Hatfiels, 1989; LaPlante et al., 1980; O'Sullivan and Byers, 1992). Women desire fewer partners than men (Buss and Schmitt, 1993; Miller and Fishkin, 1997) and seek out fewer extramarital partners (Cotton, 1975; Lawson, 1988; Spanier and Margolis, 1983; Thompson, 1983). Women and girls masturbate less often than men and boys (Arafat and Cotton, 1974; Asayama, 1975; Laumann et al., 1994; Oliver and Hyde, 1993; Sigusch and Schmidt, 1973). Women rate their sexual urges as less strong than men (Mercer and Kohn, 1979), and women are more likely to cite lack of interest and enjoyment as a reason for not having sex (Leigh, 1989).

Ratings of valence and arousal of pictures of nudes by females showed a greater variability than when the same stimuli were rated by men. This evidence is in accordance with the gender differences in erotic plasticity outlined by Baumeister (2000) who stated that female sexuality is fairly malleable, mutable, and more responsive to culture, learning, and social circumstances. This gender difference, however, emerged only on subjective ratings and not in relation to VEF.

A gender effect similar to those obtained in the present study was found by [Oliver-Rodriguez et al. \(1999\)](#) studying visual evoked potentials to face pictures of varying attractiveness in the time window ranging from 450 to 650 ms. In response to facial stimuli depicting both males and females, male participants showed a more pronounced brain response than females. As in our study the association between attractiveness ratings and potential amplitude was smaller for females. The larger P300 amplitude observed in males by [Oliver-Rodriguez et al. \(1999\)](#) could, therefore, reflect a higher sensibility to cues of physical attractiveness ([Berscheid and Walster, 1974](#); [Ford and Beach, 1951](#); [Durden-Smith and DeSimone, 1983](#)).

[Costell et al. \(1972\)](#) and [Howard et al. \(1992\)](#) revealed that males and females both respond with larger CNV amplitude to stimuli of opposite sex than to either same sex or neutral pictures. [Howard et al. \(1994\)](#) confirmed this trend in heterosexual men but found that in self-declared homosexuals CNV increased equally in response to pictures of male and female nudes. Sexual preference is a matter of positive incentive and valence, and there are no data available proving a sensibility of CNV to valence with a wide range of affective pictures (Summary see: [Birbaumer et al., 1990](#)). CNV and CMV may indicate the amount of incentive, motivation and preparation oriented toward the S2 and constitute an unspecific measure of all types of preparatory responses including sexual motivation.

In a MEG study on neural processing of human faces, [Swithenby et al. \(1998\)](#) found a M1 component in the occipito-temporal region with a mean latency of 140 ms which differentiated significantly human faces from other images. Another MEG study by [Streit et al. \(1999\)](#) which used the Ekman and Friesen set of pictures with basic facial expressions found that the earliest activation specific for emotional content of faces appeared in the posterior sector of superior right temporal cortex at about 160 ms. [Watanabe et al. \(1999\)](#) reported a mean latency of 131 ms for the M1 component in response to faces with opened and closed eyes. The latency of 126 ms found in the present study is only slightly earlier than the one reported by [Watanabe et al. \(1999\)](#). This early component found for pictures of nudes may, therefore, partially be attributed to the presence of faces. The lack of an increased amplitude to nudes in female participants and the earlier latency found in this study, however, may imply an additional effect of the erotic content of the stimuli.

If confirmed these results suggest an extremely early analysis of “prepared” emotional stimuli in the ventral visual stream. [Streit et al. \(1999\)](#) also confirmed the presence of a second component selectively activated by affective stimuli in the medial temporal cortex at about 200 ms.

Dipole sources are consistent with activity in the occipital-temporal cortex for both the first and second component with a more posterior activity for the first component and a more rostro-ventral activation for the second component, paralleling the results of [Swithenby et al. \(1998\)](#), [Streit et al. \(1999\)](#) and [Watanabe et al. \(1999\)](#).

Since the gender effect was present only on the first component, we suggest that the two magnetic components represent distinct neural processing of the same stimuli. The early component may reflect the more “prepared” evolutionary relevant analysis while the second may indicate a more general emotional or face related

processing stage. Streit et al. (1999) suggested that the unusually short latency of the M1 may be partly the result of a priming-by-repetition effect caused by back-projections from high-order visual areas.

Comparing the reported electrophysiological data with regional cerebral blood flow data using PET (Redouté et al., 2000; Stoléru et al., 1999; Rauch et al., 1999; Pfau, 1999) substantial differences in activation patterns emerge. rCBF increase in males watching nude females was mainly confined to right orbitofrontal, anterior cingulate, head of caudate, putamen and claustrum. Penile tumescence and perceived sexual arousal was correlated with rCBF in the right superior frontal gyrus, left postcentral gyrus, fusiform gyri, left precuneus and left temporal gyrus. Temporoparietal areas showed deactivation and were negatively correlated with perceived sexual arousal and penile tumescence, whereas inferior parietal regions and other regions, were positively correlated with sexual arousal but also with humorous arousal caused by non-sexual material. In contrast to females, the increased amplitude of the first component that is specific for sexual or at least positive arousal appeared at more posterior locations in males. It is conceivable that fast processing of affective significance involving thalamic, limbic (amygdala) and cortical areas either cannot be detected with the slow rCBF measures or the time was insufficient for accumulation of metabolic arousal for PET. The relatively weak occipital “trigger” might be responsible for later accumulation of metabolic arousal in frontal and cingulate structures.

The main limitation of the present study relies on the choice of a neutral set of stimuli. If the results obtained with the exposure to pictures of nudes were compared with a set of pictures of clothed males and females, the attribution of the gender difference to the erotic content of the stimuli would have been more clear. Such a design may have ruled out the possibility that the gender difference of the first component could be attributed to a gender difference in the processing of pictures of human faces or bodies' figures in general. However, the study involved two sets of stimuli with opposite content (same sex and opposite sex pictures of nudes) for both male and female participants. The presence of the valence effect in the M1 component which was found exclusively for male participants cannot be explained by the face-effect only since neither Watanabe et al. (1999) nor Swithenby et al. (1998) report a gender difference in magnetic evoked fields in response to face specific stimuli.

## References

- Arafat, I.S., Cotton, W.L., 1974. Masturbation practices of males and females. *Journal of Sex Research* 10, 293–307.
- Ard, B.N., 1977. Sex in lasting marriages: A longitudinal study. *Journal of Sex Research* 13, 274–285.
- Asayama, S., 1975. Adolescent sex development and adult sex behavior in Japan. *Journal of Sex Research* 11, 91–112.
- Baumeister, R.F., 2000. Gender differences in erotic plasticity: the female sex drive as socially flexible and responsive. *Psychological Bulletin* 126, 347–374.

- Beck, J.G., Bozman, A.W., Qualtrough, T., 1991. The experience of sexual desire: Psychological correlates in a college sample. *Journal of Sex Research* 28, 443–456.
- Bergström-Walan, M.B., Nielsen, H.H., 1990. Sexual expression among 60–80-year-old men and women: A sample from Stockholm, Sweden. *Journal of Sex Research* 27, 289–295.
- Berscheid, E., Walster, E., 1974. Physical attractiveness. In: Berkowitz, L. (Ed.), *Advances in Experimental Social Psychology*, vol. 7. Academic Press, New York, pp. 157–215.
- Birbaumer, N., Canavan, A.G., Rockstroh, B., 1990. Slow potentials of the cerebral cortex and behavior. *Physiological Review* 70, 1–41.
- Bradley, M.M., Lang, P.J., 1994. Measuring emotion: The self-assessment Manikin and the semantic differential. *Journal of Behavior Therapy and Experimental Psychiatry* 25, 49–59.
- Buss, D.M., 1989. Sex differences in human mate preferences: Evolutionary hypotheses tested in 37 cultures. *Behavioral and Brain Sciences* 12, 1–14.
- Buss, D.M., Schmitt, D.P., 1993. Sexual strategies theory: An evolutionary perspective on human mating. *Psychological Review* 100, 204–232.
- Byers, E.S., Heinlein, L., 1989. Predicting initiations and refusals of sexual activities in married and cohabiting heterosexual couples. *Journal of Sex Research* 26, 210–231.
- Carretié, L., Iglesias, J., Garcia, T., Ballesteros, M., 1996. N300, P300 and the emotional processing of visual stimuli. *Electroencephalography and Clinical Neurophysiology* 103, 298–303.
- Center for the Study of Emotion and Attention, 1994. *The International Affective Picture System [photographic slides]*. Center for Research in Psychophysiology, University of Florida, Gainesville, FL.
- Clark, R.D., Hatfiels, E., 1989. Gender differences in receptivity to sexual offers. *Journal of Psychology and Human Sexuality* 2, 39–55.
- Costa, M., Ricci Bitti, P.E., 1999a. Gender differences on subjective rating and startle reflex to nude, unpleasant, and neutral affective pictures. *Psychophysiology* 36, S42 (Abstract).
- Costa, M., Ricci Bitti, P.E., 1999b. Gender differences in viewing time to affective pictures measured by EOG. *Psychophysiology* 36, S42 (Abstract).
- Costell, R.M., Lunde, D.T., Kopell, B.S., Wittner, W.K., 1972. Contingent negative variation as an indicator of sexual object preference. *Science* 177, 718–720.
- Cotton, W.L., 1975. Social and sexual relationships of lesbians. *Journal of Sex Research* 11, 139–148.
- Cuthbert, B.N., Schupp, H.T., Bradley, M.M., Birbaumer, N., Lang, P.J., 2000. Brain potentials in affective picture processing: Covariation with autonomic arousal and affective report. *Biological Psychology* 52, 95–111.
- Durden-Smith, J., DeSimone, D., 1983. *Sex and The Brain*. Arbor House, New York.
- Ellis, B.J., Symons, D., 1990. Sex differences in sexual fantasy: An evolutionary psychological approach. *Journal of Sex Research* 27, 527–555.
- Eysenck, H.J., 1971. Masculinity–femininity, personality and sexual attitudes. *Journal of Sex Research* 7, 83–88.
- Ford, C.S., Beach, F.A., 1951. *Patterns of Sexual Behavior*. Harper & Row, New York.
- Howard, R.C., Longmore, F.J., Mason, P.A., 1992. Contingent negative variation as an indicator of sexual object preference: revisited. *International Journal of Psychophysiology* 13, 185–188.
- Howard, R.C., Longmore, F.J., Mason, P.A., Martin, J.L., 1994. Contingent negative variation (CNV) and erotic preference in self-declared homosexuals and in child sex offenders. *Biological Psychology* 38, 169–181.
- Hultin, L., Rossini, P., Romani, G.L., Högstedt, P., Tecchio, F., Pizzella, V., 1996. Neuromagnetic localization of the late component of the contingent negative variation. *Electroencephalography and Clinical Neurophysiology* 98, 435–448.
- Johnston, V.S., Miller, D.R., Burlison, M.H., 1986. Multiple P3s to emotional stimuli and their theoretical significance. *Psychophysiology* 23, 684–693.
- Julien, D., Bouchard, C., Gagnon, M., Pomerleau, A., 1992. Insiders' views of marital sex: A dyadic analysis. *Journal of Sex Research* 29, 343–360.
- Knott, R., Boyd, K., Singer, B., 1988. Empirical tests of sexual selection theory: Predictions of sex differences in onset, intensity, and time course of sexual arousal. *Journal of Sex Research* 24, 73–89.

- LaPlante, M.N., McCormick, N., Brannigan, G.G., 1980. Living the sexual script: college students' views of influence in sexual encounters. *Journal of Sex Research* 16, 338–355.
- Laumann, E.O., Gagnon, J.H., Michael, R.T., Michaels, S., 1994. *The Social Organization of Sexuality: Sexual Practices in the United States*. University of Chicago Press, Chicago.
- Lawson, A., 1988. *Adultery: An Analysis of Love and Betrayal*. Basic Books, New York.
- Leigh, B.C., 1989. Reasons for having and avoiding sex: Gender, sexual orientation, and relationship to sexual behavior. *Journal of Sex Research* 26, 199–209.
- Leitenberg, H., Henning, K., 1995. Sexual fantasy. *Psychological Bulletin* 117, 469–496.
- Mercer, G.W., Kohn, P.M., 1979. Gender difference in the integration of conservatism, sex urge, and sexual behaviors among college students. *Journal of Sex Research* 15, 129–142.
- Miller, L.C., Fishkin, S.A., 1997. On the dynamics of human bonding and reproductive success: Seeking windows on the adapted for human environmental interface. In: Simpson, J., Kenrick, D. (Eds.), *Evolutionary Social Psychology*. Erlbaum, Mahwah, NJ, pp. 197–235.
- Murnen, S.K., Stockton, M., 1997. Gender and self-reported sexual arousal in response to sexual stimuli: A meta-analytic review. *Sex Roles* 37, 135–153.
- Oliver, M.B., Hyde, J.S., 1993. Gender differences in sexuality: A meta-analysis. *Psychological Bulletin* 114, 29–51.
- Oliver-Rodriguez, J.C., Guan, Z., Johnston, V.S., 1999. Gender differences in late positive components evoked by human faces. *Psychophysiology* 36, 176–185.
- O'Sullivan, L.F., Byers, E.S., 1992. College students' incorporation of initiator and restrictor roles in sexual dating interactions. *Journal of Sex Research* 29, 435–446.
- Palomba, D., Angrilli, A., Mini, A., 1997. Visual evoked potentials, heart rate responses and memory to emotional pictorial stimuli. *International Journal of Psychophysiology* 27, 55–67.
- Pfaus, J.G., 1999. Neurobiology of sexual behavior. *Current Opinion in Neurobiology* 9 (6), 751–758.
- Quinsey, V.L., Ketssetzis, M., Earls, C., Karamanoukian, A., 1996. Viewing time as a measure of sexual interest. *Ethology and Sociobiology* 17, 341–354.
- Rauch, S.L., Shin, L.M., Dougherty, D.D., Alpert, N.M., Orr, S.P., Lasko, M., Macklin, M.L., Fischman, A.J., Pitman, R.K., 1999. Neural activation during sexual and competitive arousal in healthy men. *Psychiatry Research: Neuroimaging* 91, 1–10.
- Redouté, J., Stoléru, S., Grégoire, M.-C., Costes, N., Cinotti, L., Lavenne, F., Le Bars, D., Forest, M.G., Pujol, J.F., 2000. Brain processing of visual sexual stimuli in human males. *Human Brain Mapping* 11, 162–177.
- Reed, J.P., Reed, R.S., 1972. Pornography research using direct erotic stimuli. *Journal of Sex Research* 8, 237–246.
- Schmidt, G., Sigusch, V., 1970. Sex differences in response to psychosexual stimulation by films and slides. *Journal of Sex Research* 6, 268–283.
- Sigusch, V., Schmidt, G., 1973. Teenage boys and girls in West Germany. *Journal of Sex Research* 9, 107–123.
- Sigusch, V., Schmidt, G., Reinfeld, A., Wiedermann-Sutor, I., 1970. Psychosexual stimulation: Sex differences. *Journal of Sex Research* 6, 10–24.
- Spanier, G.P., Margolis, R.L., 1983. Marital separation and extramarital sexual behavior. *Journal of Sex Research* 19, 23–48.
- Stoléru, S., Grégoire, M.C., Gerard, D., Decety, J., Lafarge, E., Cinotti, L., Lavenne, F., Le Bars, D., Vernet-Maury, E., Rada, H., Collet, C., Mazoyer, B., Forest, M.G., Magnin, F., Spira, A., Comar, D., 1999. Neuroanatomical correlates of visually evoked sexual arousal in human males. *Archives of Sexual Behavior* 28, 1–21.
- Streit, M., Ioannides, A.A., Liu, L., Wölwer, W., Dammers, J., Gross, J., Gaebel, W., Müller-Gärtner, H.W., 1999. Neurophysiological correlates of the recognition of facial expressions of emotion as revealed by magnetoencephalography. *Cognition Brain Research* 7, 481–491.
- Symons, D., 1979. *The Evolution of Human Sexuality*. Oxford University Press, Oxford.
- Swithenby, S.J., Bailey, A.J., Bräutigam, S., Joseph, O.E., Jourmäki, V., Tesche, C.D., 1998. Neural processing of human faces: A magnetoencephalographic study. *Experimental Brain Research* 118, 501–510.

- Thompson, A.P., 1983. Extramarital sex: a review of the research literature. *Journal of Sex Research* 19, 1–22.
- Watanabe, S., Kakigi, R., Koyama, S., Kirino, E., 1999. Human face perception. In: Yoshimoto, T. (Ed.), *Recent Advances in Biomagnetism*. Tohoku University Press, Tohoku, pp. 720–723.
- Williamson, S.J., Kaufman, L., 1987. Analysis of neuromagnetic signals. In: Gevins, A.S., Rémond, A. (Eds.), *Methods of Analysis of Brain Electrical and Magnetic Signals. EEG Handbook (revised series)*, vol. 1. Elsevier, New York, pp. 405–448.
- Williamson, S.J., Lue, Z., Karron, D., Kaufman, L., 1991. Advantages and limitations of magnetic source imaging. *Brain Topography* 4, 169–180.