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Gender differences in cardiovascular and electrodermal responses to public speaking task: the role of anxiety and mood states

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Abstract

Gender moderates psychophysiological responses to stress. In addition to the hormonal background, different psychological states related to social stressors, such as anxiety and mood, could affect this response. The purpose of this study was to examine the existence of gender differences in the cardiovascular and electrodermal responses to a speech task and their relationship with anxiety and the mood variations experienced. For this, non-specific skin conductance responses (NSRs), heart rate (HR), and finger pulse volume (FPV) were measured at rest, and during preparation, task and recovery periods of an academic career speech in undergraduate men ($n = 15$) and women ($n = 23$), with assessment of changes in the state version of the State–Trait Anxiety Inventory (STAI-S) and in the Profile of Mood States (POMS) questionnaires. Men and women did not differ in trait anxiety, hostility/aggressiveness, or in the appraisal of the task, which were evaluated with the trait version of the State–Trait Anxiety Inventory (STAI-T), the Buss and Durkee Hostility Inventory (BDHI), and a self-report elaborated by ourselves, respectively. Women had higher FPV in all periods except during the task, and were more reactive to the stressor in state anxiety, and in the amplitude of NSRs. No gender differences for HR and for the frequency of NSRs were found. Anxiety and mood states were differently related to cardiovascular and electrodermal measurements in men and women. Further studies should consider the hormonal variations in addition to the psychological dimensions, in order to offer a more integrative perspective of the complex responses to stress. © 2001 Elsevier Science B.V. All rights reserved.

Keywords: Gender; Heart rate; Finger pulse volume; Electrodermal activity; Anxiety; Mood; Speech task

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1. Introduction

Studying the psychophysiological responses to social stressors in the laboratory provides information as to how people react when confronted with different controlled situations that simulate what could occur in real daily life. Public speaking is a powerful psychosocial stressor (Saab et al., 1989; Girdler et al., 1990), which includes different tasks, such as stressful interviews, marital and family interactions, discussions or role-plays concerning everyday problems, and speech, among others (Smith et al., 1996). Since speech tasks produce an enhanced cardiovascular reactivity (Al'Absi et al., 1997), they have been widely used to study the predisposition to suffer cardiovascular disorders (Krittayaphong et al., 1995).

Interest in gender in studying stress reactivity has increased (Matthews et al., 1991; Lash et al., 1995; Davis and Matthews, 1996; Steptoe et al., 1996, 2000; Girdler et al., 1997; Salvador et al., in press), possibly in an attempt to throw more light on the underlying mechanisms involved. The higher rate of cardiovascular disorders in men than in women (Lundberg, 1998) has been associated with higher levels of testosterone in men (Cohen and Hickman, 1987; Haffner et al., 1988), or with a buffering effect of female sex hormones (Polefrone and Manuck, 1987; Saab, 1989). It has also been linked to the psychological aspects of job demands, which are rapidly changing, with more and more women employed in the same jobs as men (Frankenhaeuser, 1991).

In general, women react to laboratory stressors with higher heart rate (HR) responses (Stoney et al., 1987; Girdler et al., 1990; Lester et al., 1994; Fichera and Andreassi, 2000), whereas men show greater blood pressure (BP) (Lawler et al., 1995; Shapiro et al., 1995; Steptoe et al., 1996; Fichera and Andreassi, 2000) and finger pulse volume (FPV) changes (Benschop et al., 1998), although various studies have not found any significant differences (Lash et al., 1991; Girdler et al., 1993; Parker Jones et al., 1996). Greater levels of urinary excretion of epinephrine (Barnett et al., 1987) and of peripheral alpha- and beta-adrenergic receptors (Freedman et al., 1987) in men than in women when confronting laboratory stressors may help to explain the higher BP reactivity in the former (Fichera and Andreassi, 2000). In women, decreased vagal activity in response stress may underlie the greater HR reactivity (Collins and Frankenhaeuser, 1978). Furthermore, it has been recently suggested that gender may be a confounding factor in the relationship between HR reactivity and variability (Sharpley et al., 2000).

Electrodermal activity (EDA) has been used as a clinical index of several stress-related psychophysiological disorders (Hugdahl, 1995). Electrodermal responses to laboratory stressors, such as stressful films (Köhler et al., 1995), the Stroop task (Guirado et al., 1995; Moya-Albiol et al., 2001; Salvador et al., in press), or an electric shock (Boucsein, 1992) have been analyzed, but few studies have included this measure in response to a public speaking task (Knight and Borden, 1979; Puigcerver et al., 1989). Its association with physiological parameters apart from cardiovascular measures is still little known (Carver and Scheier, 1994). In neutral conditions, men usually have higher EDA than women (Martínez-Selva et al., 1987); however, in some situations, such as the threat of an electric shock (Kopacz and Smith, 1971), women may be more responsive to environmental conditions (Venables and Mitchell, 1996). To our knowledge, no studies have compared the EDA responses to a speech task in men and women.

Psychological states are considered to be important moderators of the physiological responses to social stressors. In both men and women, anxiety has been related to higher electrodermal (Naveteur and Freixa-Baqué, 1987) and cardiovascular responses (Lang et al., 1983; Matthews et al., 1986; Saab et al., 1989; Heimberg et al., 1990) to social stressors, but not always (Knight and Borden, 1979; McKinney et al., 1983; Puigcerver et al., 1989; Baggett et al., 1996). In general, public speaking produces a worsening of mood, although it can be relatively independent of the cardiovascular stress responses (Bongard et al., 1997). In previous studies, we have not found any association in men (Moya-Albiol et al., 2001), but women who had worse mood showed lower HR, and higher EDA in response to the Stroop task (unpublished data), suggesting a different pattern of association between physiological and mood variables for each gender. Moreover, in response to a mental arithmetic task, harassed men showed largest reactivity in cortisol and in diastolic BP, whereas harassed women showed a more pronounced response in HR and self-reported hostility (Earle et al., 1999). In another study, women reported more tension, distress and fear than men during the presentation of filmed vignettes of socially stressful situations (Morris-Prather et al., 1996). These results have all contributed to link negative affect and gender with the development of cardiovascular diseases. Nevertheless, how anxiety and mood states may moderate gender differences in autonomic responses to public speaking tasks is not known.

The main purpose of this study is to examine gender differences in several physiological responses to a speech task. In addition to HR and FPV as cardiovascular measures, amplitude and frequency of non-specific skin conductance responses (NSRs) have been included to further investigate gender differences in stress reactivity. We hypothesized higher HR and EDA responses in women, but higher FPV responses in men, following the findings reported in the literature. The study also attempted to advance our understanding of the underlying mechanisms and specifically to throw more light on the role of emotional dimensions as moderators of gender differences. We hypothesized that physiological responses are mediated by changes in state anxiety and mood, at least in women. Taking into account the above-mentioned results, we would expect a different pattern of association for each gender in response to the speech task, these emotional aspects being more related to the autonomic responses in women than in men. With this in view, NSRs, HR, and FPV were measured during an academic career speech in undergraduate students, while state anxiety and mood were evaluated before and after the task. Trait anxiety, hostility and aggressiveness were measured to control their influence on gender autonomic differences. Several characteristics of the task and the performance (such as motivation, perception of effort, or degree of perceived stress, among others) were also assessed.

Table 1
Mean (S.D.) of anthropometric characteristics and trait questionnaires

	Men ($n = 15$)	Women ($n = 23$)
Age (years)	23.07 (2.99)	22.39 (1.64)
Height (m)*	1.78 (0.09)	1.62 (0.06)
Weight (kg)*	76.47 (10.77)	55.13 (6.04)
BMI (kg/m^2)*	24.04 (2.58)	20.90 (1.69)
STAI trait	19.27 (10.96)	17.69 (7.85)
BDHI total	30.67 (13.04)	31.48 (8.70)
BDHI assault	2.33 (2.05)	2.87 (2.05)
BDHI verbal hostility	6.93 (2.55)	7.69 (2.26)
BDHI indirect hostility	5.07 (2.12)	5.04 (1.58)
BDHI suspicion	2.80 (2.40)	2.17 (2.14)
BDHI resentment	2.07 (1.49)	2.09 (1.78)
BDHI irritability	5.47 (3.07)	5.91 (2.59)
BDHI negativism	2.73 (1.39)	2.22 (1.20)
BDHI guilt	3.27 (2.63)	3.48 (1.90)

*$P < 0.01$

2. Method

2.1. Subjects

The final sample of this study was composed of 38 undergraduate students of the Faculty of Psychology of the University of Valencia (15 males and 23 females) who participated voluntarily in the study. Subjects' average for age was 22.66 years (S.D. = 2.26) and for body mass index 22.14 kg m^{-2} (S.D. = 2.58). Table 1 provides anthropometric characteristics for men and women. Subjects were initially screened using a general questionnaire to evaluate habits, health aspects and drug intake. They were healthy, right-handed, and free of drugs and the women did not take contraceptives. After checking for the absence of physical activity 12 h prior to testing, they signed an informed consent.

2.2. Self-reports

Trait anxiety, as well as hostility and aggressiveness, were evaluated by the Spanish versions of the Trait version of the State–Trait Anxiety Inventory (STAI-T) (Spielberger et al., 1970) and of the Buss and Durkee Hostility Inventory (BDHI) (Buss and Durkee, 1957), respectively. The State version of the State–Trait Anxiety Inventory (STAI-S) (Spielberger et al., 1970) was used to evaluate state anxiety.

Mood was evaluated by the 'right now' version of the Profile of Mood States (POMS) (McNair et al., 1971), which is composed of six subscales: tension; depression; anger; vigor; fatigue; and confusion. A total measure was also computed by adding up all but the vigor scale. The higher the total score, the worse is the mood.

The task and performance were assessed by a list of nine items based on previous studies (Baggett et al., 1996). The Likert items, ranked by a five-point scale, assessed: motivation; perception of effort; degree of perceived stress; task difficulty; evaluation of their own performance; frustration developed due to the task; expected outcome of the evaluation; and internal and external attribution.

2.3. Procedure

After arriving at the laboratory, subjects were instructed about the questionnaires they had to fill in. Experimental sessions were carried out in the morning from 09:00 to 13:00 h. Subjects were accommodated in a first room where they completed the STAI-S and the POMS questionnaires (pre). After washing their hands, they were taken into the next room, where the recording phase was performed. This room was sound-attenuated and temperature-controlled (21 ± 2°C), and light was kept constant throughout all sessions. Electrodes were attached and subjects were strongly encouraged to be comfortable and relaxed. They remained in this situation for 10 min, but only the last 5 min were recorded to obtain baseline levels (rest period). Afterwards, recording was stopped and the experimenter gave the following instructions: 'You have 2.5 min to prepare a speech of 2.5 min duration on this topic (the experimenter gave them a paper where aspects of academic careers were listed), which will be evaluated by a teacher according to its consistency, adequacy and argumentative structure. Your performance will be considered for your academic qualification'. When the 2.5-min had elapsed (preparation period), recording was briefly interrupted while the evaluator went into the experimental room and sat in front of the subject. The experimenter told the subject to start and the need to speak for the entire 2.5-min period was strongly emphasized. To enhance the stress of the situation the tape- and video-recording apparatus was switched on in sight of the subject at this moment. The evaluator did not speak or provide any facial expressions, but took notes during the speech. After these 2.5 min (task period), the evaluator left the room and the subject remained for another 5 min without stimulation (recovery period). During the 20-min that each experimental session lasted, data were continuously recorded and monitored out of sight of the subject. Afterwards, subjects were immediately taken back into the first room where they completed the STAI-S (post), the POMS (post), and the items referring to appraisal of the situation. Furthermore, the STAI-T and the BDHI self-reports were administered.

2.4. Electrophysiological recording

Two Ag/AgCl electrodes (TSD103A) with a contact area of 6 mm in diameter were used to measure NSRs. Adhesive collars were used to locate the electrodes on the middle phalanxes of the index and thumb fingers of the non-dominant hand. Hypoallergenic gel (G100) was used as contact medium between skin and electrode. A skin conductance module (GSR100A) amplified the electrical signal by a circuit of a constant voltage below 0.5 V.

A photoelectric transducer (TS100A) was used to evaluate changes in FPV. It was attached by an adhesive collar to the distal phalanx of the index finger of the dominant hand. Variations in the FPV were acquired by a photopletysmograph amplifier (PPG100A), and the magnitude of the pulse was determined by the difference between the lowest point and its peak. HR was extrapolated from FPV data by AcqKnowledge software.

NSRs and FPV modules were a part of a physiological recording system composed of 16 modules (BIOPAC Systems Inc., Santa Barbara, CA 93117). This system was connected to a signal pre-amplifier (universal interface module, UIM100), and this in turn to a computer (PC-486) which contained hardware adapted to acquisition of data (MP100) and software prepared for storing data (AcqKnowledge for Windows).

2.5. Data reduction and analysis

The physiological recording system registered 10 data points s^{-1} for each variable. 'Rest' period was reduced to 3 representative min, 'preparation' to 1.5 min, 'task' to 1.5 min and 'recovery' to 3 min using AcqKnowledge software. HR, FPV, and NSRs were counted in 30-s sequences (six sequences for rest and recovery periods and three for preparation and task) coinciding with the beginning, the middle and the end of the condition. The selection of data was made taking into account previous research, the selected minutes being the most representative of the cardiovascular and electrodermal responses. They were the most stable minutes, because they were free of artifacts. This method has been previously used in several studies which have used similar variables (Puigcerver et al., 1989; Stein and Boutcher, 1993; Baggett et al., 1996).

Any artifact-free change in skin conductance equal to or higher than 0.05 $\mu\Omega^{-1}$ was considered to be a response. Two different measurements of NSRs, amplitude and frequency, were recorded, the former being expressed in $\mu\Omega^{-1}$ and the latter in number of responses. FPV was expressed in V and HR in beats min^{-1}.

Gender differences in psychological traits (anxiety, hostility and aggressiveness), and in appraisal were examined by one-way ANOVAs. ANOVAs of repeated measures with 'period' (rest, preparation, task, and recovery) as within-subjects factor, and 'gender' as between-subjects factor on HR, FPV, and NSRs were carried out. Greenhouse–Geisser adjustments for degree of freedom were carried out. Following this procedure, simple main-effect tests between periods were performed by repeated-measures ANOVAs. For mood and state–anxiety scores, ANOVAs of repeated measures (pre and post) with 'gender' as between-subjects factor were performed. Post hoc analyses were carried out by one-way ANOVA. In order to control potential basal differences, ANCOVAs were also carried out using baseline values as covariate.

Table 2
Mean (S.D.) of appraisal scores

	Men ($n = 15$)	Women ($n = 23$)
Motivation	4.20 (0.56)	3.69 (0.97)
Effort	2.93 (0.96)	2.69 (1.10)
Stress	2.80 (1.26)	3.39 (1.03)
Difficulty	1.87 (1.06)	2.30 (0.97)
Performance	3.60 (0.74)	3.26 (0.91)
Frustration	1.73 (1.10)	1.87 (1.18)
Evaluation	3.00 (0.92)	3.00 (0.90)
Internal attribution	3.57 (0.92)	3.50 (1.02)
External attribution	2.07 (0.86)	2.31 (0.89)

Spearman rank correlation tests were carried out to examine relationships between physiological variables and anxiety and mood states. Only the total POMS score was considered.

All statistical analyses were performed with SPSS 8.0 for Windows. The alpha level was fixed at 0.05. Data are expressed as mean ± S.D.

3. Results

3.1. Psychological traits

No significant differences between men and women in the STAI-T and in the total and different scales of the BDHI inventory appeared (Table 1). No gender differences were found with regards to appraisal scores (Table 2).

3.2. Stress period

3.2.1. State anxiety and mood

There were no significant differences between men and women in state anxiety and mood at baseline. For state anxiety (Fig. 1), a significant effect for the 'gender × time' interaction was found [$F(1,36) = 4.87$, $P < 0.03$], with a significant increase in women [$F(1,22) = 4.30$, $P < 0.05$] and no significant decrease in men. However, only a significant effect for 'time' was found for anger [$F(1,36) = 4.31$, $P < 0.045$], depression [$F(1,36) = 9.05$, $P < 0.005$] and fatigue [$F(1,36) = 6.08$, $P <$

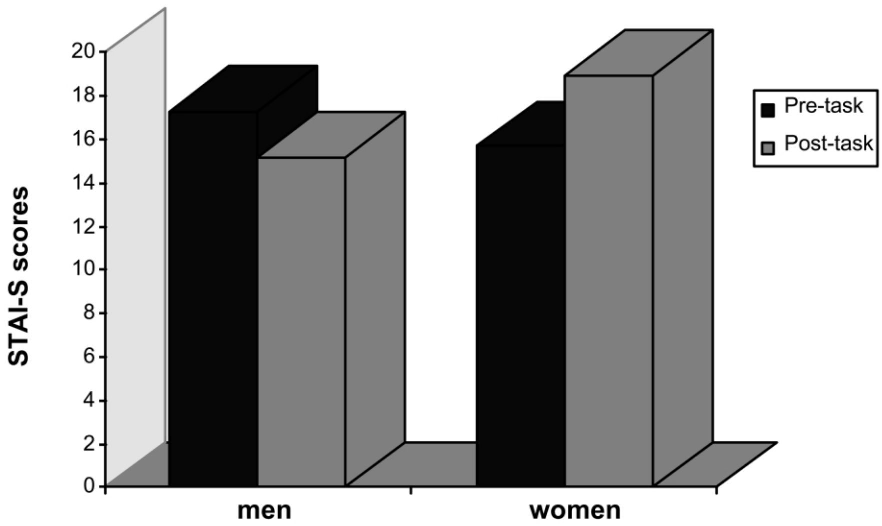

Fig. 1. Basal and post-task state anxiety for men and women.

0.019], scales with decreases in both groups (Fig. 2).

For both state anxiety and mood, the same results were found when baseline values were included as covariates.

3.2.2. Cardiovascular activity

For both HR and FPV (Fig. 3), the laboratory stressor proved to be efficient, since the factor 'period' was significant [$F(1.40,50.47) = 23.12$, $P < 0.001$ and $F(1.51,54.58) = 3.58$, $P < 0.05$, respectively]. Subjects showed a significant increment in HR while they prepared [$F(1,37) = 41.47$, $P < 0.001$] and presented the speech [$F(1,37) = 24.91$, $P < 0.001$] in comparison to the rest period, with higher values in task than in preparation [$F(1,37) = 5.59$, $P < 0.02$]. Moreover, recovery HR levels were significantly lower than those during rest [$F(1,37) = 8.77$, $P < 0.005$], preparation [$F(1,37) = 62.23$, $P < 0.001$], and task [$F(1,37) = 32.65$, $P < 0.001$] periods. For FPV, a significant diminution in task compared to preparation [$F(1,37) = 9.03$, $P < 0.005$], and an increase in recovery in regard to the task values [$F(1,37) = 23.35$, $P < 0.001$] were found, with recovery levels being significantly higher than those of the preparation period [$F(1,37) = 15.46$, $P < 0.001$].

The factor 'gender' was significant only for FPV [$F(1,36) = 8.04$, $P < 0.007$]. Post hoc analysis showed that FPV values were significantly higher for women in rest [$F(1,37) = 4.78$, $P < 0.03$], preparation [$F(1,37) = 4.57$, $P < 0.04$], and recovery [$F(1,37) = 6.00$, $P < 0.02$] periods. When baseline values were employed as covariate, significant effects for 'gender' disappeared.

3.2.3. Electrodermal measures

The public speaking task proved to be efficient in eliciting the expected results (Fig. 4), since for both amplitude and frequency of NSRs the factor 'period' was significant [$F(2.32,83.60) = 40.33$, $P < 0.001$ and $F(2.07,74.57) = 124.59$, $P < 0.001$]. Post hoc analyses showed a significant increase in preparation [$F(1,37) = 51.73$, $P < 0.001$ and $F(1,37) = 117.53$, $P < 0.001$, respectively] and task periods [$F(1,37) = 60.77$, $P < 0.001$ and $F(1,37) = 138.07$, $P < 0.001$] compared to the rest period, a significant increase in task period compared to preparation [$F(1,37) = 13.16$, $P < 0.001$ and $F(1,37) = 15.79$, $P < 0.001$], and a significant diminution in recovery with respect to preparation [$F(1,37) = 34.27$, $P < 0.001$ and $F(1,37) = 290.02$, $P < 0.001$, respectively] and task [$F(1,37) = 67.20$, $P < 0.001$ and $F(1,37) = 232.72$, $P < 0.001$, respectively] periods.

No significant baseline gender differences for

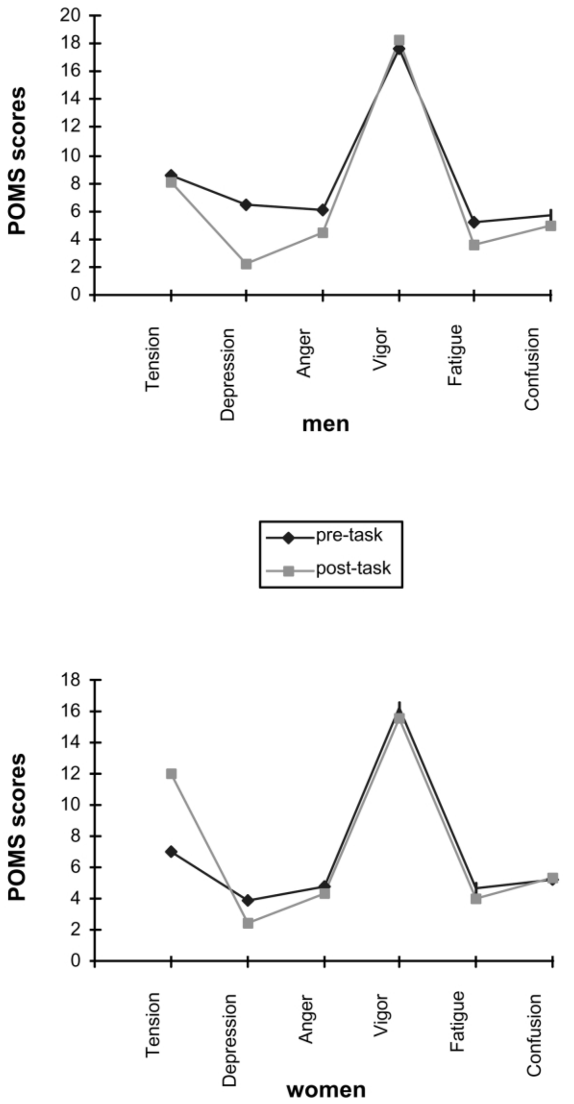

Fig. 2. Basal and post-task mood for men and women.

either amplitude or frequency of NSRs were found. The interaction 'gender × period' resulted in significant effects for the amplitude of NSRs [$F(2.32,83.60) = 3.21$, $P < 0.04$], but no differences were found in the case of frequency. Post hoc analyses indicated that only in the task period did women show significantly higher amplitude of NSRs than men [$F(1,37) = 4.34$, $P < 0.04$]. Including baseline values as covariates, the same results were found in the frequency, but a tendency to significance was found in the amplitude [$F(1,37) = 3.37$, $P < 0.07$].

3.3. Relationships between psychological states and physiological variables

Only in women did negative emotions experienced before the task correlate significantly with physiological measures. Concretely, pre-task anxiety (STAI-S) correlated positively with NSRs amplitude during preparation ($r = 0.41$, $P < 0.05$) and with HR in every period ($r = 0.71$, $P < 0.001$, $r = 0.70$, $P < 0.001$, $r = 0.54$, $P < 0.007$ and $r = 0.78$, $P < 0.001$ for rest, preparation, task and

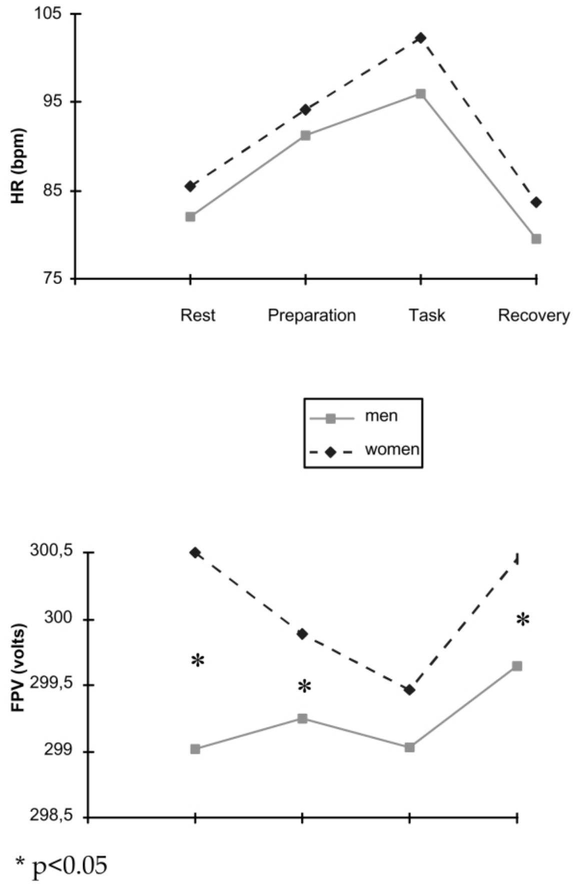

Fig. 3. HR and FPV during rest, preparation, task and recovery periods of the speech for men and women. When baseline values of FPV were employed as covariate, significant effects for 'gender' disappeared.

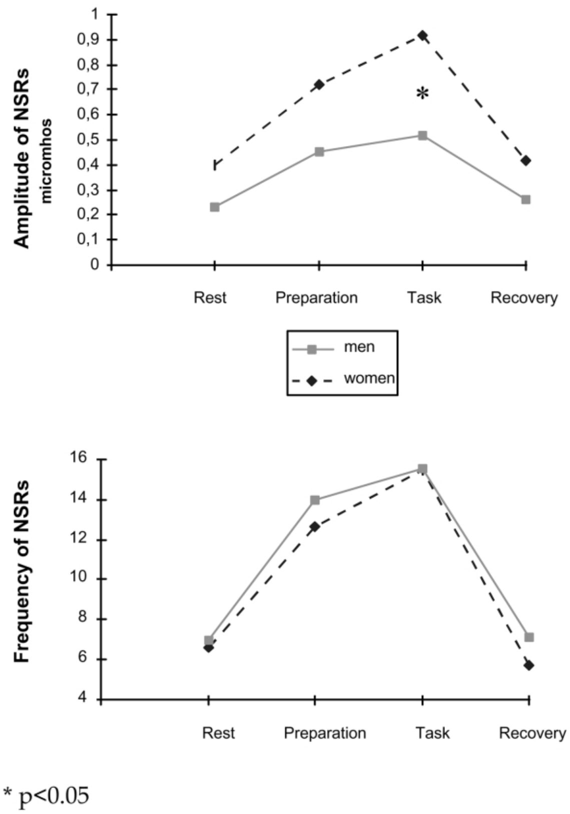

Fig. 4. Amplitude and frequency of NSRs during rest, preparation, task and recovery periods of the speech for men and women.

recovery, respectively). Also, the POMS-t score correlated positively with HR in rest and recovery periods ($r = 0.42$, $P < 0.047$, and $r = 0.58$, $P < 0.004$, respectively). After the task, anxiety was positively correlated to HR during recovery ($r = 0.47$, $P < 0.024$), and negatively to FPV during rest and recovery ($r = -0.55$, $P < 0.006$, and $r = -0.43$, $P < 0.04$, respectively). There was also a positive correlation between mood after the task and HR during recovery ($r = 0.54$, $P < 0.007$).

On the other hand, significant correlations appeared only in men after the public speaking task. Anxiety was positively correlated to FPV during the task period ($r = 0.613$, $P < 0.015$), and negative mood (POMS-t) was negatively associated with NSRs frequency during recovery ($r = -0.51$, $P < 0.05$).

The statistic Fisher's Z was employed to compare the pattern of relationships in men and women. The pattern of correlations between pre-task anxiety and HR was significantly different ($Z = 2.43$, 2.38, 2.38 and 2.97 for rest, preparation, task, and recovery periods, respectively; $P < 0.05$), as well as that between post-task anxiety and FPV ($Z = -2.33$, -4.32 and -2.45 for rest, task, and recovery periods, respectively; $P < 0.05$). Moreover, the correlation between POMS-t before the speech and HR during recovery was also significantly different for men and women ($Z = 2.14$; $P < 0.05$).

4. Discussion

Our results show gender differences in autonomic reactivity to public speaking and point to the sensitivity of electrodermal measures together with cardiovascular variables as indices of these differences. They also offer interesting gender-dependent patterns of relationship between anxiety and mood states, and cardiovascular and electrodermal stress responses.

We have found a HR increase during the preparation and speech with respect to the rest period, which is in agreement with previous studies (Sgoutas-Emch et al., 1994; Kirschbaum et al., 1995; Al'Absi et al., 1997), whereas 5 min after the task, the subjects had recovered the initial HR levels, as in other studies (Steptoe et al., 1990, 1993). Although it has been assumed that women have higher HR reactivity to laboratory stressors than men (Stoney et al., 1987; Girdler et al., 1990; Lester et al., 1994; Fichera and Andreassi, 2000), other studies have described the opposite trend (Lash et al., 1991; Girdler et al., 1993; Parker Jones et al., 1996). We have not found HR gender differences, but FPV amplitude was significantly higher for women during rest, preparation and recovery periods of the speech. Only in the task period were the differences attenuated, which suggests that they have a higher vasoconstriction than men in this kind of task, in accordance with another study which has reported higher FPV responses to stress in men (Benschop et al., 1998). Nevertheless, no gender differences were found for FPV after covariating the baseline values.

In general, laboratory tasks elicit an increase in the EDA during the performance compared to rest (Siddle et al., 1996) and preparation (Puigcerver et al., 1989) periods, followed by a decrease when the task is finished (Köhler et al., 1995). This pattern has also been found in this experiment for both amplitude and frequency of NSRs. Concerning gender differences, women showed higher NSRs amplitude during the speech task than men, an effect which is not due to differences in baseline values. This pattern has been previously found, but after using anxiogenous tasks, such as the threat of an electric shock (Kopacz and Smith, 1971). It is important to take these results into account, due to the fact that it has not been considered that EDA could be moderated by gender in response to social stressors, such as the speech task. Nevertheless, after a standard stimulus tape, females have shown larger skin conductance responses than males (Venables and Mitchell, 1996). In addition, it is worth noting that only amplitude, but not frequency, of NSRs was different, which shows that it is important to include more than one measure to evaluate psychophysiological changes in response to stressors.

Men and women showed similar hostility, aggressiveness and guilt when evaluated through the BDHI. Hostility and anger are the psychological dimensions most frequently associated with cardiovascular diseases in men and women (Greenglass, 1996; Houston et al., 1997; Bongard et al., 1998). In the laboratory, hostility has not been associated with heightened CVR to traditional non-social tasks, but has been related to reactivity in interpersonal contexts (Suls and Wan, 1993). In a previous study, men showed greater BP reactivity and women greater HR reactivity in response to a public speaking task, but personality did not play a role, except for highly hostile men (Fichera and Andreassi, 2000). These men had a larger increase in diastolic BP than those showing low hostility, but the HR reactivity was not significantly different between them. Trait anxiety may moderate the psychophysiological responses to stressful situations (Naveteur and Freixa-Baqué, 1987), but gender differences in this trait aspect or in the appraisal of the situation have not been found. Hence, gender differences in the physiological responsiveness to the speech were not due to differences in hostility, aggressiveness, trait anxiety or appraisal, as has been shown by the BDHI, STAI, and appraisal scores.

There is empirical evidence of a significant relationship between anxiety and coronary heart disease (Kawachi et al., 1994; Greenglass, 1996), which makes it more relevant to consider this variable in studying stress responsiveness. In our study, changes in state anxiety were significantly higher in women compared with men, which indicates that the former are more sensitive to this stressor, as has been previously mentioned (Saab et al., 1989; Allen et al., 1993). A specific pattern of relationships in each gender was also found. In women, the basal anxiety was positively correlated to the amplitude of NSRs during the preparation and to HR along all periods. In addition, post-stressor scores were also positively correlated to HR during recovery, but negatively to FPV during rest and recovery. In another experiment, women with higher STAI-S scores had higher cardiovascular responses during the performance of a public speaking task (Saab et al., 1989). As in other studies, men did not show significant correlations between state anxiety and HR (Puigcerver et al., 1989; Baggett et al., 1996), but a positive correlation between STAI-S (post) and FPV during task was obtained. Anxiety and HR response were positively related only in women, and the pattern of relationships between FPV and state anxiety is inverse in men and women. Anxiety plays a clearer role when studying the cardiovascular response to the speech task in women than in men.

Research relating mood and electrophysiological responses to social stressors is scarce, with most investigation focused on depressive patients. In this study, no gender differences in mood were detected before and after the task, but a different association between mood and electrophysiological responses has been found for each gender. Our results differ from those reported by others, which indicated that mood and cardiovascular responses to public speaking tasks can be relatively independent (Bongard et al., 1997). Nevertheless, a recent study has found that apathy was significantly correlated with HR reactivity, but not with electrodermal reactivity in patients with acquired brain damage (Andersson et al., 1999). For women, a worse mood was related to higher HR. Similarly, harassed women showed higher HR reactivity in response to a mental arithmetic task than harassed men (Earle et al., 1999). In addition, in patients with cardiovascular diseases, those who had higher scores in negative mood showed higher HR responses to a public speaking task (Sheffield et al., 1998). In men, as opposed to women, mood was related to electrophysiological variables when it was measured after the speech and showed lower NSRs frequency during recovery, a pattern which could be related to that reported in depressive patients, who had lower skin conductance basal levels than healthy subjects (Miquel et al., 1999). This inhibition has been explained by inhibitory mechanisms in the information processing of the central nervous system (Boucsein, 1992).

The pattern of relationships between anxiety and mood states and cardiovascular and electrodermal measures in response to a speech task further our knowledge of how the psychological aspects may moderate gender differences in response to stress. Experimental studies using anxiety and mood as independent variables in both men and women would clarify the findings described in our study. Further research should also consider hormonal gender differences and their relationship to electrophysiological and psychological aspects. All this would offer a more integrative perspective when studying gender differences in response to stress.

In conclusion, this study extends the gender differences found in several cardiovascular variables to other psychophysiological measures, such as NSRs and FPV, in response to a public speaking task. In this sense, electrodermal responses were higher in women as compared with men. Women were more reactive in FPV than men; nevertheless, in contrast to other research, no gender differences for HR were found. Without gender differences in trait anxiety, hostility and appraisal, the influence of state anxiety and mood for gender-dependent differences in response to social stress is suggested by the different pattern of relationship between these variables and cardiovascular and electrodermal measures for men and women. Both negative emotions, state anxiety and mood are more related to the physiological output in women than in men.

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References

Al'Absi, M., Bongard, S., Buchanan, T., Pincomb, W.A., Licinio, J., Lovallo, W.R., 1997. Cardiovascular and neuroendocrine adjustment to public speaking and mental arithmetic stressors. Psychophysiology 34, 266–275.

Allen, M.T., Stoney, C.M., Owens, J.F., Matthews, K.A., 1993. Hemodynamic adjustments to laboratory stress: the influence of gender and personality. Psychosom. Med. 55, 505–517.

Andersson, S., Krogstad, J.M., Finset, A., 1999. Apathy and depressed mood in acquired brain damage: relationship to lesion localization and psychophysiological reactivity. Psychol. Med. 29, 447–456.

Baggett, H.L., Saab, P.G., Carver, C.S., 1996. Appraisal, coping, task performance, and cardiovascular responses during the evaluated speaking task. Pers. Soc. Psychol. Bull. 22, 483–494.

Barnett, R.C., Biener, L., Baruch, G.K., 1987. Gender and Stress. The Free Press, New York.

Benschop, R.J., Geenen, R., Mills, P.J. et al., 1998. Cardiovascular and immune responses to acute psychological stress in young and old women: a meta-analysis. Psychosom. Med. 60, 290–296.

Bongard, S., Pfeiffer, J.S., Al'Absi, M., Hodapp, V., Linnenkemper, G., 1997. Cardiovascular responses during effortful active coping and acute experience of anger in women. Psychophysiology 34, 459–466.

Bongard, S., Al'Absi, M., Lovallo, W.R., 1998. Interactive effects of trait hostility and anger expression on cardiovascular reactivity in young men. Int. J. Psychophysiol. 28, 181–191.

Boucsein, W., 1992. Electrodermal Activity. Plenum Press, New York.

Buss, A.H., Durkee, A., 1957. An inventory for assessing different kinds of hostility. J. Consul. Psychol. 21, 343–349.

Carver, C.S., Scheier, M.F., 1994. Coping dispositions and situational coping in a stressful transaction. J. Pers. Soc. Psychol. 66, 184–195.

Cohen, J.C., Hickman, R., 1987. Insulin resistance and diminished glucose tolerance in powerlifters ingesting anabolic steroids. J. Clin. Endocrinol. Metab. 64, 960–963.

Collins, A., Frankenhaeuser, M., 1978. Stress responses in male and female engineering students. J. Human Stress 4, 43–48.

Davis, M.C., Matthews, K.A., 1996. Do gender-relevant characteristics determine cardiovascular reactivity? Match versus mismatch of traits and situation. J. Pers. Soc. Psychol. 71, 527–535.

Earle, T.L., Linden, W., Weinberg, J., 1999. Differential effects of harassment on cardiovascular and salivary cortisol stress reactivity and recovery in women and men. J. Psychosom. Res. 46, 125–141.

Fichera, L.V., Andreassi, J.L., 2000. Cardiovascular reactivity during public speaking as a function of personality variables. Int. J. Psychophysiol. 37, 267–273.

Frankenhaeuser, M., 1991. The psychophysiology of sex differences as related to occupational status. In: Frankenhaeuser, M., Lundberg, U., Chesney, M. (Eds.), Women, Work and Health. Plenum, New York, pp. 39–61.

Freedman, R.R., Sabharwal, S.C., Desai, N., 1987. Sex differences in peripheral vascular adrenergic receptors. Circ. Res. 61, 581–585.

Girdler, S., Hinderliter, A., Light, K., 1993. Peripheral adrenergic receptor contributions to cardiovascular reactivity: influence of race and gender. J. Psychosom. Res. 37, 177–193.

Girdler, S., Jamner, L.D., Shapiro, D., 1997. Hostility, testosterone, and vascular reactivity to stress: effects of sex. Int. J. Behav. Med. 4, 242–263.

Girdler, S.S., Turner, J.R., Sherwood, A., Light, K.C., 1990. Gender differences in blood pressure control during a variety of behavioral stressors. Psychosom. Med. 52, 571–591.

Greenglass, E.R., 1996. Anger suppression, cynical distrust, and hostility: implications for coronary heart disease. In: Spielberger, C.D., Sarason, I.G., Brebner, J.M.T., Greenglass, E., Laungani, P., O'Roark, A.M. (Eds.), Stress and Emotion. Anxiety, Anger and Curiosity. Taylor & Francis, Washington, pp. 205–225.

Guirado, P., Salvador, A., Miquel, M. et al., 1995. Ansiedad y respuestas electrofisiológicas a una tarea de estrés mental tras un ejercicio aeróbico máximo. Rev. Psicol. Deporte 7/8, 19–29.

Haffner, S.M., Katz, M.S., Stern, M.P., Dunn, J.F., 1988. The relationship of sex hormones to hyperinsulinemia and hyperglycemia. Metabolism 37, 683–688.

Heimberg, R.G., Hope, D.A., Dodge, C.S., Becker, R.E., 1990. DSM III-R subtypes of social phobia: comparison of generalized social phobics and public speaking phobics. J. Nerv. Ment. Dis. 178, 172–179.

Houston, B.K., Babyak, M.A., Chesney, M.A., Black, G., Ragland, D.R., 1997. Social dominance and 22-year all-cause mortality in men. Psychosom. Med. 59, 5–12.

Hugdahl, K., 1995. Psychophysiology: The Mind–Body Perspective. Harvard University Press, United States.

Kawachi, I., Golditz, G.A., Ascherio, A. et al., 1994. Prospective study of phobic anxiety and risk of coronary heart disease in men. Circulation 89, 1992–1997.

Kirschbaum, C., Prüssner, J.C., Stone, A.A. et al., 1995. Persistent high cortisol responses to repeated psychological stress in a subpopulation of healthy men. Psychosom. Med. 57, 468–474.

Knight, M.L., Borden, R.J., 1979. Autonomic and affective reactions of high and low socially anxious individuals awaiting public performance. Psychophysiology 16, 209–213.

Köhler, T., Scherbaum, N., Ritz, T., 1995. Psychophysiological responses of borderline hypertensives in two experimental situations. Psychother. Psychosom. 63, 44–53.

Kopacz, F.M., Smith, B.D., 1971. Sex differences in skin conductance measures as a function of shock threat. Psychophysiology 16, 209–213.

Krittayaphong, R., Light, K.C., Biles, P.L., Ballenger, M.N., Sheps, D.S., 1995. Increased heart rate response to laboratory-induced mental stress predicts frequency and duration of daily life ambulatory myocardial ischemia in patients with coronary artery disease. Am. J. Cardiol. 76, 657–660.

Lang, P.J., Levin, D.N., Miller, G.A., Kozak, M.J., 1983. Fear behavior, fear imagery, and the psychophysiology of emotion: the problem of affective response integration. J. Abnorm. Psychol. 92, 276–306.

Lash, S.J., Eisler, R.M., Southard, D.R., 1995. Sex differences in cardiovascular reactivity as a function of the appraised gender relevance of the stressor. Behav. Med. 21, 86–94.

Lash, S.J., Gillespie, B.L., Eisler, R.M., Southard, D.R., 1991. Sex differences in cardiovascular reactivity: effects of gender relevance of the stressor. Health Psychol. 10, 392–398.

Lawler, K.A., Wilcox, Z.C., Anderson, S.F., 1995. Gender differences in patterns of dynamic cardiovascular regulation. Psychosom. Med. 57, 357–365.

Lester, N., Nebel, L.E., Baum, A., 1994. Psychophysiological and behavioral measurement of stress. In: Avison, W.R., Gotlib, I.H. (Eds.), Stress and Mental Health: Contemporary Issues and Prospects for the Future. Plenum Press, New York, pp. 290–314.

Lundberg, U., 1998. Work and stress in women. In: Orth-Gomer, K., Chesney, M.A., Wenger, N.K. (Eds.), Women, Stress and Heart Disease. Lawrence Erlbaum Associates, Mahwah, New Jersey, pp. 41–56.

Martínez-Selva, J.M., Gómez-Amor, J., Olmos, E., Navarro, N., Román, F., 1987. Sex and menstrual cycle differences in the habituation and spontaneous recovery of the electrodermal orienting reaction. Pers. Individ. Differ. 8, 211–217.

Matthews, K.A., Davis, M.C., Stoney, C.M., Owens, J.F., Caggiula, A.R., 1991. Does the gender relevance of the stressor influence sex differences in psychophysiological responses? Health Psychol. 10, 112–120.

Matthews, K.A., Manuck, S.B., Saab, P.G., 1986. Cardiovascular responses of adolescents during a naturally occurring stressor and their behavioural and psychophysiological predictors. Psychophysiology 23, 198–209.

McKinney, M.E., Gatchel, R.J., Paulhus, P.B., 1983. The effects of audience size on high and low speech-anxious subjects during an actual speaking task. Bas. Appl. Soc. Psychol. 4, 73–87.

McNair, D.M., Lorr, M., Droppleman, L.F., 1971. How to Use the Profile of Mood States (POMS) in Clinical Evaluations. Educational and Industrial Testing Service, San Diego.

Miquel, M., Fuentes, I., García-Merita, M., Rojo, L., 1999. Habituation and sensitization processes in depressive disorders. Psychopathology 32, 35–42.

Morris-Prather, C.E., Harrell, J.P., Collins, R., Leonard, K.L., Boss, M., Lee, J.W., 1996. Gender differences in mood and cardiovascular responses to socially stressful stimuli. Ethn. Dis. 6, 123–131.

Moya-Albiol, L., Salvador, A., Costa, R. et al., 2001. Psychophysiological responses to the Stroop task after a maximal cycle ergometry in elite sportsmen and physically active subjects. Int. J. Psychophysiol. 40, 47–59.

Naveteur, J., Freixa-Baqué, E., 1987. Individual differences in electrodermal activity as a function of subjects' anxiety. Pers. Individ. Differ. 8, 615–626.

Parker Jones, P., Spraul, M., Matt, K.S., Seals, D.R., Skinner, J.S., Ravussin, E., 1996. Gender does not influence sympathetic neural reactivity to stress in healthy humans. Am. J. Physiol. 270, H350–H357.

Polefrone, J.M., Manuck, S.B., 1987. Gender differences in cardiovascular and neuroendocrine response to stressors. In: Barnett, R.C., Biener, L., Baruch, G.K. (Eds.), Gender and Stress. Free Press, New York, pp. 13–38.

Puigcerver, A., Martinez-Selva, J.M., Garcia-Sanchez, F.A., Gomez-Amor, J., 1989. Individual differences in psychophysiological and subjective correlates of speech anxiety. J. Psychophysiol. 3, 75–81.

Saab, P.G., 1989. Cardiovascular and neuroendocrine response to challenge in males and females. In: Schneiderman, N., Weiss, S.M., Kaufman, P.G. (Eds.), Handbook of Research Methods in Cardiovascular Behavioral Medicine. Plenum, New York, pp. 453–481.

Saab, P.G., Matthews, K.A., Stoney, C.M., McDonald, R.H., 1989. Premenopausal and postmenopausal women differ in their cardiovascular and neuroendocrine responses to behavioral stressors. Psychophysiology 26, 270–280.

Salvador, A., Ricarte, J., González-Bono, E., Moya-Albiol, L. Effects of physical training on endocrine and autonomic responsiveness to acute stress. J. Psychophysiol., in press.

Sgoutas-Emch, S.A., Cacioppo, J.T., Uchino, B.N. et al., 1994. The effects of an acute psychological stressor on cardiovascular, endocrine, and cellular immune response: a prospective study of individuals high and low in heart rate reactivity. Psychophysiology 31, 264–271.

Shapiro, D., Goldstein, I.B., Jamner, L.D., 1995. Effects of anger/hostility, defensiveness, gender and family history of hypertension on cardiovascular reactivity. Psychophysiology 32, 425–435.

Sharpley, C.F., Kamen, P., Galatsis, M., Heppel, R., Veivers, C., Claus, K., 2000. An examination of the relationship between resting heart rate variability and heart rate reactivity to a mental arithmetic stressor. Appl. Psychophysiol. Biofeedback 25, 143–153.

Sheffield, D., Krittayaphong, R., Cascio, W.E. et al., 1998. Heart rate variability at rest and during mental stress in patients with coronary artery disease: differences in patients with high and low depression scores. Int. J. Behav. Med. 5, 31–47.

Siddle, D.A., Lipp, O.V., Dall, P., 1996. The effects of task type and task requirements on the dissociation of skin conductance responses and secondary task probe reaction time. Psychophysiology 33, 73–83.

Smith, T.W., Limon, J.P., Gallo, L.C., Ngu, L.Q., 1996. Interpersonal control and cardiovascular reactivity: goals, behavioral expression, and the moderating effects of sex. J. Pers. Soc. Psychol. 70, 1012–1024.

Spielberger, C.D., Gorsuch, R.L., Lushene, R.E., 1970. Manual for the State–Trait Anxiety Inventory. Consulting Psychologists Press, Palo Alto, CA Spanish version 1982, TEA, Madrid.

Stein, P.K., Boutcher, S.H., 1993. Heart-rate and blood-pressure responses to speech alone compared with cognitive challenges in the Stroop task. Percept. Mot. Skills 77, 555–563.

Steptoe, A., Fieldman, G., Evans, O., Perry, L., 1996. Cardiovascular risk and responsivity to mental stress: the influence of age, gender and risk factors. J. Cardiovasc. Risk 3, 83–93.

Steptoe, A., Kearsley, N., Walters, N., 1993. Cardiovascular activity during mental stress following vigorous exercise in sportsmen and inactive men. Psychophysiology 30, 245–252.

Steptoe, A., Lundwall, K., Cropley, M., 2000. Gender, family structure and cardiovascular activity during the working day and evening. Soc. Sci. Med. 50, 531–539.

Steptoe, A., Moses, J., Mathews, A., Edwards, S., 1990. Aerobic fitness, physical activity and psychophysiological reactions to mental tasks. Psychophysiology 27, 264–274.

Stoney, C.M., Davis, M.C., Mathews, K.A., 1987. Sex differences in physiological responses to stress and coronary heart disease: a causal link? Psychophysiology 24, 127–131.

Suls, J., Wan, C., 1993. The relationship between trait hostility and cardiovascular reactivity: a quantitative review and analysis. Psychophysiology 30, 615–626.

Venables, P.H., Mitchell, D.A., 1996. The effects of age, sex and time of testing on skin conductance activity. Biol. Psychol. 43, 87–101.