Title: Sex differences in the psychophysiological response to an intergroup conflict

Authors:

Adrián Alacreu-Crespo[1, 6]

Vicente Peñarroja[2]

Vanesa Hidalgo[3,5]

Vicente Martínez-Tur[4]

Alicia Salvador[5]

Miguel-Ángel Serrano[1] (corresponding author)

Affiliations:

[1] Department of Psychobiology, University of Valencia, Valencia, Spain

Address: Av. Blasco Ibañez, 21, Valencia (46010), Spain

[2] Faculty of Economics and Business. Universitat Oberta de Catalunya (UOC), Spain

[3] Department of Psychology and Sociology, Area of Psychobiology, University of Zaragoza, Teruel; Aragon Health Research Institute, Aragon (Spain)

[4] IDOCAL, University of Valencia, Valencia, Spain

[5] Laboratory of Cognitive Social Neuroscience, Department of Psychobiology and IDOCAL, University of Valencia, Valencia, Spain

[6]Department of Emergency Psychiatry and Acute Care, CHU Montpellier, Hopital Lapeyronie, Montpellier, France. INSERM Unit 1061, University of Montpellier, Montpellier, France. Street Name & Number: 371 Av. du Doyen Gaston Giraud City, State, Postal code, Country: Montpellier, Occitanie, 34090, France

Highlights

- Intergroup conflict induced more conflict perception and negative mood.
- During conflict, participants showed decreases in parasympathetic activation.
- During conflict, only women showed decreases in testosterone levels.
- Conflict perception only correlated with psychophysiological responses in women.
- Results suggest that men and women interpret intergroup conflict differently.

Abstract:

Conflict induces psychophysiological responses, but less is known about responses to intergroup conflict. Intergroup relationships activate social processes, adding complexity to people's physiological responses. This study analyzes the psychophysiological responses to intergroup conflict considering sex differences. Thus, 150 young people were distributed in 50 groups in two conditions (conflict vs. non-conflict). Conflict was created in the interaction between two groups (three people each) in the laboratory. Their responses were compared to a control group. Mood, heart rate variability, cortisol, and testosterone were measured. Results showed that intergroup conflict induced a less pronounced decrease in negative and positive mood, and a reduction in parasympathetic activity (RMSSD of IBI). Moreover, women in conflict showed lower testosterone levels than men in conflict and control women. Finally, women's conflict perception correlated with their psychophysiological response. Results suggest that intergroup conflict induces emotional, cardiovascular, and endocrine responses, and that men and women interpret conflict differently.

Keywords: intergroup conflict; mood; cardiovascular; cortisol; testosterone; sex differences

1. Introduction

In humans, as in other social species, conflicts between groups are very common. They are frequently elicited by limited resources that promote agonistic or competitive behaviors. However, in a broader sense, intergroup conflict has been conceptualized as "the perceived incompatibility of goals or values between two or more individuals, which emerges because these individuals classify themselves as members of different social groups" (Böhm, Rusch, & Baron, 2018). Intergroup conflict has usually been studied in social psychology using different approaches based on concepts such as social identity, social threat, or discrimination, although an interdisciplinary approach was recently proposed (Böhm et al., 2018). Despite the high occurrence and important psychosocial consequences of conflict, such as aggression or stress, most of the research on the psychophysiological response to conflict has been carried out in interpersonal conflicts, without contemplating intergroup conflict, even though there are differences between interpersonal and intergroup interactions (Pemberton, Insko, & Schopler, 1996; Wildschut, Pinter, Vevea, Insko, & Schopler, 2003). Social processes such as group identification, group creation, or intergroup bias (Hewstone, Rubin, & Willis, 2002) may influence the way participants interpret the situation and, consequently, their conflict response in intergroup interactions. In fact, the interaction with the outgroup generally represents a threat to in-group members (Trawalter, Adam, Chase-Lansdale, & Richeson, 2012) that induces stress responses (Mendes, Blascovich, Lickel, & Hunter, 2002; Page-Gould, Mendes, & Major, 2010; Sampasivam, Collins, Bielajew, & Clément, 2016; Sawyer, Major, Casad, Townsend, & Mendes, 2012; Townsend, Major, Gangi, & Mendes, 2011).

Conflict-induced stress involves the activation of the autonomic nervous system (ANS) and the hypothalamic-pituitary-adrenal (HPA) axis, with subsequent cardiovascular changes and the secretion of cortisol (C) (Baumeister & Leary, 1995; Salvador, 2012), increasing vulnerability to health problems stemming from the dysregulation of these stress systems (Blascovich & Tomaka, 1996). However, conflict can also induce the activation of the hypothalamus-pituitary-gonadal (HPG) (Henry & Stephen, 1977; Koolhaas & Bohus, 1989), with changes in the secretion of testosterone (T). These endocrine responses have been related to different emotions and behaviors. Specifically, C has been related to fear and behavioral inhibition (Roelofs et al., 2009), whereas higher T has been related to *parochial altruism*, that is, higher favoritism toward in-group members and higher hostility toward the out-group (Reimers, Büchel, & Diekhof, 2017; Reimers & Diekhof, 2015). Low C and high T have been related to aggressive behavior (Terburg, Morgan, & van Honk, 2009), whereas higher parasympathetic activation, measured through Heart rate variability (HRV), is related to higher levels of cooperative behavior (Beffara, Bret, Vermeulen, & Mermillod, 2016). Thus, conflict would elicit high arousal and negative emotions (Blascovich & Tomaka, 1996), with verbal and non-verbal behaviors associated with anger, contempt, and disgust (Matsumoto, Hwang, & Frank, 2012, 2014), fear (Halperin & Gross, 2011), and greater anger/hostility, confusion, and tension/anxiety (Vannucci, Ohannessian, Flannery, De Los Reyes, & Liu, 2018). Together, the physiological and emotional changes associated with the conflict can influence an individual's short-term and long-term behavior, inducing stress responses or aggressive behavior. Hence, it is necessary to study intergroup conflict from a physiological and emotional point of view.

As mentioned above, only a few studies have analyzed psychophysiological responses to intergroup conflicts. For example, Ricarte et al. (2001) examined the psychophysiological response of mixed-sex groups of young people, employing a role-play to induce an intergroup conflict between newly created groups and using the minimal group paradigm (Tajfel & Turner, 1979). They found an increase in heart rate (HR) in both men and women during the conflict, although this increase was higher in women. Kivlighan et al. (2005) reported a T increase in men, but decreases in women, during a group rowing ergometer competition, whereas Oxford et al. (2010) reported a high C and low T response in high-ranking men in a videogame competition between groups. Therefore, intergroup conflict or group competition seems to induce a cardiovascular response (CV) and changes in the activity of the HPA and HPG axes.

In addition to sex differences in the physiological responses to conflict, differences in the emotional response have also been found, with women reporting higher negative mood than men (Wood and Eagly, 2012). In interpersonal conflict situations, some recent results suggest that sex differences in the interpretation of the situation could influence the T reactivity (Makhanova, McNulty, Eckel, Nikonova, & Maner, 2018). These sex differences have been explained by Role Congruity Theory (Eagly & Karau, 2002), which proposes that women's role during a social interaction is usually more social than men's, which is more agentic.

The aim of this research was to study the emotional, CV, and endocrine responses to an intergroup conflict, considering sex differences and controlling for group influence. Small groups (composed of 3 people) participated in an intergroup role-play conflict or a control condition. Based on previous studies, we hypothesized that intergroup conflict would induce higher negative mood, parasympathetic withdrawal, and C and T responses. Furthermore, based on Role Congruity Theory (Eagly & Karau, 2002), we hypothesized that women would have more negative affect than men, associated with higher activation of the CV system and C (Kelly et al., 2008; Kivlighan et al., 2005; Kudielka et al., 2004; Ricarte et al., 2001; Stroud et al., 2002), whereas T would be higher in men (Makhanova et al., 2018). We hypothesized that conflict perception would be associated with psychophysiological responses to conflict in both sexes. In addition, because there is evidence that belonging to a group could influence the individual's psychophysiological responses (Levenson & Ruef, 1992), it is necessary to control this condition in order to correctly analyze the psychophysiological responses in groups.

2. Methods and materials

2.1. Participants

An initial sample of 150 healthy Caucasian undergraduate students from the University of Valencia (Spain) participated in this study. The sample was recruited through informative talks (in classes after lectures in the university), and then a screening questionnaire was used to check whether they met the study prerequisites. The exclusion criteria were: presence of cardiovascular, endocrine, neurological, or psychiatric disease, presence of a stressful life event during the past year, smoking ten or more cigarettes per day, alcohol or other drug abuse, and doing more than 10 hours of physical activity *per* week. For each session, we contacted six participants of the same sex by telephone, in order to form two teams of three participants each. Thus, we recruited 50 teams with three participants of the same sex in each. These teams were randomly submitted to one of the different conditions: 32 teams in the conflict condition (CC; 12 teams of men and 20 teams of women) and 18 teams in the non-conflict condition (NCC; 8 teams of men and 10 of women).

Before each session, participants were asked to maintain their general habits, sleep as long as usual, refrain from heavy physical activity the day before the session, and not consume alcohol since the night before the session. Additionally, they were instructed to drink only water and refrain from eating, brushing their teeth, smoking, or taking any stimulants, such as coffee, cola, caffeine, tea or chocolate, two hours prior to the session. Six participants were excluded because they did not follow these recommendations, and two other participants were excluded because they were considered outliers on the body mass index (BMI; BMI + 3 SD) (2 women from the CC, and 3 women and 3 men from the NCC).

Therefore, the final sample was composed of 142 participants (60 men and 82 women). Participants' mean age was 21.16 years (SE = ± 0.19), and their mean BMI was 22.56 Kg/m^2 (SE = ± 0.27). Ninety-four subjects participated in the CC (36 men and 58 women; M = 21.29, SE = ± 0.25 years of age, and a BMI of M = 22.58, SE = ± 0.31 Kg/m2), whereas 48 subjects (21 men and 27 women; M = 20.96, SE = ± 0.34 years of age and a BMI of M = 23.11, SE = ± 0.43 Kg/m2) participated in the NCC (see Table 1).

Participants were asked to attend a 3h session that took place in a laboratory at the Faculty of Psychology at the University of Valencia. All the sessions were held between 15:30 and 18:30h in order to control the circadian rhythms of the hormones. Once all the sessions had ended, participants were informed about the rationale for the study, and they received €9 (about 12 USD) for their participation.

2.2. Procedure

Each session was conducted by two male experimenters. When the participants arrived at the laboratory, they were informed about the general study procedure, and they signed the informed consent approved by the Ethics Research Committee of the University of Valencia. The study was conducted according to the Declaration of Helsinki. Moreover, participants were asked whether they had followed the recommendations given previously, and about demographic variables such as weight, height, and perceived socioeconomic status (SES). Later, participants were distributed into six individual rooms. In addition, an HR monitor was placed on each participant in order to start HR acquisition at the same time in all participants.

Conflict condition. To provoke intergroup conflict, participants performed the task known as "Viking Investments" (Greenhalgh, 1993). This task consisted of a conflict role-play between two teams, where one team represents a real estate investment company and the other represents a carpentry business. Following the Howard et al. (2007) procedure, each team received a different description of the conflict. This information was intended to make each team think that the other team was responsible for the problems caused. It is important to note that participants did not have to be experts to understand and defend their position in the conflict, and the complexity and multifaceted nature of the conflict did not make it possible to determine a clear winner or loser in the established period of 10 min. This duration was previously found to be ideal for generating conflict, and it was not long enough to allow the two teams to arrive at a position accepted by both teams.

The session started with a 15-min *habituation* phase in order to ensure the participants' adaptation to the laboratory setting. During this phase, participants completed a mood scale (pre-task) and collected the first saliva sample (baseline) in an individual room. To avoid disturbing participants' baseline CV, they did not receive any specific instructions to keep their eyes open or closed or breathe differently from usual. Next, the task took place in three phases (Figure 1). For 35 min, in the *individual preparation* phase, participants had to individually read the description of the conflict according to his/her team. Next, each participant on each team was moved from an individual room to a team room. Each team was instructed to prepare a discussion meeting that would take place later with the other team (20 min) (*pre-interaction* phase). At the end of this phase, participants provided the second saliva sample (pre-interaction sample). Then, the interaction between the two teams took place (*interaction* phase). To achieve a dispute with a conflictive nature, teams were seated face-to-face in the interaction room. Moreover, participants only had 10 min to interact with the other team. This short time period only allowed participants to become aware of the intergroup conflict and the different perspectives of the two teams. An experimenter was present in the interaction room and instructed participants to start the meeting, stating that it was important to become immersed in the role. During this phase, participants could freely intervene with their arguments. The experimenter did not mediate in the interaction, and participants were free to do or say anything, but without varying their positions. Once the conflict had ended, participants returned to the individual rooms and again completed the mood scale (post-task) and the conflict perception scale, and they provided the third, fourth, and fifth saliva samples at 0 (Post-0), 30 (Post-30), and 45 (Post-45) minutes after the interaction, respectively. Finally, the experimenter thanked the participants and informed them that the experimental session was over.

Non-conflict condition. The NCC condition was similar to the CC condition, except that the interaction between the two teams was not a conflict situation. For this purpose, participants received the same cases to read, but with different instructions from those for the CC condition in the *pre-interaction* and *interaction* phases. They were instructed to prepare a summary of their case, according to their team, in order to explain it to the other team during the meeting in the interaction phase. It is important to note that, as in the CC, teams were seated face to face in the interaction room, but they only had to explain their cases. The scales completed, the timing of the saliva samples, and the phase durations were the same for the two conditions. A summary of the entire procedure is shown in Figure 1.

Insert here Figure 1

2.4. Questionnaires and scales

Mood. The Spanish version (Sandín et al., 1999) of the Positive and Negative Affect Scale (PANAS; Watson et al., 1988) was used. This questionnaire provides scores in two dimensions: positive and negative affect. The two-dimensionality of the Spanish version of the PANAS has been confirmed, with $\alpha = 0.89$ for positive mood and $\alpha = 0.91$ for negative mood.

Conflict perception. All the participants answered two sub-scales of the Conflict Type Perception Test (Jehn, Greer, & Levine, 2008): (i) Task Conflict (disagreements about ideas and opinions related to the task with the members of the other team) and (ii) Relation Conflict (disagreements about personal ideas that are not task-related with the members of the other team), composed of six and four items, respectively. This version has been used in previous studies (Martínez-Tur et al., 2014). Participants have to assess the level of conflict experienced between their team and the other team, based on statements rated on a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). A high degree of internal consistency was found in our sample, with α = 0.90 for Task Conflict and α = 0.86 for Relation Conflict.

2.3. Cardiovascular measures

Heart rate was measured using a Polar©RS800cx watch (Polar CIC, USA), which consists of a chest belt for the detection and transmission of the heartbeats and a Polar watch for data storage; this device is very useful in research (Perandini et. al., 2009). The Polar watch measures R-R intervals with a sampling frequency of 1000 Hz. We used this instrument because it allows participants to move to different rooms depending on the procedure. Data were analyzed using the Heart Rate Variability (HRV) software Kubios Analysis (Biomedical Signal Analysis Group, University of Kuopio, Finland; Tarvainen et al., 2014). Following the recommendations of the Task Force (1996), we analyzed the HR in periods of 5 minutes, exactly in the middle of the following periods: (i) Baseline, (iii) Pre-interaction, (iv) Interaction, and (v) Post-interaction periods. We eliminated the time spent moving to another room from the data, as well as the time when the subjects were completing the questionnaires. Automatic Kubios artifacts were fixed with the appropriate degree of correction.

In the absence of a good direct SNS marker, we computed the HR mean as an index of sympathetic activation / parasympathetic withdrawal, although it has some limitations. Furthermore, the Root Mean Square Successive Difference (RMSSD) of beat-to-beat Inter Beat Interval (IBI) was also computed, which is considered an index related to Respiratory Sinus Arrhythmia and, thus, to the parasympathetic branch (Task Force, 1996). Finally, we obtained the dominant/peak frequency of the heart rate variability spectrum in the high-frequency band (HFhz), which is an acceptable estimate of respiratory frequency.

2.4. Saliva sampling and biochemical analyses

Five saliva samples were collected from each participant: (i) Baseline, (ii) Pre-interaction, (iii) Post-0, (iv) Post-30, and (v) Post-45, in order to obtain the hormonal response. Saliva was directly collected from mouth to vial by depositing 5 ml. Participants took no more than 5 min. to fill each vial. Samples were centrifuged (5000 rpm, 15+2ºC) and frozen at -20ºC until determination.

Salivary C levels were determined in duplicate with the Spectria Cortisol RIA kit from Orion Diagnostica (Espoo, Finland). Assay sensitivity was 0.8 nmol/l. For each subject, all the samples were analyzed in the same trial. The within- and inter-assay variation coefficients were all below 8%.

Salivary T concentrations were determined in duplicate with the salivary testosterone enzyme-immunoassay kit from Salimetrics (Suffolk, UK). Assay sensitivity was < 1.0 pg/ml. For each subject, all the samples were analyzed in the same trial. The within- and inter-assay variation coefficients were all below 10%.

2.5. Data reduction and statistical analyses

The Kolmogorov-Smirnoff test was used to check the normality of the variables measured. Task conflict, C, and T values did not have a normal distribution and were normalized with the Log10 method. After that, we calculated the mean of each cardiovascular variable using all the periods (i.e. Baseline, Pre-interaction, Interaction, and Post-interaction) and the Area Under the Curve with respect to ground (AUCg: Pruessner et al., 2003), for each hormone (Baseline, Pre-interaction, Post-0, Post-30, and Post-45). Moreover, we calculated the reactivity index of the interaction (Interaction – Baseline) for mood, CV, C, and T. To check the homogeneity of independent factors (i.e. condition and sex), first, chi-square analyses were performed between Condition (CC/NCC) and Sex (men/women), and second, ANOVAs were conducted, with Condition and Sex as independent factors, and Age, BMI, SES, Baseline mood, HR, RMSSD of IBI, HFhz, C, and T as dependent variables. Because there were significant differences in age, BMI, and SES, their influence on cardiovascular and endocrine variables was controlled.

To test our principal hypotheses, we examined whether Hierarchical Linear Modeling (HLM), using Team as the cluster variable, was needed in our analyses. HLM takes into account the hierarchical structure of the data (e.g., individuals who are nested within teams), and it allows the simultaneous examination of the relationships between variables at different levels of analysis (e.g., individual and group levels), as well as possible cross-level interactions (Raudenbush and Bryk, 2002; Snijders and Bosker, 1999). To do so, we examined the differences in the – 2loglikelihood between the null model and the model, using team as cluster for all the variables analyzed in this study (see Table 2). Significant differences in the – 2loglikelihood between the null model and the model with team as cluster indicated the need for HLM. Table 2 also shows the Intra-Class Correlation (ICC) index for each dependent variable. ICC represents the proportion of variation in the outcome variables due to team membership.

When HLM was required, the following steps were taken in the analysis to build a two-level model with predictors at the individual and group levels. First, we conducted a null model for the dependent variables, which is a requirement for cross-level analysis (Heck & Thomas, 2000; Raudenbush & Bryk, 2002). Second, we tested the random intercept model using Team as the cluster variable. Third, we introduced the covariates at the individual level, if necessary. Fourth, we introduced the fixed effects of Sex at the individual level. Fifth, we tested the random slopes of Sex, which were allowed to vary across teams. Sixth, we introduced the fixed effects of Condition at the group level. Finally, we introduced the cross-level interaction between Condition and Sex. We used a model comparison procedure to check whether the effect of adding the fixed and random effects to each model was statistically significant. In the results section, we only describe the results for the model with the best fit. Table 3 shows the results of the final model for all the variables where HLM was used. When the model showed significant cross-level interactions, *post-hoc* simple slopes analyses with Bonferroni correction of the degrees of freedom were conducted.

When HLM was not necessary, two-way ANOVAs or ANCOVAs were carried out, with Condition and Sex as between-subject factors, and covariates when necessary. *Post-hoc* tests were performed with Bonferroni correction. The decision about whether to use HLM is explained in the results section for each variable. For more information about the model comparison results and the p values for the non-significant main effects and interactions, please consult the supplementary material.

Pearson correlation analyses were performed in order to study the relationships between the perception of Task and Relation Conflict and the psychophysiological responses (reactivity indexes) for men and women separately.

The alpha significance level was fixed at 0.05, and the 95% CI was reported for HLM. Partial eta squared was reported for ANOVAs and ANCOVAs as a measure of the effect size. $1 - \beta$ was reported as a measure of a posteriori power. All the statistical analyses were performed with R 3.4.2.

3. Results

3.1. Preliminary Analyses

Chi-square did not show significant differences between the number of men and women in the two conditions ($\chi^2 = 0.07, p < .794$). ANOVAs only showed a significant effect of Condition at Baseline on C ($F_{1, 134} = 23.98$, $p < .001$, $\eta^2_p = .15$, *power* = .99), with CC participants showing higher levels than NCC participants.

Sex differences were found in BMI ($F_{1, 136} = 27.04$, $p < .001$, $\eta^2_p = .16$, *power* = .99) and HR at Baseline ($F_{1, 87} = 4.02$, $p < .048$, $\eta^2_p = .04$, *power* = .51), C ($F_{1, 134} = 8.27$, $p < .007$, $\eta^2_p = .06$, *power* = .81) and T at Baseline ($F_{1, 132} = 88.68$, $p < .001$, $\eta^2_p = .40$, *power* = 1.00). Thus, men had higher scores on BMI (M ± SE; men = 24.27 ± .41, women = 21.46 ± .36), Baseline C (M ± SE; men = 1.02 ± .02, women = .96 ± .02) and Baseline T (M ± SE; men = 1.97 ± .03, women = 1.62 ± .03), but lower scores on baseline HR (M ± SE; Men = 76.26 ± 1.88, women = 81.09 ± 1.39) than women. Due to sex-differences in BMI, which can act as a potential confounding variable for the CV (Yi, Lee, Shin, Kim, & Kim, 2013) and endocrine (Strahler, Skoluda, Kappert, & Nater, 2017) responses, BMI was used as covariate in the next analyses of these responses. Age and SES did not show significant differences (all $p > .05$). M ± SE for sociodemographic and baseline values are presented in the Table 1.

Insert here Table 1

3.2. Intraclass correlation for dependent variables

The ICC represents the total variance explained by Team membership on lower-level variables (Bliese, 2000). Thus, higher ICCs indicate a higher influence of team on the dependent variables. The variables with a large ICC were: Task conflict (ICC = .55), Relation conflict (ICC = .51), Reactivity of HR (ICC = .55), RMSSD of IBI conflict reactivity (ICC = .47), and, finally, the AUCg of T (ICC = .41). Table 2 showed the ICCs for all the variables.

Insert here Table 2

3.3. Conflict perception

For both conflict perception subscales (Task conflict and Relation conflict), the random intercepts for Team were nested ($p < .001$), and then HLM was computed for both variables.

Task conflict showed significant variance in the intercepts across Teams (SD = 0.14, CI 95% [.11, .19], χ^2 (1) = 40.62, $p < .001$). When we added the fixed effects and random slopes for Sex, the model fit did not improve significantly (all $p > .05$). The fit only improved significantly when we added the fixed effects of Condition to the model (χ^2 (1) = 32.09, $p < .001$). Finally, the Sex × Condition interaction did not significantly improve the model ($p > .201$). We found a significant effect of Condition on task conflict ($b = -0.24$, SE = .04, CI 95% [− .30, − .07], $t(47) = -6.91$, $p < .001$); CC participants had higher task conflict than NCC participants ($M \pm SE$; CC = .74 ± .02, NCC = .49 ± .02).

In the case of Relation conflict, significant variance was found in the intercepts across Teams (SD = 1.28, CI 95% [.98, 1.67], χ^2 (1) = 33.41, $p < .001$). Moreover, when we added the fixed effects of Sex, the model fit improved significantly (χ^2 (1) = 5.54, $p < .019$). Adding the random slopes of Sex did not improve the model (all $p > .05$). However, the fixed effects of Condition (χ^2 (1) = 17.23, $p < .001$) and the cross-level Sex × Condition interaction significantly improved the model fit (χ^2 (1) = 6.43, $p < .011$). We found a significant effect of Sex on Relation conflict (b = 1.48, SE = .38, CI 95% [.72, 2.25], $t(46) = 3.86$, $p < .001$); women had higher scores than men (*M* ± *SE*; Women = 4.08 ± 0.21, Men = 3.44 ± .24). In addition, the Condition × Sex interaction showed significant effects on this subscale (b = − 1.68, SE = .65, CI 95% [− 2.98, − .39], $t(46) = -2.59$, $p < .013$). *Post-hoc* analyses showed higher Relation conflict in CC women than NCC women (b = 2.45, SE = .43, $t(46) = 5.75$, $p <.001$) and both CC (b = − 1.48, SE = .38, $t(46) = -3.86$, $p < .002$) and NCC (b = − 2.24, SE = .46, $t(46) = -4.86$, $p < .001$ (Table 1) men.

3.3. Emotional response to conflict

None of the mood scales showed significant differences in the − 2loglikelihood comparison models for the null model and the second model (Table 2), and so we performed ANOVAs. *M* ± *SE* of mood scores (Raw data) are plotted in Figure 2.

For positive mood, a main effect of Condition ($F_{1, 133} = 8.22$, $p < .005$, $\eta^2_p = .06$, *power* = .81) was found. Positive mood decreased less from the basal levels after the conflict task than after the non-conflict task (*M* ± *SE*; CC = − 2.02 ± 0.51, NCC = − 4.39 ± .70). However, Sex and the Sex × Condition interaction were not significant (all $p > .05$).

For negative mood, a significant effect of Condition ($F_{1, 132} = 6.07$, $p < .015$, $\eta^2_p = .04$, *power* = .69) was found. Negative mood reactivity was higher in CC participants than in NCC participants (*M* ± *SE*; CC = − .47 ± 0.50, NCC = − 2.32 ± .69). As in the case of positive mood, Sex and the Sex × Condition interaction did not show significant effects (all $p > .05$).

Insert Figure 2 here

3.4. Cardiovascular response to conflict

We found significant differences between the null model and the model using team as cluster for Mean HR, HR reactivity, and RMSSD of IBI reactivity (See Table 2). Thus, we used HLM for Mean HR, HR reactivity, and RMSSD of IBI reactivity. Mean RMSSD of IBI, Mean HFhz, and HFhz Reactivity did not show significant differences between the null model and the second model, and so we used ANCOVAs to analyze these variables. *M* ± *SE* of cardiovascular values (Raw data) are plotted in Figure 3.

Insert Figure 3 here

3.4.1. Heart rate

The Mean HR showed significant variance in the intercepts across teams (SD = 7.20, CI 95% [5.00, 10.36], χ^2 (1) = 9.73, $p < .002$). Including Condition (χ^2 (1) = 4.73, $p < .029$) significantly improved the model. However, BMI, Sex fixed effects, Sex random slopes, and the Sex × Condition interaction did not significantly improve the model fit (all $p > .05$). We found significant effects of Condition on Mean HR ($b = -5.56$, SE = 2.54, CI 95% [− 5.56, − .56], $t(49) = -2.18$, $p < .034$), with participants in the CC showing higher HR than in the NCC (*M* ± *SE*; CC = 80.41 ± 1.63, NCC = 74.86 ± 2.01). However, the significant effects of Condition disappeared when we included the cross-level interaction term (Table 3).

HR reactivity to conflict showed significant variance in the intercepts across teams (SD = 8.29, CI 95% [6.17, 11.13], χ^2 (1) = 17.09, $p < .001$). For this variable, the model fit improved marginally when we included Condition (χ^2 (1) = 3.77, $p < .051$), but not when we included the rest of the variables (all $p >. 05$). We found a trend of Condition in the HR reactivity to conflict ($b = -5.48$, SE = 2.81, CI 95% [− 10.99, .03], $t(49) = -1.95$, $p < .057$), with higher HR reactivity in CC participants than in NCC participants (*M* ± *SE*; CC = 3.95 ± 1.77, NCC = − 1.52 ± 2.19). However, if we included the interaction term, the marginal effects of Condition disappeared (Table 3).

3.4.2. RMSSD of IBI

The ANCOVA did not show significant effects of Condition or Sex or the Sex × Condition interaction on the Mean RMSSD of IBI (all $p > .05$).

RMSSD of IBI reactivity to conflict showed significant variance in the intercepts across Teams (SD = 9.12, CI 95% [6.49, 12.81], χ^2 (1) = 13.41, $p < .001$). Only the addition of Condition significantly improved the model fit (χ^2 (1) = 3.94, $p < .047$). Adding BMI, Sex, the slopes of Sex, or the Sex × Condition interaction did not improve the model (all $p > .05$). We found a significant effect of Condition on the RMSSD of IBI reactivity to conflict ($b = 5.62$, SE = 2.85, CI 95% [0.01, 11.23], $t(49) = 1.97$, $p < .048$), with lower values in CC participants than in NCC participants (*M* ± *SE*; CC = 1.11 ± 2.14, NCC = 6.73 ± 2.48). However, the significant effects of Condition disappeared when we included the Sex × Condition interaction (Table 3).

3.4.3. Respiration

In the ANCOVA for the Mean HFhz or HFhz reactivity, no significant effects of the Condition or Sex factors or the Sex × Condition interaction were found (all $p > .05$).

3.5. Endocrine response to conflict

We performed HLM because the – 2loglikelihood between the null model and the second model was significant for both C and T AUCg ($p < .001$). However, we carried out ANCOVAs for reactivity because the variance in the intercepts across teams was not significant for C or T. BMI was used as covariate in all the analyses. Raw data and log-transformed data *M* ± *SE* of the endocrine measures are plotted in Figure 4.

Insert Figure 4 here

3.5.1. Cortisol

Regarding C AUCg, significant variance was found in the intercepts across teams (SD = 9.30, CI 95% [6.61, 13.07], $\chi^2(1) = 14.54$, $p < .001$). Moreover, adding BMI ($\chi^2(1) = 5.59$, $p < .018$), fixed effects of Sex ($\chi^2(1) = 5.07$, $p < .024$), and Condition ($\chi^2(1) = 23.33$, $p < .001$) significantly improved the model. Random slopes for Sex and the Sex × Condition interaction did not improve the model (all $p > .05$). We found a significant effect of Sex ($b = -8.61$, SE = 2.87, CI 95% [− 14.31, − 2.93], $t(47) = -3.00$, $p < .004$); men had a more pronounced curve than women (*M* ± *SE*; Men = 26.32 ± .78 min*nmol/l, Women = 23.00 ± .68 min*nmol/l). Furthermore, significant effects of Condition were also found ($b = -15.25$, SE = 2.83, CI 95% [− 20.86, − 9.65], $t(47) = -5.39$, $p < .001$); CC participants had a higher C curve than NCC participants (*M* ± *SE*; CC = 25.49 ± .61 min*nmol/l, NCC = 23.82 ± .84 min*nmol/l).

However, no significant effects of Condition or Sex or the Condition × Sex interaction were found for C reactivity (all $p > .05$).

3.5.2. Testosterone

The T AUCg showed significant variance in the intercepts across teams (SD = 23.86, CI 95% [18.70, 30.45], χ^2 (1) = 48.70, p < .001). Adding BMI (X^2 (1) = 12.05, p < .001) and the fixed effects of Sex (χ^2 (1) = 39.49, p < .001) significantly improved the fit of the model; however, the next three models with random slopes of Sex, Condition, and the Sex × Condition interaction did not improve the model fit (all p > .05). Only Sex showed significant effects on T AUCg (b = − 37.85, SE = 4.95, CI 95% [− 47.70, − 28.00], t(48) = − 7.64, p < .001), with a higher curve for men than for women ($M \pm SE$; Men = 220.34 ± 3.66 min*pg/ml , Women = 182.49 ± 3.15 min*pg/ml).

Finally, ANCOVA showed a significant effect of the Condition × Sex interaction on T reactivity ($F_{1,\,127}$ = 7.19, p < .008, η^2_p = .05, *power* = .76). *Post-hoc* analyses showed that CC women had lower T reactivity than CC men ($F_{1,\,127}$ = 5.67, p < .019, η^2_p = .04, *power* = .66) and NCC women ($F_{1,\,127}$ = 8.79, p < .004, η^2_p = .07, *power* = .84 (Table 1)).

Insert here Table 3

3.6. Relationships between Conflict perception and psychophysiological responses:

For men, there were no significant correlations between Conflict perception and the psychophysiological responses to conflict (all p > .05). However, in women, Task conflict was positively related to negative mood and HR reactivity and, in turn, negatively related to RMMSD of IBI reactivity and T reactivity. Furthermore, Relation conflict was positively associated with positive and negative mood reactivity. All the correlations are presented in Table 4.

Insert Table 4 here

4. Discussion

The current study investigated the psychophysiological responses to an intergroup conflict in young people, and possible sex differences in these responses. First, intergroup conflict induced conflict perception, increases in negative mood, decreases in RMSSD of IBI, and, as a trend, increases in HR. In addition, sex differences were observed in the T response, with lower T levels after the conflict in women than in men. In addition, women perceived higher relation conflict than men. Task and relation conflict were related to mood and physiological responses only in women.

Increases in negative mood in response to conflict are consistent with previous research (Matsumoto et al., 2012, 2014; Newheiser & Dovidio, 2015). Moreover, there was also a less pronounced decrease in positive mood compared to the non-conflict condition, and these changes in positive mood were driven by the items related to vigilance/arousal[1]. In addition, in line with the increases in negative mood and arousal, conflict increased HR and reduced RMSSD of IBI. This response is consistent with a parasympathetic withdrawal during the conflict. Additionally, high HR increases have been associated with task engagement (Seery, 2013; Seery, Weisbuch, & Blascovich, 2009). Therefore, conflict seems to activate the CV system in order to mobilize energy to cope with the situation (Obrist, 1981; Seery, 2013). Furthermore, based on the lack of differences in the respiratory index, CV responses do not seem to be affected by breathing or other demands of participating in a conflictive/negotiation conversation (Brondolo et al., 2003; Denver, Reed, & Porges, 2007). These results show that intergroup conflict would induce a similar CV activation pattern to that of interpersonal conflict (Suchday & Larkin, 2001; Waldstein, Neumann, Burns, & Maier, 1998) or group conflict with members in natural groups (e.g., different ethnic groups; Mendes et al., 2002), although with less magnitude (as the effect sizes seem to indicate).

Regarding endocrine response, on the one hand, although C AUCg was higher in the conflict condition than in the control group, this difference could be due, at least in part, to the higher baseline C levels in the conflict group. Therefore, based on our results, we cannot support HPA axis activation in response to conflict, as found previously (Coutinho et al., 2017; Laurent et al., 2013). On the other hand, we hypothesized T increases after conflict in order to promote hostile behavior toward the outgroup (Reimers et al., 2017; Reimers & Diekhof, 2015), especially in men. However, our results did not confirm this hypothesis. Recently, increases in C and decreases in T have been described in red-tail monkeys after conflict with an outgroup (Jaeggi, Trumble, & Brown, 2018). An interpretation of this different response is related to the adaptive meaning of these hormones. Thus, whereas C responses reflect physiological activation (along with the cardiovascular system), T decreases could reduce the probability of aggression toward the outgroup.

The intergroup conflict analyzed in our study was sufficient to produce significant differences in the conflict perception. The manipulation was also able to induce a weak CV and emotional response in all the participants. Indeed, our conflict manipulation showed a sex-specific relationship between conflict perceptions and physiological indices of a stress response. However, we cannot confirm that it is a social stressor. In this regard, it would be important to analyze the stress perception to find out the individual interpretation of the situation[2] and the degree of identification within the in-group. There are two possible explanations for this result. First, it is possible that intergroup conflict is not as stressful as other social stressors (interpersonal conflict or competition). Accordingly, it is possible that participants interpreted the situation as a conflict (increasing levels of conflict perception and negative mood that could slightly influence the CV system) based on the task instructions, but it was not threatening enough to induce hormonal changes. Alternatively, intergroup conflict could reduce the individual stress responses due to shared responsibility for the final result and the social support provided by the in-group. In this regard, it has been stated that the use of interpersonal tactics in a group influences team psychological safety, that is, the belief that belonging to a team is safe for interpersonal risk taking (Gelfand, Leslie, Keller, & de Dreu, 2012). In other words, being in a group could reduce the sense of risk during intergroup conflict and, therefore, feelings of stress. In line with this interpretation, HLM models provide interesting results related to these responses. Our results show that belonging to a group influences conflict perception and CV measures, but not T and C measures. Thus, human and animal research suggests that two or more individuals can mimic each other's behavior, affect, and actions (Cheng & Chartrand, 2003). This suggestion agrees with theories about affect contagion (Hatfield, Cacioppo, & Rapson, 1994), and physiological synchronization is based on this research. Recently, HRV synchronization between individuals that would improve coherence, communication, kindness, and cooperation among in-group individuals has been discussed (McCraty, 2017). However, because our study does not employ group identification measures, we cannot claim that the groups were cohesive. Future studies should investigate the relationship between group cohesion and the response to conflict.

Sex differences were found in the endocrine response. Men had higher C levels than women, as reported in other social situations (Pulopulos, Hidalgo, Puig-Pérez, & Salvador, 2018). However, CC men also showed high basal C levels, which may affect the remaining C samples. Regarding T responses, CC women showed a significant T decrease just after the conflict, compared to NCC men and women. Previously, Kivlighan et al. (2005) also reported sex differences during an intergroup competition, with T decreases in women. They interpreted this result as an effect of the social interaction among the participants during group creation because, in their study, before starting the competition, participants warmed-up with their teammates. Similarly, our participants had to prepare a strategy with their teammates. Based on this idea, we could interpret T decreases in women as a positive effect of social interaction. Thus, if we interpret that women express *"tend and befriend"* coping strategies (unlike *"fight and flight"* strategies in men) to face stress situations more than men do (Taylor et al., 2000), women's T response might tend to decrease in order to increase bonding (in the in-group) and trust behavior and avoid direct or indirect aggression from the out-group. In this regard, women may perceive the situation as threatening, but develop a *"tend and befriend"* strategy in the in-group *vs.* a possible *"fight and flight"* response from men (Taylor et al., 2000). However, it would be necessary to verify this interpretation with observational data (ethological analysis) and additional hormone measurements (i.e. oxytocin, estrogen, or arginine vasopressin (Taylor et al., 2000; Van Anders, Goldey, & Kuo, 2011).

Finally, correlation analyses showed that the perception of conflict was associated with psychophysiological responses only in women. As the current results suggest, in women, the emotional and physiological response to conflict is coherent with the perception of the situation (i.e. higher conflict perception implies higher negative and positive mood and HR). Moreover, correlations confirm the T response results, showing that a lower T response is related to higher task conflict. Thus, we interpret that, in women, higher levels of conflict perception induce a physiological and emotional response that is coherent with a threatening situation. Furthermore higher levels of conflict perception could contribute to decreasing the levels of T in women, in order to induce the *"tend and befriend"* behavioral strategy (Taylor et al., 2000). In the case of men, conflict perception (although higher in the conflict group than in the control group) was not related to the psychophysiological responses.

Overall, the present results show that intergroup conflict can induce mood changes and CV activation, regardless of the sex of the participants, partially supporting previous studies involving interpersonal conflict or competition. Moreover, results show sex differences in the T response to intergroup conflict. According to the biosocial construction model proposed by Wood and Eagly (2012), during social situations such as negotiation or conflict, the social construction of gender roles influences hormonal and social regulation to adapt to the context, inducing sex-differentiated affect, cognition, and behaviors. Furthermore, according to Role Congruity Theory (Eagly and Karau, 2002), sex differences could be explained by the fact that women engage in prosocial behavior during social interactions, whereas men's behavior is considered agentic. Thus, incongruent interactions are interpreted as threatening. Accordingly, when conflict situations are more incongruent with their role, women experience higher aversion and try to avoid them (Bear, 2011), showing more distress (Kudielka et al., 2004), irritability, and fear, and less happiness than men (Kelly et al., 2008). In any case, future studies should verify these results in order to clarify how men and women cope with intergroup conflictive situations and their consequences.

Several limitations should be noted in interpreting the present findings. First, intergroup conflict (a conflict between two companies) exposes participants to an uncommon conflictive situation in young people with limited generalization to other types of conflicts. This situation could be the reason for the absence of a stronger endocrine stress response. Accordingly, employing subjective ratings of stress or behavioral analyses of conflict would benefit the interpretation of the results. Moreover, basal C levels were different between conditions. In this regard, participating in an experimental session itself could be considered a stressor. However, although there are differences in basal C between conditions, participants in the two groups did not receive different instructions before their arrival. Another limitation is that we did not control experience with conflict, which could help participants to cope with the situation and, consequently, reduce psychophysiological responses. In contrast to these weak points, the current study provides a study design that is novel in social neuroscience, using intergroup conflict with rigorous control of both the design and participant selection and adding elements that help to understand conflict situations, including the creation of groups (Macrae & Bodenhausen, 2000).

In conclusion, intergroup conflict elicits mood and CV responses, showing some differences between men and women. Specifically in women, higher conflict perception was associated with higher mood and CV and lower T responses. Taking into account the psychobiological consequences of conflict, there is a need for more in-depth studies on the complexity of intergroup conflict.

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Footnotes

Footnote 1: The smaller decrease in positive mood in the CC compared to the NCC would be due to some PANAS items related to vigilance rather than true positive affect. Regarding this possible explanation, we checked items 12 (alert) or 19 (active) from the PANAS and performed two-way ANOVAs with the reactivity indexes for these items. We found a main effect of Condition for item 12 ($F_{1, 132} = 7.54$, $p < .007$, $\eta^2_p = .05$, *power* = .78), with CC participants showing higher scores on this item than NCC participants (M ± SE; CC = − .34 ± .13, NCC = − .88 ± .18); item 19 did not show significant results ($p > .05$).

Footnote 2: Regarding the lack of a psychometric measure testing psychological distress, we checked items 15 (nervous) or 18 (restless) from the PANAS and performed two-way ANOVAs with the reactivity indexes for these items. We found a main effect of Condition for item 15 ($F_{1, 132} = 8.97$, $p < .003$, $\eta^2_p = .06$, *power* = .85), with CC participants showing higher scores on this item than NCC participants (M ± SE; CC = − .49 ± .12, NCC = − 1.12

± .17); item 18 did not show significant results (*p* > .05). Thus, it seems that this task is able to induce psychological distress; however, it is necessary to test this in future research with direct measures of distress.

Figure legends

Figure 1: Summary of the study protocol. * Periods where the CC and NCC groups were different: In Pre-interaction, groups received different instructions (CC: Prepare strategy to enter into conflict with the other team / NCC: Prepare a summary to explain the case to the other team); in interaction, the CC group entered into conflict, and the NCC summarized the cases.

Figure 2: Mean ± Standard error of baseline and post-interaction mood scale score raw data for the conflict condition (solid line) and the non-conflict condition (dotted line).

Figure 3: Mean ± Standard error of baseline (BL), pre-interaction (Pre), interaction (Int), and post-interaction (Post) HFhz., Heart rate and RMSSD of IBI **raw data for the conflict condition (solid line) and non-conflict condition (dotted line).**

Figure 4: Mean ± Standard error of baseline (BL), Pre-interaction (Pre), Post-interaction 0´ (0), Post-interaction 30´ (30) and Post-interaction 45´ (45) Cortisol and Testosterone raw data for men (black) and women (grey) in the conflict condition (solid lines) and non-conflict condition (dotted lines).

References

Baumeister, R. F., & Leary, M. R. (1995). The Need to Belong: Desire for Interpersonal Attachments as a Fundamental Human Motivation. *Psychological Bulletin*, *117*(3), 497–529. http://doi.org/10.1037/0033-2909.117.3.497

Beffara, B., Bret, A. G., Vermeulen, N., & Mermillod, M. (2016). Resting high frequency heart rate variability selectively predicts cooperative behavior. *Physiology and Behavior*, *164*, 417–428. http://doi.org/10.1016/j.physbeh.2016.06.011

Blascovich, J., & Tomaka, J. (1996). The Biopsychosocial Model of Arousal Regulation. *Advances in Experimental Social Psychology*, *28*(C), 1–51. http://doi.org/10.1016/S0065-2601(08)60235-X

Bliese, P. D. (2000). Within-group agreement, non-independence, and reliability: Implications for data aggregation and analysis. *Multilevel Theory, Research, and Methods in Organizations: Foundations, Extensions, and New Directions*.

Böhm, R., Rusch, H., & Baron, J. (2018). The psychology of intergroup conflict: A review of theories and measures. *Journal of Economic Behavior and Organization*. http://doi.org/10.1016/j.jebo.2018.01.020

Brondolo, E., Rieppi, R., Erickson, S. A., Bagiella, E., Shapiro, P. A., McKinley, P., & Sloan, R. P. (2003). Hostility, Interpersonal Interactions, and Ambulatory Blood Pressure. *Psychosomatic Medicine*, *65*(6), 1003–1011. http://doi.org/10.1097/01.PSY.0000097329.53585.A1

Cheng, C. M., & Chartrand, T. L. (2003). Self-Monitoring Without Awareness: Using Mimicry as a Nonconscious Affiliation Strategy. *Journal of Personality and Social*

Psychology. http://doi.org/10.1037/0022-3514.85.6.1170

Coutinho, J., Oliveira-Silva, P., Mesquita, A. R., Barbosa, M., Perrone-McGovern, K. M., & Gonçalves, O. F. (2017). Psychophysiological Reactivity in Couples During a Marital Interaction Task. *Applied Psychophysiology Biofeedback*, *42*(4), 335–346. http://doi.org/10.1007/s10484-017-9380-2

Denver, J. W., Reed, S. F., & Porges, S. W. (2007). Methodological issues in the quantification of respiratory sinus arrhythmia. *Biological Psychology*, *74*(2), 286–294. http://doi.org/10.1016/j.biopsycho.2005.09.005

Eagly, A. H., & Karau, S. J. (2002). Role congruity theory of prejudice toward female leaders. *Psychological Review*, *109*(3), 573–598. http://doi.org/10.1037/0033-295X.109.3.573

Gelfand, M. J., Leslie, L. M., Keller, K., & de Dreu, C. (2012). Conflict cultures in organizations: How leaders shape conflict cultures and their organizational-level consequences. *Journal of Applied Psychology*. http://doi.org/10.1037/a0029993

Halperin, E., & Gross, J. J. (2011). Intergroup anger in intractable conflict: Long-term sentiments predict anger responses during the gaza war. *Group Processes and Intergroup Relations*, *14*(4), 477–488. http://doi.org/10.1177/1368430210377459

Hatfield, E., Cacioppo, J. T., & Rapson, R. L. (1994). *Emotional contagion*. *Emotional Contagion*.

Heck, R. H., & Thomas, S. L. (2000). *An introduction to multilevel modeling techniques*. *Personnel Psychology PersPsychol* (Vol. 77). http://doi.org/10.1177/0146621609344848

Henry, J. P., & Stephen, P. M. (1977). *Stress, Health, and the Social Environment*. New York: Springer-Verlag. http://doi.org/10.1007/978-1-4612-6363-0

Hewstone, M., Rubin, M., & Willis, H. (2002). Intergroup Bias. *Annual Review of Psychology*, *53*(1), 575–604. http://doi.org/10.1146/annurev.psych.53.100901.135109

Jaeggi, A., Trumble, B., & Brown, M. (2018). Group-level competition influences urinary steroid hormones among wild red-tailed monkeys, indicating energetic costs. *American Journal of Primatology*, *in press*. http://doi.org/10.1002/ajp.22757

Jehn, K. A., Greer, L., & Levine, S. (2008). The Effects of Conflict Types , Dimensions , and Emergent States on Group Outcomes, 465–495. http://doi.org/10.1007/s10726-008-9107-0

Kelly, M. M., Tyrka, A. R., Anderson, G. M., Price, L. H., & Carpenter, L. L. (2008). Sex differences in emotional and physiological responses to the Trier Social Stress Test. *Journal of Behavior Therapy and Experimental Psychiatry*, *39*(1), 87–98. http://doi.org/10.1016/j.jbtep.2007.02.003

Kivlighan, K. T., Granger, D. a, & Booth, A. (2005). Gender differences in testosterone and cortisol response to competition. *Psychoneuroendocrinology*, *30*(1), 58–71. http://doi.org/10.1016/j.psyneuen.2004.05.009

Koolhaas, J. M., & Bohus, B. (1989). Social control in relation to neuroendocrine and immunological responses. In *Stress, personal control and health.* (pp. 295–305).

Kudielka, B. M., Schommer, N. C., Hellhammer, D. H., & Kirschbaum, C. (2004). Acute HPA axis responses, heart rate, and mood changes to psychosocial stress (TSST) in humans at different times of day. *Psychoneuroendocrinology*, *29*(8), 983–92. http://doi.org/10.1016/j.psyneuen.2003.08.009

Laurent, H. K., Powers, S. I., Laws, H., Gunlicks-Stoessel, M., Bent, E., & Balaban, S. (2013). HPA regulation and dating couples' behaviors during conflict: Gender-specific associations and cross-partner interactions. *Physiology and Behavior*, *118*, 218–226. http://doi.org/10.1016/j.physbeh.2013.05.037

Levenson, R. W., & Ruef, A. M. (1992). Empathy: A physiological substrate. *Journal of Personality and Social Psychology*, *63*(2), 234–246. http://doi.org/10.1037/0022-3514.63.2.234

Macrae, C. N., & Bodenhausen, G. V. (2000). Social cognition: thinking categorically about others. *Annual Review of Psychology*, *51*, 93–120. http://doi.org/10.1146/annurev.psych.51.1.93

Makhanova, A., McNulty, J. K., Eckel, L. A., Nikonova, L., & Maner, J. K. (2018). Sex differences in testosterone reactivity during marital conflict. *Hormones and Behavior*. http://doi.org/10.1016/j.yhbeh.2018.07.007

Malik, M., Bigger, J., Camm, A., & Kleiger, R. (1996). Heart rate variability. Standards of measurement, physiological interpretation, and clinical use. Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology. *European Heart Journal*, *17*, 354–381. http://doi.org/0195-668X/96/030354 + 28 $18.00/0

Martínez-Tur, V., Peñarroja, V., Serrano, M. a, Hidalgo, V., Moliner, C., Salvador, A., … Molina, A. (2014). Intergroup conflict and rational decision making. *PloS One*, *9*(12), e114013. http://doi.org/10.1371/journal.pone.0114013

Matsumoto, D., Hwang, H. C., & Frank, M. G. (2012). Emotional Language and Political Aggression. *Journal of Language and Social Psychology*, *32*(4), 452–468. http://doi.org/10.1177/0261927X12474654

Matsumoto, D., Hwang, H. C., & Frank, M. G. (2014). Emotions expressed by leaders in videos predict political aggression. *Behavioral Sciences of Terrorism and Political Aggression*, *6*(3), 212–218. http://doi.org/10.1080/19434472.2013.769116

McCraty, R. (2017). New Frontiers in Heart Rate Variability and Social Coherence Research: Techniques, Technologies, and Implications for Improving Group Dynamics and Outcomes. *Frontiers in Public Health*, *5*. http://doi.org/10.3389/fpubh.2017.00267

Mendes, W. B., Blascovich, J., Lickel, B., & Hunter, S. (2002). Challenge and Threat During Social Interactions With White and Black Men. *Personality and Social Psychology Bulletin*, *28*(7), 939–952. http://doi.org/10.1177/01467202028007007

Newheiser, A. K., & Dovidio, J. F. (2015). High outgroup entitativity can inhibit intergroup retribution. *British Journal of Social Psychology*, *54*(2), 341–358. http://doi.org/10.1111/bjso.12078

Obrist, P. A. (1981). *Cardiovascular psychophysiology: A perspective*. *Psychological Medicine* (Vol. 12). http://doi.org/10.1017/S0033291700043671

Oxford, J., Ponzi, D., & Geary, D. C. (2010). Hormonal responses differ when playing violent video games against an ingroup and outgroup. *Evolution and Human Behavior*, *31*(3), 201–209. http://doi.org/10.1016/j.evolhumbehav.2009.07.002

Page-Gould, E., Mendes, W. B., & Major, B. (2010). Intergroup contact facilitates physiological recovery following stressful intergroup interactions. *Journal of*

Experimental Social Psychology, *46*(5), 854–858. http://doi.org/10.1016/j.jesp.2010.04.006

Pemberton, M. B., Insko, C. a, & Schopler, J. (1996). Memory for and experience of differential competitive behavior of individuals and groups. *Journal of Personality and Social Psychology*, *71*(5), 953–966. http://doi.org/10.1037/0022-3514.71.5.953

Pruessner, J. C., Kirschbaum, C., Meinlschmid, G., & Hellhammer, D. H. (2003). Two formulas for computation of the area under the curve represent measures of total hormone concentration versus time-dependent change. *Psychoneuroendocrinology*, *28*(7), 916–931. http://doi.org/10.1016/S0306-4530(02)00108-7

Pulopulos, M. M., Hidalgo, V., Puig-Pérez, S., & Salvador, A. (2018). Psychophysiological response to social stressors: Relevance of sex and age. *Psicothema*. http://doi.org/10.7334/psicothema2017.200

Raudenbush, S. W., & Bryk, A. S. (2002). *Hierarchical Linear Models: Applications and Data Analysis Methods*. *Advanced quantitative techniques in the social sciences 1* (Vol. 2nd).

Reimers, L., Büchel, C., & Diekhof, E. K. (2017). Neural substrates of male parochial altruism are modulated by testosterone and behavioral strategy. *NeuroImage*, *156*, 265–276. http://doi.org/10.1016/j.neuroimage.2017.05.033

Reimers, L., & Diekhof, E. K. (2015). Testosterone is associated with cooperation during intergroup competition by enhancing parochial altruism. *Frontiers in Neuroscience*, *9*(MAY). http://doi.org/10.3389/fnins.2015.00183

Ricarte, J., Salvador, a, Costa, R., Torres, M. J., & Subirats, M. (2001). Heart Rate and Blood Pressure Responses to a Competitive Role-Playing Game. *Aggressive Behavior*, *27*(June 1998), 351–359. http://doi.org/10.1002/ab.1020

Roelofs, K., van Peer, J., Berretty, E., Jong, P. de, Spinhoven, P., & Elzinga, B. M. (2009). Hypothalamus-Pituitary-Adrenal Axis Hyperresponsiveness Is Associated with Increased Social Avoidance Behavior in Social Phobia. *Biological Psychiatry*, *65*, 336–343. http://doi.org/10.1016/j.biopsych.2008.08.022

Salvador, A. (2012). Steroid hormones and some evolutionary-relevant social interactions. *Motivation and Emotion*, *36*, 74–83. http://doi.org/10.1007/s11031-011-9265-2

Sampasivam, S., Collins, K. A., Bielajew, C., & Clément, R. (2016). The effects of outgroup threat and opportunity to derogate on salivary cortisol levels. *International Journal of Environmental Research and Public Health*, *13*(6), 1–13. http://doi.org/10.3390/ijerph13060616

Sand??n, B., Chorot, P., Lostao, L., Joiner, T. E., Santed, M. A., & Valiente, R. M. (1999). Escalas PANAS de afecto positivo y negativo: Validacion factorial y convergencia transcultural. *Psicothema*, *11*(1), 37–51. http://doi.org/ISSN 0214-9915

Sawyer, P. J., Major, B., Casad, B. J., Townsend, S. S. M., & Mendes, W. B. (2012). Discrimination and the stress response: Psychological and physiological consequences of anticipating prejudice in interethnic interactions. *American Journal of Public Health*, *102*(5), 1020–1026. http://doi.org/10.2105/AJPH.2011.300620

Seery, M. D. (2013). The Biopsychosocial Model of Challenge and Threat: Using the Heart to Measure the Mind. *Social and Personality Psychology Compass*, *7*(9), 637–653. http://doi.org/10.1111/spc3.12052

Seery, M. D., Weisbuch, M., & Blascovich, J. (2009). Something to gain, something to lose: The cardiovascular consequences of outcome framing. *International Journal of Psychophysiology*, *73*(3), 308–312. http://doi.org/10.1016/j.ijpsycho.2009.05.006

Snijders, T. A. B., & Bosker, R. J. (1999). *Multilevel analysis: An introduction to basic and advanced multilevel modeling*. *Comparative and General Pharmacology*.

Strahler, J., Skoluda, N., Kappert, M. B., & Nater, U. M. (2017). Simultaneous measurement of salivary cortisol and alpha-amylase: Application and recommendations. *Neuroscience and Biobehavioral Reviews*. http://doi.org/10.1016/j.neubiorev.2017.08.015

Stroud, L. R., Salovey, P., & Epel, E. S. (2002). Sex differences in stress responses: social rejection versus achievement stress. *Biological Psychiatry*, *52*(4), 318–327. http://doi.org/10.1016/S0006-3223(02)01333-1

Suchday, S., & Larkin, K. T. (2001). Biobehavioral responses to interpersonal conflict during anger expression among anger-in and anger-out men. *Annals of Behavioral Medicine : A Publication of the Society of Behavioral Medicine*, *23*(4), 282–90. http://doi.org/10.1207/S15324796ABM2304_7

Tajfel, H., & Turner, J. (1979). An integrative theory of intergroup conflict. In *The Social Psychology of Intergroup Relations* (pp. 33–47). http://doi.org/10.1016/S0065-2601(05)37005-5

Taylor, S. E., Klein, L. C., Lewis, B. P., Gruenewald, T. L., Gurung, R. a. R., & Updegraff, J. a. (2000). Biobehavioral responses to stress in females: Tend-and-befriend, not fight-or-flight. *Psychological Review*, *107*(3), 411–429. http://doi.org/10.1037//0033-295X.107.3.411

Terburg, D., Morgan, B., & van Honk, J. (2009). The testosterone-cortisol ratio: A hormonal marker for proneness to social aggression. *International Journal of Law and Psychiatry*, *32*, 216–223. http://doi.org/10.1016/j.ijlp.2009.04.008

Townsend, S. S. M., Major, B., Gangi, C. E., & Mendes, W. B. (2011). From “in the air” to “under the skin”: cortisol responses to social identity threat. *Personality & Social Psychology Bulletin*, *37*(2), 151–64. http://doi.org/10.1177/0146167210392384

Trawalter, S., Adam, E. K., Chase-Lansdale, P. L., & Richeson, J. A. (2012). Concerns about appearing prejudiced get under the skin: Stress responses to interracial contact in the moment and across time. *Journal of Experimental Social Psychology*, *48*(3), 682–693. http://doi.org/10.1016/j.jesp.2011.12.003

Van Anders, S. M., Goldey, K. L., & Kuo, P. X. (2011). The Steroid/Peptide Theory of Social Bonds: Integrating testosterone and peptide responses for classifying social behavioral contexts. *Psychoneuroendocrinology*. http://doi.org/10.1016/j.psyneuen.2011.06.001

Vannucci, A., Ohannessian, C. M. C., Flannery, K. M., De Los Reyes, A., & Liu, S. (2018). Associations between friend conflict and affective states in the daily lives of adolescents. *Journal of Adolescence*. http://doi.org/10.1016/j.adolescence.2018.03.014

Waldstein, S. R., Neumann, S. A., Burns, H. O., & Maier, K. J. (1998). *Role-played interpersonal interaction: ecological validity and cardiovascular reactivity. Annals* *of behavioral medicine : a publication of the Society of Behavioral Medicine* (Vol. 20).

Watson, D., Clark, L. a, & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: the PANAS scales. *Journal of Personality and Social Psychology*, *54*(6), 1063–70. http://doi.org/10.1037/0022-3514.54.6.1063

Wildschut, T., Pinter, B., Vevea, J. L., Insko, C. A., & Schopler, J. (2003). Beyond the Group Mind: A Quantitative Review of the Interindividual-Intergroup Discontinuity Effect. *Psychological Bulletin*. http://doi.org/10.1037/0033-2909.129.5.698

Yi, S. H., Lee, K., Shin, D. G., Kim, J. S., & Kim, H. C. (2013). Differential association of adiposity measures with heart rate variability measures in Koreans. *Yonsei Medical Journal*, *54*(1), 55–61. http://doi.org/10.3349/ymj.2013.54.1.55

Table 1: M ± SE of sociodemographic variables, conflict, mood, cardiovascular, and hormonal variables In both conditions in men and women.

	Men	Women	Men	Women
Sociodemographic				
Age	21.59 ± .39	21.00 ± .32	20.67 ± .57	21.26 ± .35
BMI^{S}	23.68 ± .42	21.48 ± .37	24.77 ± .83	21.44 ± .59
SES	6.05 ± .20	6.11 ± .15	6.48 ± .24	6.22 ± .19
Conflict				
Task Conflict$^{\sharp}$	.71 ± .03	.76 ± .02	.51 ± .04	.48 ± .031
Relation Conflict$^{*\,\sharp}$	3.82 ± .30	5.31 ± .23	3.06 ± .39	2.86 ± .35
PANAS				
Positive mood baseline	28.47 ± .82	28.00 ± .68	29.71 ± 1.10	27.31 ± .99
Conflict reactivity positive mood$^{\sharp}$	- 2.16 ± .78	- 1.91 ± .64	- 4.05 ± 1.03	- 4.69 ± .93
Negative mood baseline	22.53 ± .79	21.93 ± .66	23.86 ± 1.07	21.12 ± .96
Conflict reactivity negative mood$^{\sharp}$	- .27 ± .74	- .66 ± .60	- 2.43 ± .98	- 2.19 ± .88
Cardiovascular				
Heart rate baseline$^{c\,S}$	78.57 ± 2.35	82.25 ± 1.87	73.95 ± 2.84	79.93 ± 2.04
Mean Heart rate$^{c\,\sharp}$	78.82 ± 2.63	82.29 ± 2.09	71.33 ± 3.30	77.90 ± 2.48
Heart rate Conflict reactivity $^{c\,\sharp}$	2.56 ± 2.49	5.78 ± 1.98	- 1.08 ± 3.01	- 1.74 ± 2.16
RMSSD of IBI baseline^{c}	40.78 ± 4.19	38.69 ± 3.34	45.04 ± 5.07	36.44 ± 3.64
Mean RMSSD of IBI^{c}	42.89 ± 3.75	41.66 ± 2.99	49.72 ± 4.52	40.56 ± 3.31
RMSSD of IBI Conflict reactivity $^{c\,\sharp}$	1.80 ± 4.20	.43 ± 2.13	7.37 ± 5.31	6.06 ± 2.39
HFhz baseline^{c}	.22 ± .02	.24 ± .01	.23 ± .02	.24 ± .01
Mean HFhz^{c}	.20 ± .01	.23 ± .01	.23 ± .01	.23 ± .01
Conflict reactivity HFhz^{c}	- .06 ± .03	- .07 ± .03	- .03 ± .04	- .01 ± .03
Hormones				
Cortisol baseline$^{c\,\sharp\,S}$	1.08 ± .026	1.04 ± .02	.97 ± .034	.88 ± .03
Cortisol AUCg $^{c\,\sharp\,S}$	27.11 ± .93	23.89 ± .77	25.52 ± 1.25	22.12 ± 1.12
Cortisol Conflict reactivity ^{c}	- .14 ± .03	- .19 ± .02	- .21 ± .04	- .15 ± .03
Testosterone baseline$^{c\,S}$	1.96 ± .03	1.62 ± .03	1.98 ± .05	1.63 ± .040
Testosterone AUCg $^{c\,S}$	221.12 ± 3.69	180.74 ± 3.15	219.36 ± 4.94	185.75 ± 4.34
Testosterone Conflict reactivity $^{c\,*}$	- .05 ± .02	- .12 ± .02	- .08 ± .03	- .03 ± .02

Note: CC = Conflict condition, NCC = Not-conflict condition, BMI = Body mass index, SES = Socioeconomic status, RMSSD of IBI = Root mean square successive difference of inter-beat interval, HFhz = High frequency hertz, AUCg = Area under the curve with respect to ground

^{c} Covaried with BMI (22.66) Mean. * $p < 0.05$ for Conflict × Sex $^{\sharp}$ $p < 0.05$ for Conflict ^{S} $p < 0.05$ for Sex

Table 2: Intraclass correlation with team as a cluster variable for all the variables analyzed using hierarchical linear models (HLM) and the differences in – 2loglikelihood between the null model (model I) and the model with Team as cluster (model II).

	ICC	χ^2	*p*
Task conflict	*r* = .55	40.62	.001
Relation conflict	*r* = .51	33.41	.001
Positive mood conflict reactivity	*r* = .08	0.51	.471
Negative mood conflict reactivity	*r* = .14	2.59	.107
Mean Heart rate	*r* = .18	9.73	.002
Heart rate conflict reactivity	*r* = .55	17.09	.001
Mean RMSSD of IBI	*r* = .14	0.97	.323
RMSSD of IBI conflict reactivity	*r* = .47	13.41	.001
Mean HFhz	*r* = .19	0.37	.545
HFhz Conflict reactivity	*r* = .16	0.79	.373
Cortisol AUCg	*r* = .24	14.54	.001
Cortisol conflict reactivity	*r* = .08	0.24	.623
Testosterone AUCg	*r* = .41	48.70	.001
Testosterone conflict reactivity	*r* = .02	0.001	.978

Note: ICC = Intraclass correlation, AUCg = Area under the curve with respect to ground, RMSSD = Root mean square successive difference, HFhz = High frequency hertz

Table 3: Results of multilevel analyses of the main effects, cross level interactions, and random effects in the model with the best fit for each variable:

	Task conflict^{lg}	Relation conflict	Mean HR	HR CR	RMSSD CR
Intercept (γ_{00})	0.73 (0.03)***	3.82 (0.30)***	81.77 (8.15)***	− 3.59 (8.07)	5.03 (10.18)
Main predictors					
Ind-level: BMI (γ_{10})^{c}	–	–	− .16 (.33)	0.28 (0.32)	− 0.14 (0.39)
Ind-level: Sex (γ_{20})^{a}	0.02 (0.04)	1.48 (0.38)***	4.72 (2.68)	2.49 (2.85)	− 1.34 (3.75)
Gr-Level: Condition (γ_{03})^{b}	− 0.24 (0.04)***	− 0.76 (0.49)	− 5.56 (2.54)*	− 5.48 (2.81)^{t}	5.62 (2.85)*
Cross-level interactions					
Sex × Condition (γ_{23})	–	− 1.69 (0.65)**	–	–	–
Random effects					
Team (σ_{00})	0.10	0.76	6.32	6.50	11.77
Sex Slope (τ_{10})	0.12	1.00	8.20	10.08	12.49
Intercept-slope cov. (τ_{01})	− .78	− .69	− .67	− .53	− .95
Residual	0.13	1.27	7.81	7.27	10.18

	Cortisol AUCg^{lg}	Testosterone AUCg^{lg}
Intercept (γ_{00})	134.80 (9.27)***	190.31 (14.84)***
Main predictors		
Ind-level: BMI (γ_{10})^{c}	− 1.03 (0.38)**	1.32 (0.59)*
Ind-level: Sex (γ_{20})^{a}	− 8.61 (2.87)**	− 37.83 (4.95)***
Gr-Level: Condition (γ_{03})^{b}	− 15.25 (2.83)***	–
Cross-level interactions		
Sex × Condition (γ_{23})	–	–
Random effects		
Team (σ_{00})	4.48	11.95
Sex Slope (τ_{10})	8.38	–
Intercept-slope cov. (τ_{01})	− .51	–
Residual	11.79	–

Notes: *** $p < .001$, ** $p < 0.01$, * $p < 0.05$, ^{t} $p < 0.07$, ^{lg} log-transformed dependent variables; ^{c} Covariate, ^{a} Women = 0, ^{b} Control = 0; GR = Group Reactivity, AUCg = Area under the curve with respect to the ground, HR = Heart rate, CR = Conflict Reactivity, RMSSD = Root mean squared successive difference, BMI = Body mass index, cov. = Covariance

Table 4: Pearson correlations between the conflict perception scales and the reactivity indexes segmented by sex (Men/Women):

	Men		Women	
	Task Conflict	Relation Conflict	Task Conflict	Relation Conflict
+ mood CR	r = .14	r = − .01	r = .13	**r = .23***
− mood CR	r = .15	r = .11	**r = .23***	**r = .34****
HR CR	r = − .05	r = − .16	**r = .35****	r = .05
RMSSD of IBI CR	r = .06	r = .16	**r = − .27***	r = .04
Cortisol CR	r = .13	r = .12	r = − .06	r = − .13
Testosterone CR	r = .13	r = .14	**r = − .28***	r = − .17

Note: ** $p < 0.01$, * $p < 0.05$, + mood = Positive mood, − mood = Negative mood, CR = Conflict reactivity, HR = Heart rate, RMSSD = Root mean square successive difference of inter beat interval

Figure 1:

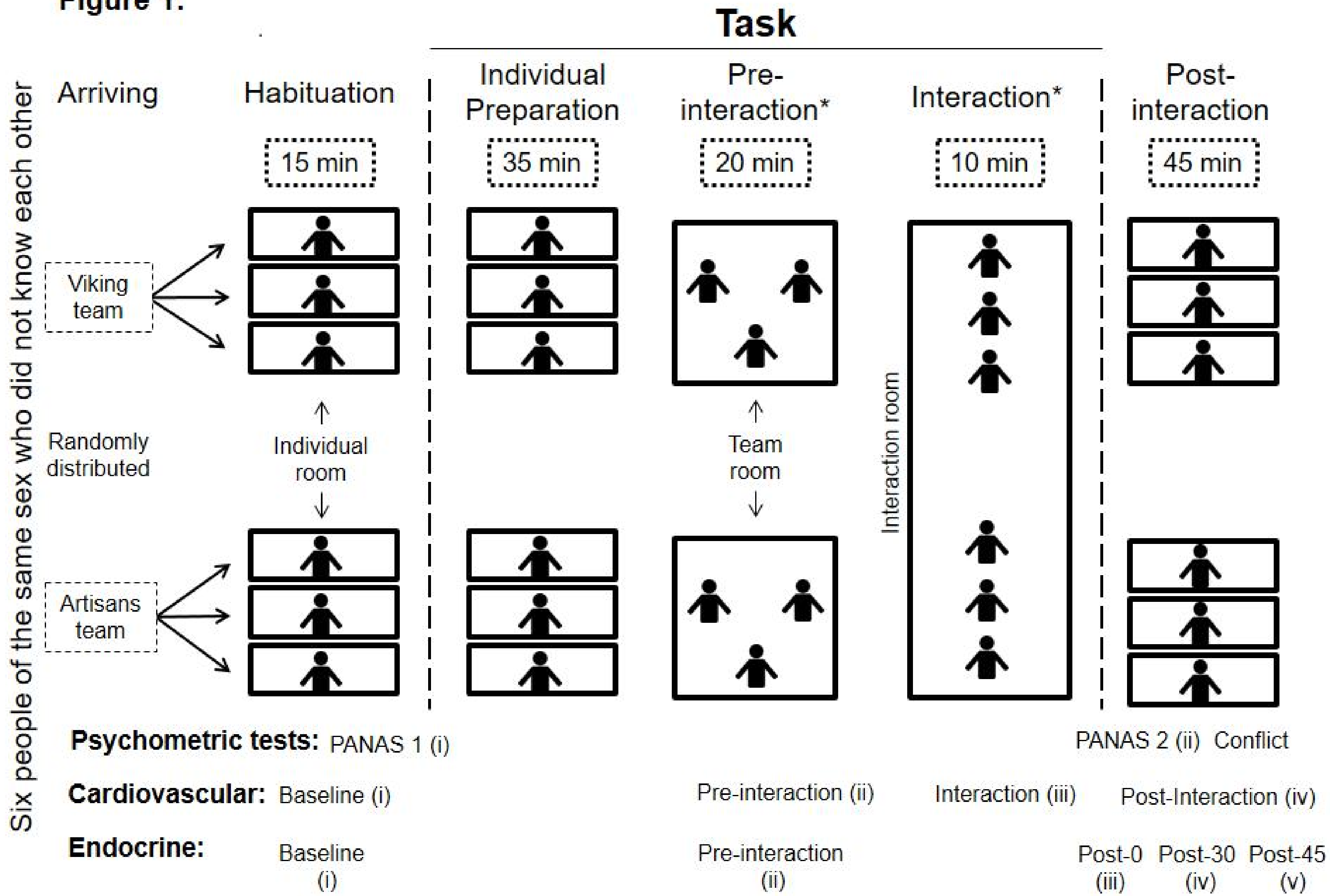

Task
Arriving
Habituation
Individual Preparation
Pre-interaction*
Interaction*
Post-interaction
15 min
35 min
20 min
10 min
45 min
Six people of the same sex who did not know each other
Viking team
Randomly distributed
Artisans team
Individual room
Team room
Interaction room
Psychometric tests: PANAS 1 (i)
PANAS 2 (ii) Conflict
Cardiovascular: Baseline (i)
Pre-interaction (ii)
Interaction (iii)
Post-Interaction (iv)
Endocrine:
Baseline (i)
Pre-interaction (ii)
Post-0 (iii)
Post-30 (iv)
Post-45 (v)

Figure 2

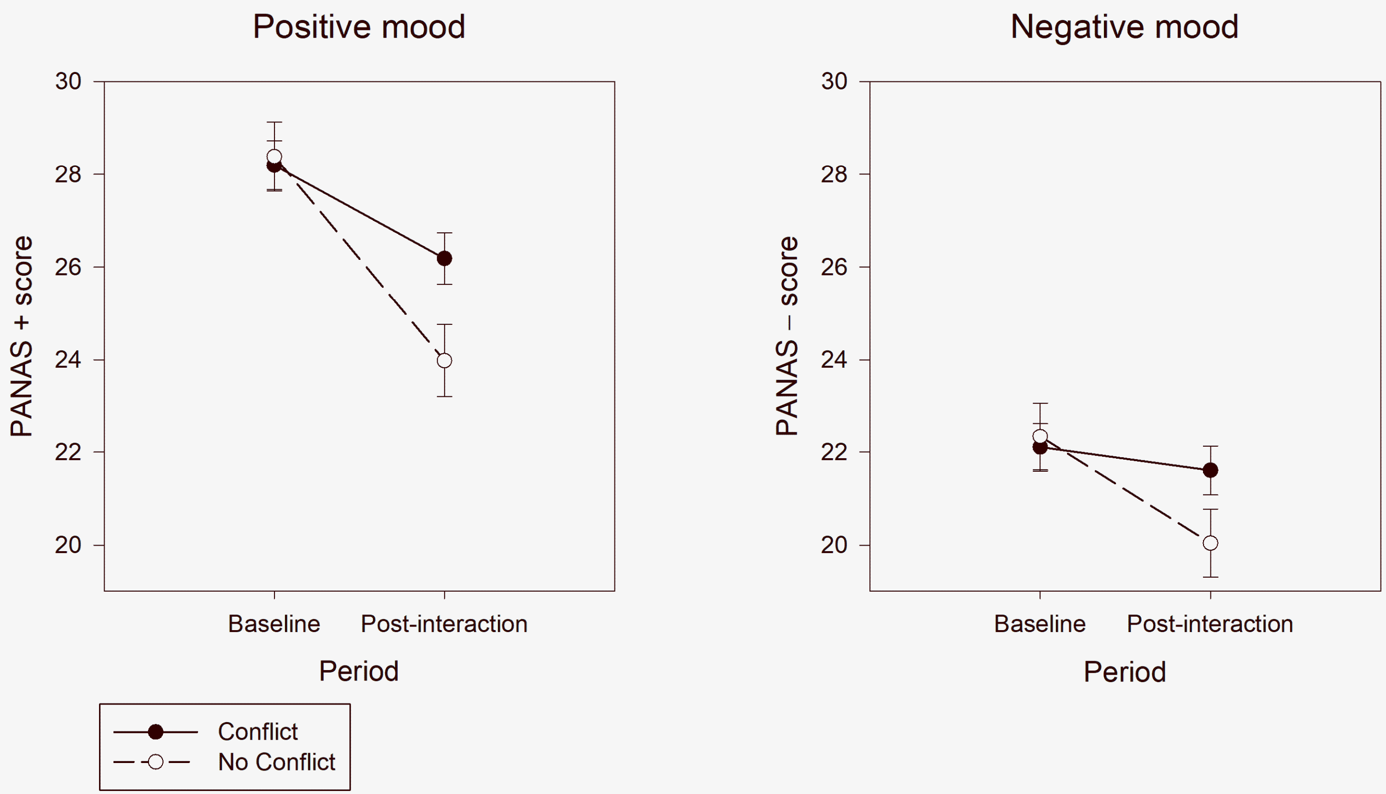

Positive mood
Negative mood
PANAS + score
PANAS – score
30
28
26
24
22
20
Baseline
Post-interaction
Period
Conflict
No Conflict

Figure 3

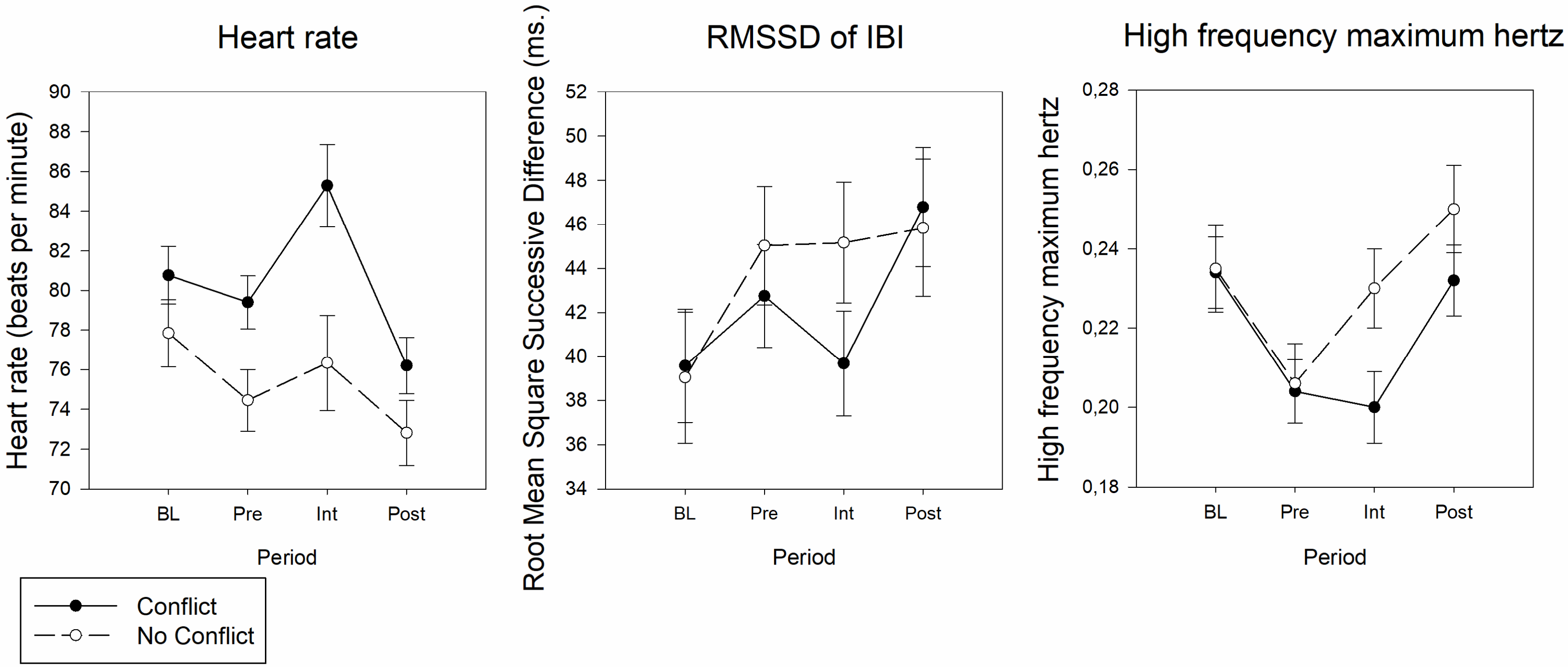
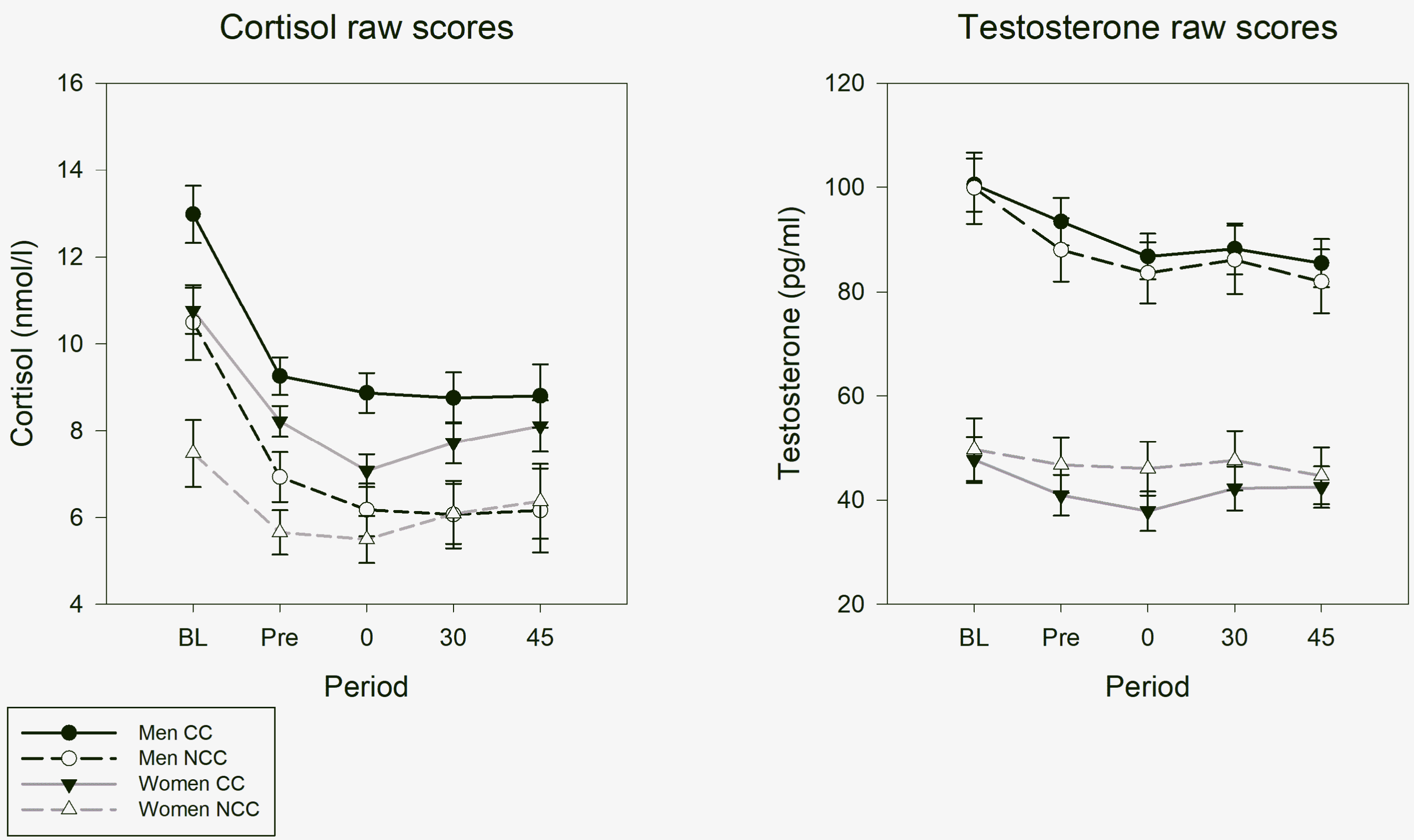

Heart rate
Heart rate (beats per minute)
90
88
86
84
82
80
78
76
74
72
70
BL
Pre
Int
Post
Period
RMSSD of IBI
Root Mean Square Successive Difference (ms.)
52
50
48
46
44
42
40
38
36
34
BL
Pre
Int
Post
Period
High frequency maximum hertz
High frequency maximum hertz
0,28
0,26
0,24
0,22
0,20
0,18
BL
Pre
Int
Post
Period
Conflict
No Conflict

Figure 4



Cortisol raw scores
16
14
12
10
8
6
4
Cortisol (nmol/l)
BL
Pre
0
30
45
Period
Testosterone raw scores
120
100
80
60
40
20
Testosterone (pg/ml)
BL
Pre
0
30
45
Period
Men CC
Men NCC
Women CC
Women NCC

1