Sex Differences in Emotional Concordance

Authors

Julina A. Rattel*[1], Iris B. Mauss[2], Michael Liedlgruber[1], Frank. H. Wilhelm[1]

[1] Clinical Stress and Emotion Laboratory, Division of Clinical Psychology, Psychotherapy and Health Psychology, Department of Psychology, University of Salzburg, Salzburg, Austria
[2] University of California, Berkeley, USA

*Correspondence
Julina A. Rattel, M.Sc.
University of Salzburg,
Department of Psychology,
Hellbrunner Straße 34,
5020 Salzburg, Austria

Email: julina.rattel@sbg.ac.at

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Abstract

Emotions involve response synchronization across experiential, physiological, and behavioral systems, referred to as concordance or coherence. Women are thought to be more emotionally aware and expressive than men and may therefore display stronger response concordance; however, research on this topic is scant. Using a random-order film-average design, we assessed concordance among experiential (arousal, valence), autonomic (electrodermal activity, heart rate, preejection-period, respiratory-sinus-arrhythmia), respiratory (respiratory-rate), and behavioral (corrugator and zygomatic electromyography) responses to 15 two-minute films varying in valence and arousal. We then calculated for each participant and pair of measures a within-subject correlation index using averages from the 15 films. Pronounced individual concordance of up to 0.9 was observed. Arousal-physiology and valence-behavior concordances were particularly pronounced. Women displayed higher concordance than men for almost all measures. Findings indicate stronger psychophysiological response coupling in women than men and provide novel insights into affective differences between the sexes.

Keywords: affective neuroscience; emotion; gender differences; psychophysiology

Sex differences in emotional concordance

Emotion theories commonly postulate that emotional activation involves synchronization of experiential (self-report), physiological, and behavioral response systems, a phenomenon commonly referred to as response concordance or coherence (e.g., Ekman, 1972; Lazarus, 1991; Levenson, 1994; Scherer, 1984). The typical fight-flight response, for instance, triggers the subjective experience of threat, facial expressions of fear, increased physical unrest (preparation for action), as well as a broad pattern of psychophysiological activation primarily controlled by sympathetic nervous system efferent activity. In this way, emotion is conceptualized as a dynamic interplay between different response systems that help people adapt to changes in environmental demands (e.g., Stemmler, 2004). Although a high degree of response concordance during emotional activation is commonly assumed in humans (e.g., Lazarus, 1991; Levenson, 1994), empirical findings widely differ (see Hollenstein & Lanteigne, 2014 for an overview), with past studies either reporting significant concordance (e.g., Ekman, Friesen, & Ancoli, 1980; Mauss, Levenson, McCarter, Wilhelm, & Gross, 2005) or little to no concordance (e.g., Lang, 1968; for review, see Mauss & Robinson, 2009).

According to Hollenstein and Lanteigne (2014), diverging findings could be resolved by addressing theoretical and methodological concerns, as well as by identifying possible moderators. To point out few examples, theoretical concerns could be addressed by studying concordance across instances of emotion and across different emotional states (Barrett, 2006) and not just one prescribed basic emotion (e.g., fear; Grossberg & Wilson, 1968; Van Egeren, Feather, & Hein, 1971). In terms of methodological concerns, although there is a recommendation that concordance should be assessed as within-subject covariation of measures across varying emotional states for each individual and then averaged across individuals (e.g., Butler, Gross, & Barnard, 2014; Brown et al., 2019; Mauss et al., 2005), it has mostly been assessed as a between-subject correlation. In terms of moderators, specific psychological traits have been shown to affect emotional concordance (e.g., Brown et al., 2019; Lanteigne, Flynn, Eastabrook, & Hollenstein, 2014; Mauss, Wilhelm, & Gross, 2004). In addition, biological sex, a particularly fundamental trait with clear implications for concordance, may well explain some of the diverging results. It has already been shown that women display higher concordance than men to specific negative emotional states (e.g., during an exam: Doornen, 1986; during a stress task: Avero & Calvo, 1999) and findings have been less clear for broader sets of emotional states elicited by pictures (Lang, Greenwald, Bradley, & Hamm, 1993). In sum, the empirical basis for appraising sex differences in emotional concordance is scant particularly on the background of large methodological diversity across studies. The present study was set out to study sex differences in emotional concordance across different emotional states, across a broad range of psychophysiological and behavioral measures, and using a novel film-based within-subject approach.

Concordance between Experiential and Physiological Responses

Strong (e.g., Friedman, Stephens, & Thayer, 2014) as well as weak (e.g., Mandler, Mandler, Kremen, & Sholiton, 1961) concordance has been reported between experiential and physiological responses. However, generally stronger concordance has been reported for the specific emotion fear (e.g., Grossberg & Wilson, 1968; Van Egeren et al., 1971), and differences in the strength of concordance across studies likely result from different types of emotion induction (e.g., stress task vs. pictures). Past studies either induced specific emotional states or a broad range of emotional states that vary along the affective space; affective space models organize response patterns along the general dimensions of valence (positive/negative) and arousal (less versus more; see Bradley & Lang, 2000a; Christie & Friedman, 2004). As past research showed that valence and arousal are two, somewhat related, but distinct measures of emotional experience (Mauss & Robinson, 2009 for a review), emotional concordance may differ when comparing valence- vs. arousal-related concordance. In addition, past studies often used different physiological measures, which could further explain differences in strength of concordance indices; the most commonly used physiological measures were electrodermal activity (EDA) and cardiovascular responses (primarily heart rate, HR).

Using pictures varying along the affective space, EDA has been more closely linked to arousal than valence (Greenwald, Cook, & Lang, 1989; Lang et al., 1993; see also Anders, Lotze, Erb, Grodd, & Birbaumer, 2004) and this relationship seems independent of stimulus valence (e.g., Bradley & Lang, 2000a; Lang et al., 1993), though, not invariantly (Kron, Pilkiw, Banaei, Goldstein, & Anderson, 2015). In addition, strong concordance between HR and valence compared to moderate concordance between HR and arousal has been reported (e.g., Bradley & Lang, 2000a; Greenwald et al., 1989; Lang et al., 1993). However, on the whole, results for cardiovascular responses are rather inconclusive (see Cacioppo, Berntson, Larsen, Poehlmann, & Ito, 2000 for a meta-analysis). In reaction to films, weak concordance between HR and valence has been reported, with arousal not being assessed (computing within-subject correlations; Sze, Gyurak, Yuan, & Levenson, 2010). In sum, EDA seems to vary more closely along self-reported arousal, whereas findings for HR are rather inconclusive and findings seem to depend on modality of emotion induction (picture vs. films). In any case, these findings highlight the importance to assess both self-reported valance and arousal when studying response concordance,

Concordance between Experiential and Behavioral Responses

Strong (e.g., Ekman, Davidson, & Friesen, 1990; Rosenberg & Ekman, 1994), low to moderate (e.g., Cacioppo, Martzke, Petty, & Tassinary, 1988; Lang et al. 1993), as well as weak concordance (e.g., Fernandez-Dols, Sanchez, Carera, & Ruiz-Belda, 1997) has been reported between experiential and behavioral responses. As pointed out above, differences between studies are likely due to differences in emotion induction and response measures used. The most commonly used behavioral response measure is facial muscular activity, assessed by electromyography (EMG) (see Mauss & Robinson, 2009 for a review). Corrugator muscle activity typically increases with increasing unpleasantness of a stimulus, across the whole spectrum of valence, whereas zygomatic muscle activity increases with increasing pleasantness for pleasant stimuli only (e.g., see Bradley & Lang, 2000a; Larsen, Norris, & Cacioppo, 2003, for reviews).

Using pictures varying along the affective space, Lang and colleagues (1993; see also Greenwald et al., 1989) reported strong concordance between corrugator EMG and increasing unpleasantness (bipolar valence scale) and no concordance with arousal; however, they also reported moderate concordance between zygomatic EMG and increasing pleasantness, as well as arousal. To our knowledge, no other studies have yet investigated this in reaction to pictures or films varying along the affective space. Thus, although generally higher concordance between facial (particularly corrugator) EMG and self-reported valence has been found compared to arousal, research on this is scarce.

Sex Differences in Response System Concordance

Although rarely investigated, emotional concordance is likely moderated by biological sex. This assumption is based on studies indicating that women are more “in touch” with their emotions (referring to the construct of emotional awareness, e.g., Ashmore & Del Boca 1979; Brody & Hall, 2008), more facially expressive (e.g., Dimberg & Lundquist, 1990; Lang, et al., 1993), and report their emotional experiences as more intense (e.g., Fischer, Rodriguez Mosquera, van Vianen, & Manstead, 2004; Grossman & Wood, 1993), compared to men. The importance of sex differences is increasingly recognized in research on brain function and anatomy (e.g. Cahill & Aswad, 2015). In terms of emotional concordance, previous studies either investigated average sex differences with regard to reactivity to discrete emotional states (e.g., happy, sad, fear; e.g. Kreibig, Wilhelm, Roth, Gross, 2007; Kring, & Gordon, 1998; Wilhelm et al., 2017), by categorizing and comparing positively and negatively valenced stimuli (pictures: e.g., Bradley, Codispoti, Cuthbert, & Lang, 2001; Bradley, Codispoti, Sabatinelli, & Lang, 2001; Bradley, Lang, & Cuthbert, 1993; sounds: Bradley & Lang, 2000b), by using a free recall task (Neumann & Waldstein, 2001), or during stress induction (Avero & Calvo, 1999; Poppelaars, Klackl, Pletzer, Wilhelm, & Jonas, 2019; Van Doornen, 1986). The recent study by Wilhelm et al. (2017) underlines that women and men may differ in their average sympathetic and parasympathetic response patterns to aversive films (indicating defense vs. orienting) and those physiological sex differences likely influence emotional concordance along the affective valence and arousal dimensions.[1] Some of these average sex difference studies also provide between-subject concordance estimates. Probably due to the different qualities of emotion induction tasks and the limitations of the between-subject approach, concordance results vary, and no clear picture with regard to sex differences in emotional concordance has yet emerged.

Across the valence and arousal dimensions, the study by Lang and colleagues (1993) is one of the few studies that used the recommended within-subject approach investigating sex differences. In response to pictures, contrary to assumptions – which may be due to inclusion of erotic stimuli – it found higher concordance between EDA and arousal in men than women (with valence data not reported; Lang et al., 1993; see also Greenwald et al., 1989). Moreover, Lang and colleagues (1993) found no sex differences in concordance between HR and self-report measures (for both arousal and valence; see also Greenwald et al., 1989). Furthermore, they found higher concordance between corrugator as well as zygomatic EMG and valence for women compared to men (with arousal data not reported),

[1] Note that the current analysis of concordance is based on data from this study. Theoretically positioned within the response cascade model, it investigated sex differences in average emotional response to fear, sadness, pride, and serenity films.

though, not invariantly (Greenwald et al., 1989). Thus, very few studies have investigated sex differences in emotional concordance along the affective valence and arousal dimensions, and more research is needed. Recent findings point to strong individual differences in concordance indices (between self-reported valence and physiology, range .17 to .60; see Brown et al., 2019) and those may in part be explained by sex differences.

The Present Study

The present study examined effects of biological sex and self-reported affect (arousal and valence treated as separate dimensions) on response concordance. All three major response domains (experiential, physiological, and behavioral) were sampled, using the recommended within-subject approach (Butler et al., 2014; Hollenstein & Lanteigne, 2014, but deviating from the recommended online rating dial approach for reasons outlined below). To enhance ecological validity and emotion induction strength we used a series of 2-min film-stimuli. Compared to static pictures with typical presentation times of a few seconds, films provide a dynamic story context and allow for sufficient time for the emotional response to unfold, thus yielding higher ecological and construct validity (Rottenberg, Ray, & Gross, 2007). We selected 15 film clips – three threat-, loss-, achievement-, and recreation-related films, respectively, and three emotionally neutral clips) varying across both the arousal and valence dimensions (see Friedman et al., 2014). The film clips were presented in randomized order, thereby bypassing problems of serial autocorrelation in studies examining continuous responses within one dynamic film stimulus (e.g., Mauss et al., 2005).

The longer physiological recording windows used by the present study were particularly important to allow for the analysis of established sympathetic and parasympathetic activity markers, namely pre-ejection period (PEP) and respiratory sinus arrhythmia (RSA; Berntson, Cacioppo, & Quigley, 1993), which have been neglected in previous concordance studies and require averaging over 1-2 minutes to provide reliable estimates. In addition, we measured respiration, an important but often neglected emotion response domain (e.g., Wilhelm, Gevirtz, & Roth, 2001). These and other physiological and behavioral (facial corrugator and zygomatic EMG) emotion response estimates were averaged for each film and related to self-reported arousal and valence ratings measured at the end of each film. To our knowledge, no study has yet investigated to what degree these additional measures are concordant with self-reported valence and arousal and if women and men differ on this.

To obtain a concordance index for each individual and each investigated pair of measures, a within-subject Spearman correlation across films (i.e., using 15 measurement points) was computed. Using our novel approach, we expected moderate to strong concordance indices (i.e., pairwise correlations significantly different from zero), both on an individual and on a group level, for many if not all pairs of measures. We hypothesized that women would display higher concordance than men across most pairs of measures. Additionally, we tentatively expected self-reported arousal to be more strongly related to autonomic and respiratory physiological measures than self-reported valence, based on the conceptual overlap of self-reported arousal and psychophysiological activation; we, in turn, expected valence to be more strongly related to behavioral EMG measures of facial expression, as, e.g., smiling or frowning can clearly signal emotional valence.

We additionally considered two potential drivers of sex differences. First, men may display less response variation in self-reported arousal and valence across films than women, thus limiting the potential of these measures to correlate with other measures. Second, related to their higher emotional expressiveness, women may display more gross body movement than men, which may through metabolic rather than emotional pathways elicit a higher degree of congruent variation in autonomic or respiratory responses (e.g., Obrist, 1976). Therefore, additional analyses tested whether variation in self-reported arousal, valence, and body movement mediated the investigated relationship between biological sex and concordance.

Method

Participants

Fifty-two Caucasian students were recruited at University of Salzburg and participated in exchange for 15 Euros or course credit. Exclusion criteria were current self-reports of psychosis, psychotropic medication use, affective disorder, serious medical conditions, substance abuse/dependency, history of traumatic head injury, and cannabis or alcohol consumption within 24 hours before the experiment. Based on these criteria, four participants were excluded. Furthermore, two participants were excluded from the analyses due to cardiac arrhythmia and two because of poor data quality, leaving 44 participants (22 women) for analyses. The study was approved by the local ethics committee.

Due to our novel study design optimizing emotion induction and reliability of physiological measurements we expected relatively high concordances and reasonable power to detect sex differences in concordance. We conducted a power analysis using GPower (Faul, Erdfelder, Lang, & Buchner, 2007), testing for global MANOVA effects; based on an intermediate to large effect size (f^2(V)=.25) for an alpha level of $p < .05$, with a power of .80, a minimum sample size of 42 participants was required. In a previous study using a different film emotion induction design (continuous sec-by-sec experience, physiology, and behavior sampling over one 5-min film), concordances were around .74 between experience and facial behavior and in the order of .30 to .50 between experience and physiology, implying moderate to strong effects (Mauss et al., 2005). Note that no previous study tested sex differences in emotional concordance across the affective dimensions of valence and arousal in one model, and in the study of Lang et al. (1993) no information on standard deviation of concordance indices was provided, hence, no informative *a-priori* effect sizes were available for sex differences.

Men and women differed neither in age (men: M=24.45, SD=3.56; women: M=23.09, SD=3.90; $t(42)$=1.21, p=.232, d=.36) nor in habitual TV consumption (men: M=1h 34min, SD=1h 9min; women: M=1h 55min, SD=1h 16min; $t(41)$=.96, p=.343, d=.29) or horror/thriller film consumption (on a scale from 1 = "not at all" to 5 = "very often", men: M=2.93, SD=1.45; women: M=2.32, SD=1.16; $t(42)$=1.55, p=.129, d=.47).

Procedure

Initially, participants provided informed consent and filled out several questionnaires. During a 20-min laboratory adaptation phase, participants were equipped with measurement electrodes/sensors and soundproof headphones. They were accustomed to the measurements during a 3-min quiet sitting resting baseline, seated in an upright posture. Next, participants watched 15 film clips consisting of three threat-, loss-, achievement-, and recreation-related, and neutral clips, with these five emotional states randomized within three sets. Sets were additionally randomized using a Latin square design. Participants rated each film immediately after its presentation. Films were separated by 1-min intervals, with additional breaks (2-5min) allowing participants to recover and refocus after the fourth and eleventh film clip. Participants were allowed to talk, stretch their muscles, and drink some water during these breaks.

Stimuli

Film stimuli were presented on a 24''LED monitor with a 1920×1080 resolution at a viewing distance of 65cm, using E-Prime 2.0 presentation software (Psychology Software Tools, Sharpsburg, PA). In a previous pilot study, film clips from German dubbed movies and television shows were chosen that mapped to the affective space dimensions of bipolar valence and arousal. Their length ranged from 1min 53s to 2min 32s, with an average length of 2min 11s. The films depicted threat-, sadness-, achievement-, and recreation-related, as well as neutral contents. Threat-related clips depicting a physical threat by a perpetrator were excerpted from the movies *I still know what you did last summer, Copykill, and Friday the 13th*. Loss-related clips depicted the loss of a loved person and were excerpted from *The Champ, My Girl,* and *Moulin Rouge.* Achievement-related clips were taken from Internet sources depicting skill challenges and sports events with special achievements in front of an audience (*"human flag" Guinness World Record challenge, 100 m world record of Usain Bolt,* and *climbing challenge in the German TV show "Wetten, dass").* Recreation-related clips were taken from Internet sources and depicted calm and tranquil activities (*Qi Gong exercises, receiving a massage,* and *Tahiti beach scenes).* Neutral clips were taken from instruction videos and documentaries from Internet sources (weather forecast, life in the monastery, sealing wooden floor with silicone; details on the film clips including exact sources and cutting instructions, as well as mean ratings for the respective emotional states are provided in Wilhelm et al., 2017). Therefore, presenting 15 film clips in total yielded 15 measurement points across emotional states.

Measures

Autonomic, respiratory, and facial muscular-behavioral responses during film viewing were recorded using a Porti 32-channel-amplifier (TMSi, Twente Medical Systems International, EJ Oldenzaal, The Netherlands) and the software Polybench 1.2 (TMSi). The signals were digitized with a 1000 Hz-sampling rate and further processed using the software ANSLAB (Wilhelm, Grossman, & Roth, 1999; Blechert, Peyk, Liedlgruber, & Wilhelm, 2016). The current analysis focuses on standard physiological variables that are commonly used. Results from additional, more specialized measures such as pulse amplitude from pulse plethysmography, cardiac output from impedance cardiography, and minute volume from respiratory excursions showed similar results as the other cardiovascular and respiratory measures and can be obtained from the authors on request.

Experiential measures. Using horizontal digital visual analogue scales, participants' subjective emotional experience to each film clip was assessed immediately after each clip by arousal and valence ratings (Arousal: "How calm or excited did you feel during the preceding film clip? (left anchor: "*very calm*"; right anchor: "*very excited*"); Valence: "How pleasant or unpleasant were your feelings during the preceding film clip?" (left anchor: "*very unpleasant*", 0; right anchor: "*very pleasant*", 100)); anchors were accompanied by illustrative emoticons (Bradley & Lang, 1994), placed in fixed intervals along the rating continuum. Rating positions were transformed to a 0 (left anchor) to 100 (right anchor) scale. To facilitate interpretability of valence ratings, the polarity of the valence scale was reversed (by computing 100-x; higher scores (>50) indicating negative valence, 50 indicating neutral valence, and lower scores (<50) indicating positive valence).

Autonomic measures. Electrodermal activity (EDA) was assessed using a specialized amplifier module (Becker Meditec, Karlsruhe, Germany) and two non-disposable 10mm inner diameter Ag/AgCl electrodes filled with isotonic gel (TD-246, MedCat, Netherlands) placed on the thenar and hypothenar eminences of the left hand. In addition to skin conductance level (SCL), we computed non-specific skin-conductance response rate per minute (nsSCR, in 1/min). NsSCR is less influenced by the typically large individual differences in skin characteristics like dryness and sweat gland density and by electrode drifts across longer experiments than skin conductance level (SCL, Boucsein, 2012; Wilhelm & Roth, 1998a); fluctuations with an increase larger than 0.02μS were considered a response.

Cardiovascular activity was measured by electrocardiography (ECG) and impedance cardiography (ICG) systems (TMSi). ICG and ECG were measured using disposable 55mm diameter Ag/AgCl solid-gel electrodes attached to alcohol-cleansed skin sites. For ECG, electrodes were placed on the upper sternum and lowest rib on the left side. The ground electrode was applied at the xiphoid process of the sternum. R-waves were determined automatically, followed by a visual check and occasional editing of misdetections due to movement artifacts and ectopic beats. ICG was measured by placing eight electrodes pairwise on trunk and neck, following established conventions. Data was analyzed according to guidelines (Sherwood et al., 1990): In brief, the ICG raw dZ/dt signal was ensemble-averaged in synchrony with the ECG R-wave. Characteristic B-, E-, and X-points of the signal were determined automatically and inspected visually. The following cardiovascular parameters were computed (for details, see Blechert et al., 2016): 1) heart rate (HR, in beats per minute (bpm); using ECG data), 2) preejection period (PEP, in ms; an established measure inversely related to cardiac sympathetic activity, using ECG and ICG data), 3) respiratory sinus arrhythmia (RSA), a measure of cardiac parasympathetic activation, defined as natural cyclical variations in HR related to breathing (Berntson et al., 1997); RSA was operationalized as high frequency (0.13–0.5 Hz) complex-demodulated RR-interval amplitude (in ms; using ECG data) because this method is less susceptible to non-stationarity than spectral measures in dynamic stimulation settings like films (Wilhelm et al., 2005).

Respiratory measures. Participants were equipped with two breathing belts (TMSi) with resistive sensors with approximately linear characteristic for typical thoracic and abdominal respiratory excursions, measuring respiratory rate (RR, in breaths per minute).

Behavioral measures. Facial muscular activity was assessed by two pairs of 2mm inner-diameter Ag/AgCl electrodes attached to alcohol-cleansed skin sites with centers approximately 1 cm apart. Electrodes for the measurement of *m. corrugator supercilii* activity were placed adjacent to the left eyebrow and for *m. zygomaticus major* activity on the left cheek halfway between mouth and ear tip (Fridlund & Cacioppo, 1986). EMG amplitude (in µV) was assessed as an index of muscular activity after signal filtering and rectification using established criteria. Furthermore, a highly sensitive 3-axial accelerometer was attached to participants' left shoulder, primarily registering movements of the trunk (in arbitrary units); those are, after signal filtering, rectification, and averaging, a reasonable index of whole-body motion or restlessness in seated participants.

Data Analyses

Spearman correlations were computed using MATLAB Statistics Toolbox R2015a (Mathworks, Inc., Natick, MA, USA) for each participant for all investigated pairs of measures; presenting 15 film clips in total yielded 15 measurement points for calculating each individual concordance index across emotional states (see Figure 1). Nonparametric correlation analysis was used as a conservative and stable estimate of concordance since bivariate distributions deviated from normality for several measure pairs. Note that our randomized study design and lack of continuous rating-dial data does not allow assessing cross-correlations with or without lags (as e.g., in Mauss et al., 2005). Inferential statistical analyses were performed in IBM SPSS Statistics 22 (IBM Corp., Armonk, NY, USA). For statistical analyses, but not for descriptive results, concordance indices were Fisher z-transformed.

The overall effects of the between-subject factor Sex (women vs. men), the within-subject factor Affect Dimension (arousal vs. valence), and the Sex × Affect Dimension interaction were computed using multivariate analysis of variance (MANOVA) including the eight dependent concordance index variables for the measure-pairs of arousal with HR, nsSCR, SCL, RR, PEP, RSA, EMG corrugator, and EMG zygomaticus and the eight dependent concordance index variables for the measure-pairs of valence with HR, nsSCR, SCL, RR, PEP, RSA, EMG corrugator, and EMG zygomaticus. The multivariate main effects for Sex and Affect Dimension were significant, while the interaction effect for Sex × Affect

Dimension was not. Follow-up analyses thus tested for main effects of Sex and Affect Dimension on each investigated concordance index using *t*-test[2].

For descriptive purposes, secondary analyses tested concordance indices against zero for women and men separately using *t*-test; additionally, *t*-tests were used to check for sex differences with regard to each self-report measure (valence and arousal) separately. Further, each subject's concordance indices were categorized as either exceeding significance threshold ($/r/>.443$; $df=13$, $p<.05$ one-tailed; note that for descriptive purposes two-tailed testing would be too conservative) or not (see Zar, 1972). Percentage exceeding this threshold was reported for women and men. It should be noted that non-significance of an individual concordance index does not preclude using this concordance index as a valid representation of this individual's specific concordance in inferential statistics.

Within-subject standard deviations (*SD*) for self-report, autonomic, respiratory, and behavioral measures across emotional films were computed and *t*-tests were used to test for sex differences. Following, to check if sex differences in concordance were primarily caused by variance restriction in self-report measures (arousal/valence *SD*), mediation analyses were performed using PROCESS (Hayes, 2012). Indirect effects were evaluated with 95% bias-corrected confidence intervals based on 10000 samples. In addition, mediation analyses testing for potential mediating effects of body movement (measured by accelerometry SD) on sex differences in concordance were calculated. Justified by overall significant MANOVA main effects and following recommendations by Perneger (1998) and others, we used an α-level of .05 for statistical analyses of the eight dependent variables.

Results

[2] Note that we did not use multilevel modelling (MLM), as the intra-class correlation (ICC) was very low (ICC=.005), indicating that almost all variance was between-subject. Moreover, calculations showed that a model including a random intercept in addition to our predictors was already overfitted, requiring a reduction in random effect structure. Therefore, a MANOVA was computed.

Using Pillai`s trace, findings from MANOVA revealed an overall significant effect of Sex on response concordance ($V = .51$, $F(8, 35) = 4.56$, $p = .001$, $\eta^2 = .51$), with women overall displaying higher response concordance than men. Moreover, a significant main effect for Affect Dimension on response concordance was found ($V = .77$, $F(8, 35) = 15.02$, $p < .001$, $\eta^2 = .77$), with concordance overall being stronger for arousal than valence. No significant interaction effect between Sex and Affect Dimension was found ($V = .21$, $F(8, 35) = 1.17$, $p = .344$, $\eta^2 = .21$).

For illustration of the novel method of concordance measurement used in this study, Figure 1 depicts exemplary data from one participant. Figure 2 and Table 1 provide detailed information on distributions as well as descriptive and inferential statistics of concordance indices for investigated pairs of measures. In the following, we provide a summary on the respective findings.

– Insert Figure 1 about here –

– Insert Figure 2 about here –

– Insert Table 1 about here –

Effects of Sex on Concordance Indices (see Figure 2 and Table 1 column "Main effect Sex")

Multivariate main effects for HR, EDA (both nsSCR and SCL), RR, PEP, RSA (marginally significant), EMG corrugator and zygomaticus (marginally significant) revealed stronger concordance with self-report measures for women than for men.

Secondary Analyses. Using *t*-test, testing concordance indices against zero for women and men separately, women displayed stronger concordance between HR acceleration and arousal, whereas men displayed stronger concordance between HR deceleration and increasing unpleasantness. Furthermore, EDA was related to both valence and arousal in women and only to arousal in men. For both women and men, RR was related to arousal and valence. PEP decreased with increasing arousal and valence in women only. RSA decreased with increasing arousal in women only. For women, increased corrugator activity was linked to increased arousal and valence; for men, corrugator activity was linked to valence only. For women, zygomatic activity was linked to increasing arousal, for men to increasing pleasantness.

Association of Self-Reported Affect Dimension with Concordance Indices

As would be expected, arousal correlated moderately with valence (*M*=.509; *SD*=.311; shared variance: R^2=.259), and women (*M*=.601; *SD*=.257) compared to men (*M*=.417; *SD*=.339) displayed a marginally larger correlation between the two ($t(42)=-2.02$, $p=.050$).

For HR, EDA (both nsSCR and SCL), RR, PEP, and RSA, arousal revealed stronger concordance indices than valence. For EMG corrugator and zygomatic activity, valence revealed stronger concordance than arousal (see Figure 2 and Table 1 column “Main effect Affect Dimension”).

No Mediating Role of Variance Restriction in Arousal and Valence on the Relationship between Sex and Concordance Indices

Women and men displayed considerable variance across films in arousal and valence and on physiological and behavioral response measures (Table 2). Women displayed more variance in valence ratings and EMG corrugator activity than men, as well as marginally more variance in arousal and RSA. No other sex differences along any response measure were found (see Table2). Mediation analyses revealed no mediating role of either arousal *SD* or valence *SD* on the relationship between sex and concordance indices, with all indirect effects’ confidence intervals including zero.

No Mediating Role of Body Movement on the Relationship between Sex and Concordance Indices

Women and men did not differ in their variance in body movement (accelerometry; see Table 2). Mediation analyses revealed no mediating role of accelerometry *SD* on the relationship between sex and concordance indices, with all indirect effects' confidence intervals including zero.

-- Insert Table 2 about here –

Discussion

The present study investigated effects of biological sex and self-reported affect dimension (arousal/valence) on response concordance across a range of emotional states elicited by 15 films. For all investigated pairs of measures, women displayed stronger concordances than men, except for a non-significant sex difference in zygomatic-valence concordance. Averaged concordance indices were as high as .66 for women and individual concordance indices were above .80 for a sizeable number of individuals; present results thus provide strong support for emotion theories postulating a synchronization of emotion responses across different emotion expression systems (e.g., Lazarus, 1991; Levenson, 1994; Scherer, 1984). Based on the conceptual overlap of psychophysiological activation and self-reported arousal (but with mixed results in previous research, Mauss & Robinson, 2009), physiological measures showed higher concordance with arousal than valence across participants. In line with previous findings (e.g., Lang et al., 1993; Mauss & Robinson, 2009), facial EMG measures showed higher concordance with valence than arousal (see row "main effect Affect Dimension" in Table 1). In the following, sex differences in emotional concordance will be discussed in more detail; note that patterns between specific physiological measures and self-report measures were not necessarily similar for women and men (see Figure 2 for a depiction of sex specific individual and mean concordance indices).

Stronger Response Concordance in Women than Men

The present study revealed higher response concordance in women than men across a range of physiological and behavioral measures. This fits with research showing that women are better than men at recognizing emotions (see review by McClure, 2000), express themselves more easily (see review by Kret & Gelder, 2012) and pay more attention to and be more aware of their emotions (e.g., Ashmore & Del Boca 1979; Brody & Hall, 2008). In the following, we would like to offer some plausible explanations for the observed sex differences in emotional concordance.

First, sex differences in emotional concordance may have emerged due to so-called display rules, prescriptive social norms that predefine when, where, and how emotions can be expressed by women and men (Brody, 2000). According to these rules, men who report fear, depression, or sadness are evaluated more negatively (e.g., Siegel & Alloy, 1990) and may therefore suppress (i.e., down-regulate) their emotions more than women (Gross & John, 1998). Response suppression is an important way of self-regulating emotions and not only affects behavior and experience but also may paradoxically increase HR and sympathetic activation (e.g., Gross & Levenson, 1993; Roberts, Levenson, & Gross, 2008). Not surprisingly, it has been linked to disrupted concordance among experience, physiology, and behavior by experimental studies (Butler et al., 2014; Dan-Glauser & Gross, 2013). As men use more suppression than women (Gross & John, 2003), an increased propensity for response suppression in men in the present study could be one plausible explanation for their lesser concordance.

Second, evolutionary accounts (e.g., adaptive calibration model of stress responsivity, Del Giudice, Ellis, & Shirtcliff, 2011) propose that evolutionary selection processes have predisposed women and men differently for specific emotional response patterns. Keeping calm and vigilant during threatening situations could have been evolutionarily adaptive particularly for men (i.e., competition and risk-taking require insensitivity to threats, social feedback, and context; see also Kring & Gordon, 1998). Women, in comparison, may have evolutionarily benefitted most from picking up social cues to facilitate communication and increasing social bonding by expressing themselves (Kret & Gelder, 2012; see also Avero & Calvo, 1999; Brody & Hall, 2008; Doornen, 1986). Therefore, one could speculate that it was evolutionarily adaptive for women to show emotional and concordant and for men to show more unemotional and discordant response patterns, possibly explaining present findings.

Third, sex differences in concordance may also be explained by sex differences in body awareness. Sze and colleagues (2010) linked higher body awareness to higher concordance between experiential and physiological measures in a sample of women (Sze et al., 2010). As women are more self-aware than men (Brody & Hall, 2008), this could possibly explain sex differences in present findings, though needs to be further tested by targeted experimental studies. Having outlined some broader implications of the present findings, we will now discuss sex differences on the different concordance indices in more detail.

Effects of affect dimension and sex on emotional concordance between experiential and physiological responses. Across films, all physiological measures cohered more with self-reported arousal than valence. Secondary analyses revealed that HR acceleration was found with increasing arousal (particularly in women), which was stronger than the HR deceleration found with increasing unpleasantness (particularly in men; note that no interaction effects were significant). In line with these findings, Lang and colleagues (1993) linked HR acceleration to increasing arousal, related to a defensive response mobilization, and HR deceleration to increasing unpleasantness, related to an orienting response towards negative pictures (which also elicited higher interest ratings and viewing time); though, in their study, this relationship was stronger for valence and no sex differences were found. The present study found HR deceleration with increasing unpleasantness in men only, whereas women showed HR acceleration with unpleasantness valence (though non-significant). This accords with past studies showing that HR responses are difficult to assess along the continuum of valence, showing much inter-individual variance, as both positive and negative stimuli can result in HR acceleration (e.g., Bradley et al., 2001; Wilhelm & Roth, 1998b). Furthermore, differences between the two studies are likely attributable to stimulus intensity, with films often eliciting stronger responses than pictures (i.e., HR deceleration to threat-related pictures, indicating an orienting response, c.f. Bradley et al., 2001, vs. HR acceleration to threat-related films, indicating a defense response; c.f. Kreibig, et al., 2007; Wilhelm et al., 2017). Moreover, as women have been shown to be more reactive to aversive films than men (e.g., Wilhelm et al., 2017; Rattel at al., 2019), switching faster from orienting (HR deceleration) to defending (HR acceleration) along the defense cascade (Lang, Bradley, & Cuthbert, 1997), a comparison between women and men with regard to increasing unpleasantness is difficult to make. To sum up, present findings revealed stronger concordance between HR and arousal than between HR and valence, with women showing stronger concordance than men.

EDA cohered more with arousal than valence in both women and men, in line with findings by Lang and colleagues (1993). However, this relationship was stronger in women, with individual concordance indices ranging from .25 to .86; for nsSCR, 91% of women, compared to 36% of men, showed individual concordance indices above the significance threshold; this points to more titrated adjustments in sympathetic activation in women than men with increasing arousal.

The present study was the first to assess response concordance between self-reported experience and less frequently used, but established and well-validated sympathetic (PEP), parasympathetic (RSA), as well as respiratory (respiration rate) measures. Converging with findings for HR and EDA, these additional physiological measures cohered more with arousal than valence, with women consistently showing more concordant responding than men. Specifically, with increasing arousal PEP decreased, though, in women only, indicative of increased β-adrenergic cardiac sympathetic activity. Therefore, results for EDA and PEP collectively point to increases in sympathetic responding along the continuum of arousal, particularly in women (Sherwood et al., 1990). This may result in women being more sensitive and responsive to their environment, preparing them for fine-tuned behavioral actions (e.g., Bosch et al., 2001; Lovallo, 2005). Moreover, RSA decreased along the continuum of arousal, though, in women only, in line with Frazier, Strauss, and Steinhauer (2004) who showed that RSA is more closely related to arousal (and decreases to both positive and negative films due to either approach or withdrawal tendencies).

This indicates that the high arousal-sympathetic concordance found in women was associated with an inverse pattern of arousal-parasympathetic concordance (Berntson et al., 1993), with higher arousal being associated with larger vagal withdrawal, mediated by downregulation of cholinergic efferent activity; this pattern of sensitive autonomic adjustment to environmental affective stimuli was not observed in men. Moreover, it has recently been shown that adjusting RSA depending on threat level is adaptive (Glenn & Michalska, 2018) and higher baseline RSA being predictive of adaptive responses under conditions of challenge (see meta-analysis by Holzman & Bridgett, 2017). Those findings are thus in line with theoretical accounts postulating that women and men adapt differently to environmental changes (e.g., Best, 2010) and with women suppressing emotions less and thus, being more emotionally reactive (e.g., Craske, 2003; Dimberg & Lundquist, 1990).

Complementing those findings, respiration rate increased with increasing arousal (to a lesser extent with increasing unpleasantness) and more so in women than men. Respiration rate is driven by muscular activity and is regulated in other brainstem centers of the central autonomic network than sympathetic efferent activity; however, similarly to sympathetic outflow from the *nucleus tractus solitarii*, it is subject to top-down influences from limbic and prefrontal areas processing emotional information (Macey, Ogren, Kumar, & Harper, 2016). In summary, present findings imply that ANS and respiratory activity more closely vary along the affective dimension of arousal than valence and this is especially the case in women.

Effects of affect dimension and sex on emotional concordance between experiential and behavioral responses. In line with the findings by Lang and colleagues (1993), secondary analyses revealed that women`s and men`s corrugator muscle activity increased with increasing unpleasantness, however, more so in women (73% of women showed a significant relationship compared to 32% of men). Moreover, women also displayed an intermediate concordance with arousal, implying that women “frowned” more in response to negative and arousing films than men.

Zygomatic muscle activity increased with increasing pleasantness and no sex differences were found; though, direct contrasts indicate that men displayed a significant relationship with valence, whereas women with arousal. Given that pride may have in part been induced by the achievement-films, findings for men may relate to research showing that men tend to express more pride than women (e.g., Hess et al., 2000; Plant, Hyde, Keltner, & Devine, 2000). Findings for women could be explained by research showing that zygomatic activity also increases when exposed to highly arousing unpleasant stimuli, e.g., related to disgust (Vrana, 1993), which may have been in part induced by the threat-films. In comparison to the present findings, Lang and colleagues (1993) found intermediate concordance for zygomatic activity with both valence and arousal, and stronger concordance with valence in women than men; this may, in part, be due to their different study design (short presentation of pictures vs. 2-min film presentation in the current study).

Sex Differences in Concordance not Explained by Response Variation

Mediational analyses indicate that sex differences in concordance cannot be attributed to mere sex differences in response variation in valence or arousal across films. Thus, emotional reactivity by itself does not seem to imply emotional concordance; vice versa, a relative lack of variation in emotional reactivity across emotion films, which could, particularly on the background of the typical “noise” of physiological measurements, mathematically easily result in zero correlations, does not seem to explain low concordances. Although men displayed less overall variance in valence ratings and corrugator muscle activity than women, this variance restriction did not explain the found sex differences in concordance involving these measures. Therefore, the present findings propose that emotional concordance and emotional reactivity are two distinct processes. Furthermore, none of the present sex differences in concordance were mediated by body movement (i.e., whole-body muscular activity and associated metabolic demands). Therefore, present results involving physiological measures can be interpreted as representing emotional rather than mere physical activation (see, e.g., Obrist, 1976; Wilhelm, Pfaltz, Grossman, & Roth, 2006; Wilhelm & Roth, 1998b).

Methodological Considerations

Response system concordance defined as coordinated changes across response systems is in line with both dimensional (e.g., Russel & Barrett, 1999) and discrete (e.g., Frederickson, 2000; Lerner & Keltner, 2000) models of emotion. In terms of the dimensional account, the present study found that although valence and arousal were moderately associated, with about 26% shared variance, concordance indices with autonomic, respiratory, and behavioral measures differed strongly between the two and further differed between sexes. This points to the importance of assessing both dimensions in future emotion concordance research and provides novel and incremental evidence in support of hybrid models that view distinct emotions as specific points on the general dimensions valence and arousal (see Christie & Friedmann, 2004; Levenson, 1988; Mauss & Robinson, 2009). Though, as the present study did not assess discrete emotional states (as we believe that these repeated detailed ratings would have led to greater disruption of the emotional experience itself) and contained too few measurement points for analyses investigating, e.g., positive compared to negative emotional states, we could not compare those two approaches. However, we believe that results would converge, as discrete and dimensional models are not necessarily incompatible (Cacioppo, Gardner, & Berntson, 1999).

Although some of the previous studies also showed high correlations between response systems (e.g., Bradley et al., 2001), differences in how concordance indices were computed should be kept in mind: averaging across stimuli first, followed by regression analyses may artificially inflate concordance indices. The present study used an intra-individual approach with fewer but highly potent stimuli to compute response concordances. This also stands in contrast to many prior studies using inter-individual correlations. Compared to inter-individual approaches, intra-individual approaches do not reduce between-subject variance (e.g., Reisenzein, 2000; Rosenberg & Ekman, 1994) and are less confounded by individual differences (e.g., Marroquín, Boyle, Nolen-Hoeksema, & Stanton, 2016). These methodological differences could further explain differences with regard to past findings in terms of strength of concordance between different measurement systems. Intra-individual approaches have generally yielded larger effect sizes and conceptually appear to be more applicable to the topic at hand (e.g., Buck, 1980; Stemmler, 1992; Reisenzein, 2000). Though, very few (especially clinical) studies have yet used intra-individual approaches (e.g., Burkhardt, Wilhelm, Meuret, Blechert, & Roth, 2010). The present study further encourages an intra-individual approach when studying emotion concordance.

The present study recorded physiological responses to films and averaged over 2 min film segments. Possibly due to higher ecological validity of films compared to pictures and broader and more reliable physiological assessment afforded by longer measurement intervals, medium-to-large concordances between response systems were found, especially for women. As increased emotion induction strength has been linked to higher response concordance (Mauss et al., 2005; Rosenberg & Ekman, 1994) our approach of using 15 films, each of about 2 minutes duration, may have resulted in particularly robust concordance estimates. The present study`s approach allowed extending previous work to putative indices of sympathetic and parasympathetic nervous system responding requiring continuous measurement durations of minutes to be valid. Therefore, present findings meaningfully extend recent analyses by Wilhelm and colleagues (2017), showing sex differences on a mean response level during fear, sadness, pride, and serenity films, to showing sex differences in emotional concordance across films.

Future Directions

Future studies should further attempt to clarify to what extent concordance is influenced by individual-trait differences. As can be seen in Figure 2, the extent of variation in individual concordance indices is generally high and although, for instance, on average, the expected negative relationship was found between both PEP and RSA with arousal for women, some women did not show a significant negative and some even a positive relationship. Besides individual differences in trait emotion suppression discussed above, we believe that, in line with findings of clinical studies, individual differences in alexithymia (linked to intact physiological responding but impaired self-report of emotional experiences, e.g., Stone & Nielson, 2001), symptoms of depression (linked to decreased affective reactivity and possibly response concordance, e.g., Rottenberg, Kasch, Gross, & Gotlib, 2002), and anxiety (linked to a mismatch in self-reported anxiety and physiological responding, e.g., Mauss et al., 2004) could explain the large individual differences in strength and direction of concordance revealed by present findings. Those individual differences in emotion (dys)regulation may correlate with or contribute to psychopathology, causing a disruption in adaptive responses and thereby resulting in maladaptive socially relevant behavioral responses. Based on our findings it may be an important and well-founded aim for future research to link those individual trait differences in emotion dysregulation with sex differences in concordance.

Moreover, as the present study investigated sex differences in response concordance across emotional states, future research should investigate sex differences in concordance for specific emotional states. Based on findings by Wilhelm et al. (2017) we suspect particularly pronounced sex differences in concordance for highly arousing, negative (e.g., threat- or anger-related) stimuli. Additionally, it would be potentially interesting to investigate if sex differences in discrete emotion state intensities can explain sex differences in response concordance; unfortunately, the present study contained too few measurement points (i.e., only three) for analyses investigating concordance within specific emotional states. Lastly, present findings on sex differences in emotional concordance should be replicated in studies using continuous online experience ratings.

Limitations

Considering the present findings, some limitations should be noted. First, the present study`s sample size was rather small for group comparisons and particularly for addressing interaction effects; thus, results need to be interpreted with caution and replicated. *A-priori* power analyses indicated at least moderate power to find intermediate effect sizes and most observed effect sizes were large; furthermore, the consistency of results across the broad array of physiological measures we assessed suggests reliability of these results. In any case, the present findings should be replicated in a study with larger N, using an ethnically diverse sample, and additionally assessing inter-individual differences in emotion (dys)regulation and other potential mechanisms to better understand the psychological underpinnings of concordance differences between sexes.

Second, whole-body movement as a potential mediator was assessed by means of an accelerometer attached to the left shoulder. Although the three-axial sensor is highly sensitive to any motion of participants, it of course is limited because leg movement and isometric muscular activity is not captured directly. However, most previous concordance studies did not include any measure of broader muscular or metabolic activity.

Third, the present study did not obtain continuous online experience ratings using a rating-dial, which has become a standard assessment tool particularly suited for addressing coherence (Hollenstein, & Lanteigne, 2014). Assessing emotional experiences subsequent to (rather than during) films could have introduced measurement error like retrospective memory bias (e.g., Feldman-Barrett, 1997). In the present study, each film clip was rated immediately after its presentation and the clips were relatively brief and induced just one emotion, thereby avoiding more severe pitfalls of retrospective ratings. Moreover, continuous rating-dial approaches may in some instances have methodological drawbacks, as a dual-task film viewing plus rating dial procedure could impede naturalistic emotion induction by increasing mental load, altering emotion self-awareness, and distracting attention away from films (e.g., Sanders, 2001; Gottman & Levenson, 1985; Rosenberg & Ekman, 1994), which may be accentuated when assessing two rating dimensions in conjunction. Most importantly, given that limitations of the film averaging approach used in the current study arguably apply equally to women and men and to each of the two assessed affect dimensions, they do not diminish the validity of our conclusions with regard to sex differences and affect dimension in emotional concordance.

Fourth, although the present study found strong associations both between experiential and physiological and between experiential and behavioral measures, the film-averaged, random-order design of the present study precludes assessment of directionality of this relationship, which is a drawback of the current approach. More fine-grained sec-by-sec experience and physiology sampling and cross-correlational analysis enabling lag modeling could potentially address such questions and also assess within-subject variations in concordance relating to dynamically changing stimuli and emotional states (Cabrieto et al., 2018). In the current study, physiological reactions to films might have triggered or enhanced subjective feelings of arousal and valence (functionalistic account, see James, 1884) or vice versa (Barrett & Russell, 2015). Our current thinking favors the view that evolution brought about highly interacting central and peripheral nervous system circuits and pathways that result in dynamically interacting, bi-directional, and recursive experiential, physiological, and behavioral responses, making it hard to dissect temporal relationships (c.f., Scherer, 2013).

Conclusion

Across almost all concordance indices, women displayed stronger concordance than men. We found stronger concordance for autonomic and respiratory measures with arousal and stronger concordance for behavioral EMG measures with valence. Present findings strengthen the view that emotions are composed of multiple response systems that cohere across multiple situations and provide novel evidence that this concordance may be stronger in women than men.

Author Notes

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References

Anders, S., Lotze, M., Erb, M., Grodd, W., & Birbaumer, N. (2004). Brain activity underlying emotional valence and arousal: A response-related fMRI study. *Human Brain Mapping*, *23*(4), 200-209.

Ashmore, R. D., & Del Boca, F. K. (1979). Sex stereotypes and implicit personality theory: Toward a cognitive—Social psychological conceptualization. *Sex Roles*, *5*(2), 219-248.

Avero, P., & Calvo, M. G. (1999). Emotional reactivity to social-evaluative stress: Gender differences in response systems concordance. *Personality and Individual Differences*, *27*, 155–170.

Barrett, L. F. (2006). Solving the emotion paradox: Categorization and the experience of emotion. *Personality and Social Psychology Review*, *10*(1), 20-46.

Barrett, L.F. & Russell, J.A. (2015). *The psychological construction of emotion*. New York, NY: Guilford Press.

Berntson, G. G., Bigger, J. T., Eckberg, D. L., Grossman, P., Kaufmann, P. G., Malik, M., ... van der Molen, M. W. (1997). Heart rate variability: origins, methods, and interpretive caveats. *Psychophysiology, 34*(6), 623–648.

Berntson, G.G., Cacioppo, J.T., & Quigley, K.S. (1993). Cardiac psychophysiology and autonomic space in humans: empirical perspectives and conceptual implications. *Psychological Bulletin, 114*(2), 296-322.

Best, D. (2010). The contributions of the Whitings to the study of the socialization of gender. *Journal of Cross-Cultural Psychology, 41*, 534–545.

Blechert, J., Peyk, P., Liedlgruber, M., & Wilhelm, F. H. (2016). ANSLAB: Integrated multi-channel peripheral biosignal processing in psychophysiological science. *Behavior Research Methods, 48*(4), 1528–1545.

Bosch, J. A., Geus, E. J., Kelder, A., Veerman, E. C., Hoogstraten, J., & Amerongen, A. V. (2001). Differential effects of active versus passive coping on secretory immunity. *Psychophysiology, 38*(5), 836–846.

Boucsein, W. (2012). *Electrodermal activity*. Springer Science & Business Media.

Bradley, M. M., Codispoti, M., Cuthbert, B. N., & Lang, P. J. (2001a). Emotion and motivation I: defensive and appetitive reactions in picture processing. *Emotion*, *1*(3), 276.

Bradley, M. M., Codispoti, M., Sabatinelli, D., & Lang, P. J. (2001b). Emotion and motivation II: sex differences in picture processing. *Emotion, 1*(3), 300–319.

Bradley, M. M., & Lang, P. J. (1994). Measuring emotion: The self-assessment manikin and the semantic differential. *Journal of Behavior Therapy and Experimental Psychiatry, 25*(1), 49–59.

Bradley, M. M., & Lang, P. J. (2000a). Measuring emotion: Behavior, feeling, and physiology. In R. D. Lane & L. Nadel (Eds.), *Cognitive neuroscience of emotion* (pp. 242-276). New York: Oxford University Press.

Bradley, M. M., & Lang, P. J. (2000b). Affective reactions to acoustic stimuli. *Psychophysiology*, *37*(2), 204-215.

Bradley, M. M., Lang, P. J., & Cuthbert, B. N. (1993). Emotion, novelty, and the startle reflex: habituation in humans. *Behavioral Neuroscience*, *107*(6), 970.

Brody, L. R. (2000). The socialization of gender differences in emotional expression: Display rules, infant temperament, and differentiation. In A. H. Fischer (Ed), *Gender and emotion: Social psychological perspectives* (pp. 24-47). Cambridge University Press.

Brody, L. R., & Hall, J. A. (2008). Gender and emotion in context. M. Lewis and J. Haviland-Jones (Eds.), *Handbook of Emotions* (pp. 395-408), 3rd edition,. N.Y.: Guilford Press.

Brown, C. L., Van Doren, N., Ford, B. Q., Mauss, I. B., Sze, J. W., & Levenson, R. W. (2019). Coherence between subjective experience and physiology in emotion: Individual differences and implications for well-being. *Emotion.*

Buck, R. (1980). Nonverbal behavior and the theory of emotion: The facial feedback hypothesis. *Journal of Personality and Social Psychology. 38*(5), 811–824.

Butler, E. A., Gross, J. J., & Barnard, K. (2014). Testing the effects of suppression and reappraisal on emotional concordance using a multivariate multilevel model. *Biological Psychology*, *98*, 6-18.

Burkhardt, S. C., Wilhelm, F. H., Meuret, A. E., Blechert, J., & Roth, W. T. (2010). Temporal stability and coherence of anxiety, dyspnea, and physiological variables in panic disorder. *Biological Psychology*, *85*(2), 226-232.

Cabrieto, J., Tuerlinckx, F., Kuppens, P., Wilhelm, F. H., Liedlgruber, M., & Ceulemans, E. (2018). Capturing correlation changes by applying kernel change point detection on the running correlations. *Information Sciences*, *447*, 117-139.

Cacioppo, J. T., Berntson, G. G., Larsen, J. T., Poehlmann, K. M., & Ito, T. A. (2000). The psychophysiology of emotion. In M. Lewis & J. M. Haviland-Jones (Eds.), *The Handbook of Emotion*. New York: Guildford Press

Cacioppo, J. T., Gardner, W. L., & Berntson, G. G. (1999). The affect system has parallel and integrative processing components: Form follows function. *Journal of Personality and Social Psychology, 76,* 839- 855

Cacioppo, J. T., Martzke, J. S., Petty, R. E., & Tassinary, L. G. (1988). Specific forms of facial EMG response index emotions during an interview: From Darwin to the continuous flow hypothesis of affect-laden information processing. *Journal of Personality and Social Psychology*, *54*(4), 592.

Cahill, L., & Aswad, D. (2015). Sex influences on the brain: an issue whose time has come. *Neuron*, *88*(6), 1084-1085.

Christie, I. C., & Friedman, B. H. (2004). Autonomic specificity of discrete emotion and dimensions of affective space: A multivariate approach. International Journal of *Physiology, 51*(2), 143–153.

Craske, M. G. (2003). *Origins of phobias and anxiety disorders: Why more women than men?* Oxford, England: Elsevier Science.

Dan-Glauser, E. S., & Gross, J. J. (2013). Emotion regulation and emotion coherence: Evidence for strategy-specific effects. *Emotion*, *13*(5), 832-842

Del Giudice, M., Ellis, B. J., & Shirtcliff, E. A. (2011). The adaptive calibration model of stress responsivity. *Neuroscience & Biobehavioral Reviews*, *35*(7), 1562-1592.

Dimberg, U. & Lundquist, L. (1990). Gender differences in facial reactions to facial expressions. *Biological Psychology, 30*(2), 151-159.

Ekman, P. (1972). Universals and cultural differences in facial expressions of emotion. In J. Cole (Ed.), *Nebraska Symposium on Motivation* (pp. 207-282). Lincoln: University of Nebraska Press.

Ekman, P., Davidson, R. J., & Friesen, W. V. (1990). The Duchenne smile: Emotional expression and brain physiology II. *Journal of Personality and Social Psychology, 58,* 342–353.

Ekman, P., Friesen, W. V., & Ancoli, S. (1980). Facial signs of emotional experience. *Journal of Personality and Social Psychology, 39*(6), 1125–1134.

Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G_Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39,* 175–191.

Feldman-Barrett, L. (1997). The relationships among momentary emotion experiences, personality descriptions, and retrospective ratings of emotion. *Personality and Social Psychology Bulletin, 23,* 1100–1110.

Fernandez-Dols, J.M., Flor, S., Carrera, P., & Ruiz-Bilda, M.A. (1997) Are spontaneous expressions and emotions linked? An experimental test of coherence. *Journal of Nonverbal Behavior, 21*(3), 163-177.

Fischer, A. H., Rodriguez Mosquera, P. M., van Vianen, A. E., & Manstead, A. S. (2004). Gender and culture differences in emotion. *Emotion, 4(1),* 87-94.

Frazier, T. W., Strauss, M. E., & Steinhauer, S. R. (2004). Respiratory sinus arrhythmia as an index of emotional response in young adults. *Psychophysiology*, *41*(1), 75-83.

Fredrickson, B.L. (2000). Cultivating positive emotions to optimize health and well-being. *Prevention & Treatment, 3*, Article 1a.

Fridlund, A. J., & Cacioppo, J. E. (1986). Guidelines for human electromyographic research. *Psychophysiology, 23*(5), 567–589.

Friedman, B.H., Stephens, C.L., & Thayer, J.F. (2014). Redundancy analysis of autonomic and self-reported, responses to induced emotions. *Biological Psychology, 98,* 19-28.

Glenn, D., & Michalska, K. (2018). A novel multi-component model of coherence in emotion reactivity: Implications for the development of psychopathology.

Gottman, J. M., & Levenson, R. W. (1985). A valid procedure for obtaining self-report of affect in marital interaction. *Journal of Consulting and Clinical Psychology, 53,* 151–160.

Gross, J. J., & John, O. P. (1998). Mapping the domain of expressivity: multimethod evidence for a hierarchical model. *Journal of Personality and Social Psychology*, *74*(1), 170.

Gross, J. J., & John, O. P. (2003). Individual differences in two emotion regulation processes: implications for affect, relationships, and well-being. *Journal of Personality and Social Psychology*, *85*(2), 348.

Gross, J. J., & Levenson, R. W. (1993). Emotional suppression: physiology, self-report, and expressive behavior. *Journal of Personality and Social Psychology*, *64*(6), 970.

Grossberg, J. M., & Wilson, H. F. (1968). Physiological changes accompany the visualization of fearful and neutral situations. *Journal of Personality and Social Psychology, 10,* 124–133.

Greenwald, M. K., Cook, E. W., & Lang, P. J. (1989). Affective judgment and psychophysiological response: Dimensional covariation in the evaluation of pictorial stimuli. *Journal of Psychophysiology, 3*(1), 51-64.

Grossman, M., & Wood, W. (1993). Sex differences in intensity of emotional experience: a social role interpretation. *Journal of Personality and Social Psychology*, *65*(5), 1010-1022.

Hayes, A. F. (2012). PROCESS: A versatile computational tool for observed variable mediation, moderation, and conditional process modeling. Retrieved from http://www.afhayes.com/public/process2012.pdf

Hess, U., Senecal, S., Kirouac, G., Herrera, P., Philippot, P., & Kleck, R. E. (2000). Emotional expressivity in men and women: Stereotypes and self-perceptions. *Cognition and Emotion*, *14*, 609–642.

Hollenstein, T., & Lanteigne, D. (2014). Models and methods of emotional concordance. *Biological Psychology*, *98*, 1-5.

Holzman, J. B., & Bridgett, D. J. (2017). Heart rate variability indices as bio-markers of top-down self-regulatory mechanisms: A meta-analytic review. *Neuroscience & Biobehavioral Reviews*, *74*, 233-255.

James, W. (1884). What is an emotion? *Mind, 9*, 188–205.

Kret, M. E., & De Gelder, B. (2012). A review on sex differences in processing emotional signals. *Neuropsychologia*, *50*(7), 1211-1221.

Kring, A. M., & Gordon, A. H. (1998). Sex differences in emotion: Expression, experience, and physiology. *Journal of Personality and Social Psychology, 74*(3), 686–703. http://dx.doi.org/10.1037/0022-3514.74.3.686.

Kreibig, S., Wilhelm, F., Roth, W., Gross, J., 2007. Cardiovascular, electrodermal, and respiratory response patterns to fear- and sadness-inducing films. *Psychophysiology. 44,* 787–806.

Kron, A., Pilkiw, M., Banaei, J., Goldstein, A., & Anderson, A. K. (2015). Are valence and arousal separable in emotional experience? *Emotion, 15*(1), 35-44.

Lang, P. J. (1968). Fear reduction and fear behavior: Problems in treating a construct. *Research in Psychotherapy, 3,* 90–102.

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (1997). Motivated attention: affect, activation, and action. In P. J. Lang, R. F. Simons, & M. Balaban (Eds.), *Attention and orienting: Sensory and motivational processes* (pp. 97-135). New Jersey: Lawrence Erlbaum Associates.

Lang, P. J., Greenwald, M. K., Bradley, M. M., & Hamm, A. O. (1993). Looking at pictures: affective, facial, visceral, and behavioral reactions. *Psychophysiology, 30*(3), 261–273.

Larsen, J. T., Norris, C. J., & Cacioppo, J. T. (2003). Effects of positive and negative affect on electromyographic activity over zygomaticus major and corrugator supercilii. *Psychophysiology, 40*(5), 776-785.

Lanteigne, D. M., Flynn, J. J., Eastabrook, J. M., & Hollenstein, T. (2014). Discordant patterns among emotional experience, arousal, and expression in adolescence: Relations with emotion regulation and internalizing problems. *Canadian Journal of Behavioural Science/Revue Canadienne des Sciences du Comportement, 46*(1), 29.

Lazarus, R. S. (1991). *Emotion and adaptation.* New York, NY: Oxford University Press.

Lerner, J.S., & Keltner, D. (2000). Beyond valence: Toward a model of emotion-specific influences on judgment and choice. *Cognition & Emotion, 14*, 473–493.

Levenson, R. W. (1988). Emotion and the autonomic nervous system: a prospectus for research on autonomic specificity. In H. L. Wagner (Ed.). Social psychophysiology and emotion: Theory and clinical applications (pp. 17–42). New York, NY: Wiley.

Levenson, R. W. (1994). Human emotions: A functional view. In P. Ekman & R. J. Davidson (Eds.), *The nature of emotion: Fundamental questions* (pp. 123-126). New York: Oxford University Press.

Lovallo, W. R. (2005). *Stress and health: Biological and psychological interactions* (2nd ed.). Thousand Oaks, CA: Sage Publications.

Macey, P. M., Ogren, J. A., Kumar, R., & Harper, R. M. (2016). Functional imaging of autonomic regulation: methods and key findings. *Frontiers in Neuroscience, 26*, 513.

Mandler, G., Mandler, J. M., Kremen, I., & Sholiton, R. (1961). The response to threat: Relations among verbal and physiological indices. *Psychological Monographs, 75* (513).

Marroquín, B., Boyle, C.C., Nolen-Hoeksema, S., & Stanton, A.L. (2016). Using emotion as information in future-oriented cognition: Individual differences in the context of state negative affect. *Personality and Individual Differences, 95*, 121-126.

Mauss, I. B., Levenson, R. W., McCarter, L., Wilhelm, F. H., & Gross, J. J. (2005). The tie that binds? Coherence among emotional experience, behavior, and autonomic physiology. *Emotion, 5,* 175–190.

Mauss, I. B., & Robinson, M. D. (2009). Measures of emotion: A review. *Cognition and Emotion, 23,* 209–237.

Mauss, I., Wilhelm, F., & Gross, J. (2004). Is there less to social anxiety than meets the eye? Emotion experience, expression, and bodily responding. *Cognition and Emotion*, *18*, 631-642.

McClure, E. B. (2000). A meta-analytic review of sex differences in facial expression processing and their development in infants, children, and adolescents. *Psychological Bulletin, 126*, 424–453.

Neumann, S. A., & Waldstein, S. R. (2001). Similar patterns of cardiovascular response during emotional activation as a function of affective valence and arousal and gender. *Journal of Psychosomatic Research, 50*(5), 245-253.

Norman, G. J., Berntson, G. G., & Cacioppo, J. T. (2014). Emotion, somatovisceral afference, and autonomic regulation. *Emotion Review, 6*, 113-123.

Obrist, P. A. (1976). The cardiovascular-behavioral interaction – as it appears today. *Psychophysiology*, *13*, 95–107.

Perneger, T. V. (1998). What's wrong with Bonferroni adjustments. *British Medical Journal, 316*(7139), 1236–1238.

Plant, E. A., Hyde, J. S., Keltner, D., & Devine, P. G. (2000). The gender stereotyping of emotions. *Psychology of Women Quarterly*, *24*, 81–92.

Poppelaars, E. S., Klackl, J., Pletzer, B., Wilhelm, F. H., & Jonas, E. (2019). Social-evaluative threat: Stress response stages and influences of biological sex and neuroticism. *Psychoneuroendocrinology*, *109*, 104378.

Rattel, J. A., Wegerer, M., Miedl, S. F., Blechert, J., Grünberger, L. M., Craske, M. G., & Wilhelm, F. H. (2019). Peritraumatic unconditioned and conditioned responding explains sex differences in intrusions after analogue trauma. *Behaviour Research and Therapy*, *116*, 19-29.

Reisenzein, R. (2000). Exploring the strength of association between the components of emotion syndromes: The case of surprise. *Cognition & Emotion, 14,* 1–38.

Roberts, N. A., Levenson, R. W., & Gross, J. J. (2008). Cardiovascular costs of emotion suppression cross ethnic lines. *International Journal of Psychophysiology*, *70*(1), 82-87.

Rosenberg, E. L. & Ekman, P. (1994). Coherence between expressive and experiential systems in emotion. *Cognition and Emotion, 8(3)*, 201-229.

Rottenberg, J., Kasch, K. L., Gross, J. J., & Gotlib, I. H. (2002). Sadness and amusement reactivity differentially predict concurrent and prospective functioning in major depressive disorder. *Emotion*, *2*(2), 135-146.

Rottenberg, J., Ray, R. D., & Gross, J. J. (2007). Emotion elicitation using films. In J. A. Coan, J. J. B. Allan (Eds.), *The Handbook of Emotion Elicitation and Assessment* (pp. 9-28). London: Oxford University Press.

Russell, J. A., & Barrett, L. F. (1999). Core affect, prototypical emotional episodes, and other things called emotion: Dissecting the elephant. *Journal of Personality and Social Psychology, 76*(5), 805-819.

Sanders, A. F. (2001). Dual task performance. *International Encyclopedia of the Social & Behavioral Sciences,* 3888-3892.

Scherer, K. R. (1984). On the nature and function of emotion: A component process approach. In K. R. Scherer & P. Ekman (Eds.), *Approaches to emotion* (pp. 293-317). Hillsdale, NJ: Erlbaum.

Scherer K. (2013). The evolutionary origin of multimodal synchronization in emotional expression. *Journal of Anthropological Sciences, 91*, 185-200.

Sherwood, A., Allen, M. T., Fahrenberg, J., Kelsey, R. M., Lovallo, W. R., & van Doornen, L. J. P. (1990). Methodological guidelines for impedance cardiography. *Psychophysiology, 27*(1), 1–23.

Siegel, S. J., & Alloy, L. B. (1990). Interpersonal perceptions and consequences of depressive-significant other relationships: a naturalistic study of college roommates. *Journal of Abnormal Psychology*, *99*(4), 361-373.

Stemmler, G. (1992). *Differential psychophysiology: Persons in situations.* Berlin, Germany: Springer-Verlag.

Stemmler, G. (2004). Physiological processes during emotion. In P. Philippot, & R. S. Feldman (Eds.), *The regulation of emotion* (pp. 33-70). New Jersey: Lawrence Erlbaum Associates.

Stone, L. A., & Nielson, K. A. (2001). Intact physiological response to arousal with impaired emotional recognition in alexithymia. *Psychotherapy and Psychosomatics*, *70*(2), 92-102.

Sze, J.A., Gyurak, A., Yuan, J.W., & Levenson, R.W. (2010). Coherence between emotional experience and physiology: does body awareness training have an impact? *Emotion, 10*(6), 803-814.

Van Egeren, L. F., Feather, B. W., & Hein, P. L. (1971). Desensitzation of phobias: Some psychophysiological propositions. *Psychophysiology, 8,* 213–228.

Van Doornen, L.J. P. (1986). Sex differences in physiological reactions to real life stress and their relationship to psychological variables. *Psychophysiology, 23*, 657-662.

Vrana, S. R. (1993). The psychophysiology of disgust: differentiating negative emotional contexts with facial EMG. *Psychophysiology, 30(3),* 279-286.

Wilhelm, F.H., Gevirtz, R., & Roth, W.T. (2001). Respiratory dysregulation in anxiety, functional cardiac, and pain disorders: assessment, phenomenology, and treatment. *Behavior Modification, 25*(4), 513-545.

Wilhelm, F. H., Grossman, P., & Roth, W. T. (2005). Assessment of heart rate variability during alterations in stress: complex demodulation vs. spectral analysis. *Biomedical Sciences Instrumentation, 41,* 346-351.

Wilhelm, F. H., Pfaltz, M. C., Grossman, P., & Roth, W. T. (2006). Distinguishing emotional from physical activation in ambulatory psychophysiological monitoring. *Biomedical Sciences Instrumentation*, *42*, 458-463.

Wilhelm, F. H., Rattel, J. A., Wegerer, M., Liedlgruber, M., Schweighofer, S., Kreibig, S. D., ... & Blechert, J. (2017). Attend or defend? Sex differences in behavioral, autonomic, and respiratory response patterns to emotion–eliciting films. *Biological Psychology*, *130*, 30-40.

Wilhelm, F.H., & Roth, W.T. (1998a). Taking the laboratory to the skies: Ambulatory assessment of self-report, autonomic, and respiratory responses in flying phobia. *Psychophysiology*, *35*(5), 596-606.

Wilhelm, F.H., & Roth, W.T. (1998b). Using minute ventilation for ambulatory estimation of additional heart rate. *Biological Psychology, 49*(1-2), 137-50.

Zar, J. H. (1972). Significance testing of the Spearman rank correlation coefficient. *Journal of the American Statistical Association*, *67*(339), 578-580.

Tables

Table 1.

Means (SD) of concordance indices for self-reported arousal and valence with physiological and behavioral measures as well as effects of Sex and Affect Dimension (arousal/valence) on concordance indices.

Concordance indices	Arousal (low – high)		Valence (pleasant – unpleasant)		Main effect Sex	Main effect Affect Dimension
	Women *M (SD)*	Men *M (SD)*	Women *M (SD)*	Men *M (SD)*		
Cardiovascular, HR	.273(.27)*** [27.3%]	-.045(.29) [18.2%]	.119(.32) [18.2%]	-.242(.21)*** [13.6%]	F(1,42)=20.27, ***p*<.001**, η^2=.33, ♀>♂, M_{Dif}=.375 [.207; .543]	F(1,42)=20.43, ***p*<.001**, η^2=.33, **A>V**, M_{Dif}=.194 [.108; .281]
Electrodermal, nsSCR	.664(.17)*** [90.9%]	.476(.27)*** [68.2%]	.334(.30)*** [36.4%]	.109(.26) [4.6%]	F(1,42)=9.85, ***p*=.003**, η^2=.18, ♀>♂, M_{Dif}=.274 [.098; .451]	F(1,42)=124.25, ***p*<.001**, η^2=.75, **A>V**, M_{Dif}=.463 [.379; .547]
Electrodermal, SCL	.428(.29)*** [50.0%]	.310(.19)*** [31.8%]	.240(.28)** [18.2%]	.032(.22) [4.5%]	F(1,42)=6.91, ***p*=.012**, η^2=.14, ♀>♂, M_{Dif}=.197 [.045; .349]	F(1,42)=41.12, ***p*<.001**, η^2=.50, **A>V,** M_{Dif}=.276 [.190; .362]
Respiration, RR	.465(.25)*** [54.6%]	.278(.39)** [50.0%]	.287(.35)** [50.0%]	.088(.26) [13.6%]	F(1,42)=4.41, ***p*=.042**, η^2=.10, ♀>♂, M_{Dif}=.220 [.009; .432]	F(1,42)=21.99, ***p*<.001**, η^2=.34, **A>V**, M_{Dif}=.235 [.134; .336]
Sympathetic, PEP	-.336(.27)*** [50.0%]	-.051(.33) [18.2%]	-.175(.28)* [18.2%]	.034(.25) [9.1%]	F(1,42)=9.86, ***p*=.003**, η^2=.19, ♀>♂, M_{Dif}=-.262 [-.430; -.094]	F(1,42)=8.67, ***p*=.005**, η^2=.17, **A>V**, M_{Dif}=-.142 [-.239; -.045]
Para-sympathetic, RSA	-.217(.39)* [36.4%]	.019(.32) [13.6%]	-.095 (.42) [31.8%]	.051(.23) [4.5%]	F(1,42)=4.00, ***p*=.052,** η^2=.09, **(♀>♂)**, M_{Dif}=-.233 [-.468; .002]	F(1,42)=4.58, ***p*=.038,** η^2=.09, **A>V**, M_{Dif}=-.093 [-.180; -.005]
Behavioral, *m. corrugator*	.299(.23)*** [18.2%]	.097(.34) [27.3%]	.478(.36)*** [72.7%]	.301(.30)*** [31.8%]	F(1,42)=5.70, ***p*=.022**, η^2=.12, ♀>♂, M_{Dif}=.239 [.037; .442]	F(1,42)=22.40, ***p*<.001**, η^2=.35, **A<V**, M_{Dif}=-.266 [-.380; -.153]
Behavioral, *m. zygomaticus*	.230(.30)** [18.2%]	.045(.27) [9.1%]	-.113(.28) [4.5%]	-.178 (.26)** [18.2%]	F(1,42)=2.86, p=.098, η^2=.06, (♀<♂), M_{Dif}=.134 [-.026; .294]	F(1,42)=39.40, ***p*<.001**, η^2=.47, **A<V**, M_{Dif}=.309 [.210; .409]

Note: Percentage values reported in brackets represent percentage of participants displaying an individually significant concordance index with /*r*/>.443; *F* = test statistic; HR = heart rate; nsSCR = non-specific skin conductance responses; SCL = skin conductance level; RR = respiratory rate; PEP = preejection period; RSA = respiratory sinus arrhythmia; see Methods for details; M_{Dif} = mean difference between affect dimensions or between women

and men (brackets indicate 95% confidence intervals).
***p<.001, **p<.01, *p<.05 for concordance indices being significantly different from zero.

Table 2.

Within-subject variance (SDs) across emotional films for self-reported arousal and valence, physiological, and behavioral measures, testing for sex differences.

	Mean SDs Women	*Mean SDs* Men	*Mean difference (with CI) between women and men*	*t*(42)	*p*	*Cohen`s d*
Arousal	26.75	22.25	4.51 [-.10; 9.11]	1.98	.055	.57
Valence	27.24	21.80	5.44 [.03; 10.85]	2.04	**.049**	.62
Cardiovascular, HR	3.39	3.02	.37 [-.58; 1.31]	.79	.437	.24
Electrodermal, nsSCR	3.09	3.14	-.06 [-.54; 43]	-.23	.817	.06
Electrodermal, SCL	.93	.69	-.24[-.51; .03]	-1.77	.084	.53
Respiration, RR	1.79	1.84	-.05 [-.51; .42]	-.214	.832	.07
Sympathetic, PEP	6.08	5.50	.59 [-1.34; 2.51]	-.62	.541	.18
Parasympathetic, RSA	5.73	4.25	1.48 [-.26; 3.22]	1.73	.093	.52
Behavioral, *m. corrugator*	2.30	1.16	1.14 [.45; 1.83]	3.39	**.002**	1.00
Behavioral, *m. zygomaticus*	.98	1.16	-.18 [-.90; .53]	-.52	.606	.27
Body movement	.21	.23	-.02 [-.15; .10]	-.36	.721	.10

Note: CI= 95% confidence intervals; see Table 1 for other abbreviations.

Figure Captions

Figure 1. Depiction of the time course of arousal and SCL and concordance between them for one example participant (Subject 223). Panel A depicts averaged responses to the 15 film clips (x-axis), yielding 15 measurement points. Black measurement points represent self-reported arousal assessed immediately after each film clip (left y-axis), light grey measurement points represent SCL averages (right y-axis) measured during the respective film clip. Panel B depicts an exemplary scatterplot (Subject 223) for arousal and SCL. Panel C depicts the ranked relationship between arousal and SCL and the resulting nonparametric correlation measure (ρ), serving as concordance index for subsequent analyses.

Figure 2. Sex differences in concordance between affect dimension (arousal/valence) and measures from autonomic, respiratory, and behavioral response systems. Each point represents one subject`s Spearman correlation of pairs of measures across 15 films (individual concordance index).

Figures

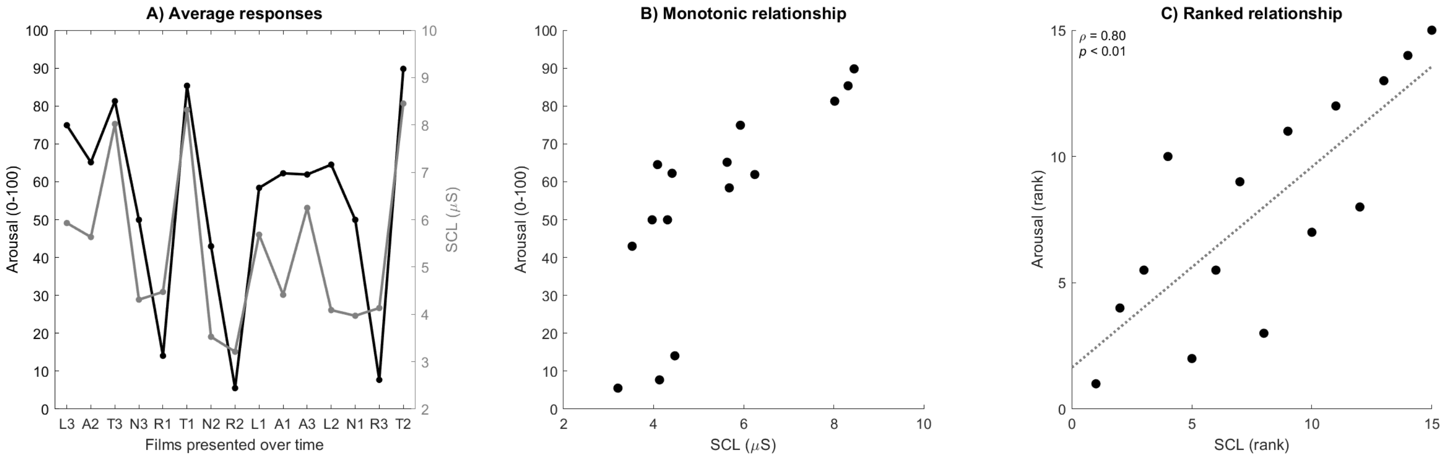

Figure 1

Note: L3 = loss film 3; A2 = achievement film 2; T3 = threat film 3; N3 = neutral film 3; R2=recreation film 2, etc; SCL = skin conductance level.

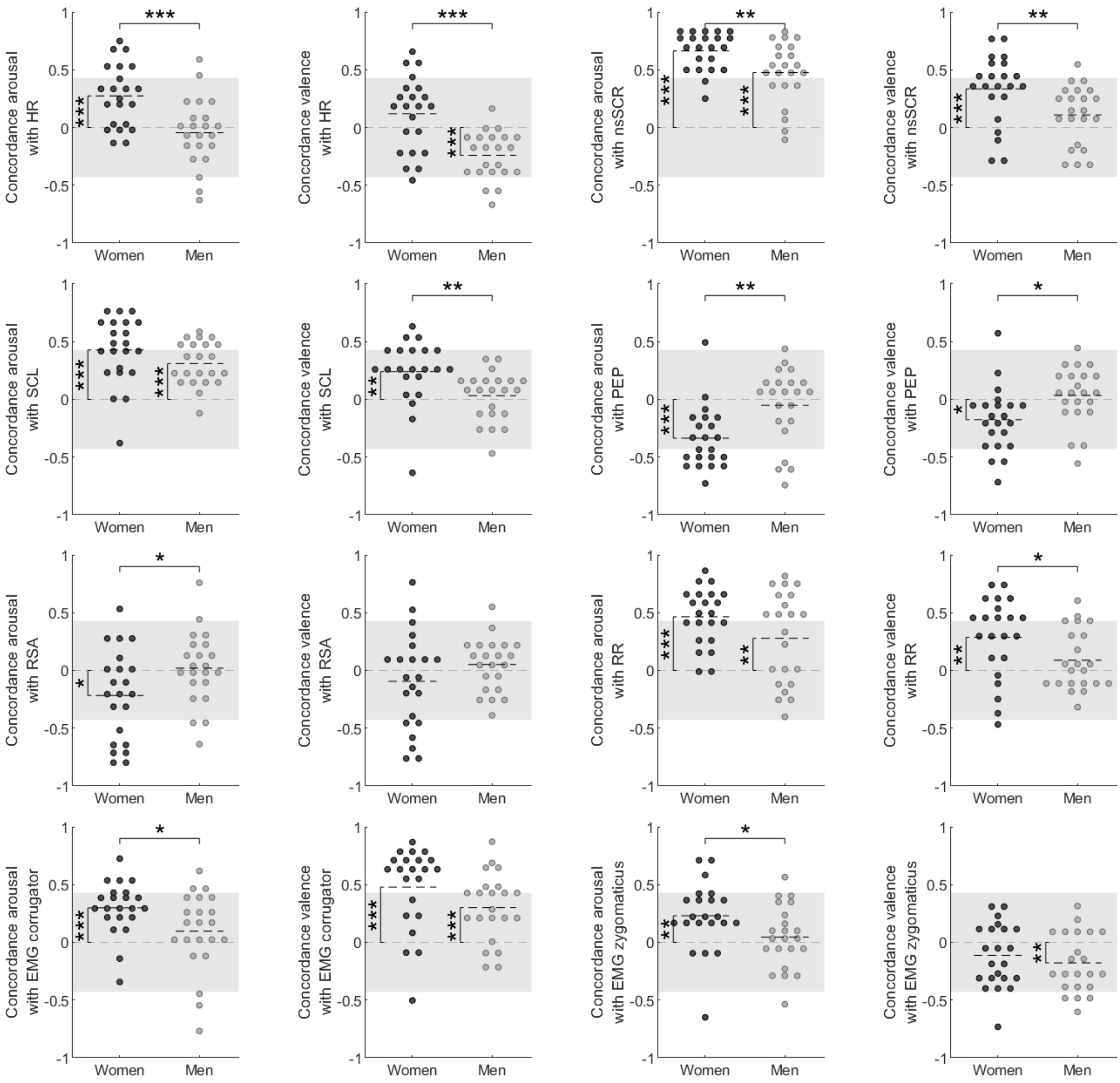

Figure 2

Note: Dashed horizontal lines represent the mean concordance for women and men, respectively; grey areas indicate regions of non-significance of individual concordance indices ($/r/ \leq .443$; df=13, one-tailed p<.05); vertical brackets indicate significant difference from zero correlation and horizontal brackets indicate significant sex differences. The directionality of concordance for valence with other measures is based on self-reported valence scaled from positive (lower scores) to negative (higher scores); thus, for example, positive concordance of valence with SCL indicates that more negative valence ratings were linked to higher SCL; see Table 1 for abbreviations.

***p<.001, **p<.01, *p<.05.