Behavioral and Physiological Stress Responses:

Within-person Concordance during Pregnancy

Robert D. Vlisides-Henry[a*], Pascal R. Deboeck[a], Wendy Grill-Velasquez[a], Shantavia Mackey[a], Dinesh K. A. Ramadurai[a], Joshua O. Urry[a], Dylan Neff[a], Sarah Terrell[d], Mengyu (Miranda) Gao[a], Leah R. Thomas[a], & Elisabeth Conradt[a,c,e], Sheila E. Crowell[a,b,c*]

[a] 380 S 1530 E, Room 502, Dept. of Psychology, University of Utah, Salt Lake City, UT, USA 84112

[b] 501 Chipeta Way, Dept. of Psychiatry, University of Utah, Salt Lake City, UT, USA 84108

[c] 30 N 1900 E, Dept. of Obstetrics and Gynecology, University of Utah, Salt Lake City, UT, USA 84132

[d] 115 Health and Human Development Building, Dept. of Human Development and Family Studies, Pennsylvania State University, State College, PA, USA 16802

[e] 295 Chipeta Way, Dept. of Pediatrics, University of Utah, Salt Lake City, UT, USA 84108

[*]**Corresponding Author:** Robert D. Vlisides-Henry, robert.vlisideshenry@psych.utah.edu and sheila.crowell@psych.utah.edu

Open Practices Statement: The hypotheses and analytic plan were pre-registered on the Open Science Framework (OSF) on December 29, 2018. The following is a private link to the pre-registration document, embargoed until manuscript acceptance—**please do not circulate this link:** https://osf.io/5dev9/?view_only=82774f7f78b24d178c960ee5420a9529. Data and code will be uploaded to OSF post-publication as feasible. Coded participant videos will *not* be uploaded to protect confidentiality, though example training tapes will be uploaded as feasible.

This is a pre-proof version of the final paper accepted at Biological Psychology in January 2021.

Please cite this paper as:

Vlisides-Henry, R. D., Deboeck, P. R., Grill-Velasquez, W., Mackey, S., Ramadurai, D. K. A., Urry, J. O., Neff, D., Terrell, S., Gao, M., Thomas, L., Conradt, E., & Crowell, S. E. (2021). Behavioral and physiological stress responses: Within-person concordance during pregnancy. *Biological Psychology, 159*, 108027. https://doi.org/10.1016/j.biopsycho.2021.108027

Acknowledgements

We would like to thank all of the participants who contributed their time and energy to help make this project possible. We would also like to thank the numerous research assistants in the Child Adaptation and Neurodevelopment (CAN) Lab at the University of Utah who assisted greatly throughout the larger study's data collection and cleaning processes. We also acknowledge tremendous support from the University of Utah OBGYN Research Network staff for help with participant screening and recruitment. Finally, we thank the University of Vice President's Clinical Translational Research Scholars program for their mentorship and grantsmanship assistance.

This manuscript was supported by the National Institute of Mental Health under awards R21MH109777 and R01MH119070-01 (SEC & EC), a Career Development Award from the National Institute on Drug Abuse, 7K08DA038959-02 (EC), as well as grants from the University of Utah Consortium for Families and Health Research and Interdisciplinary Research Pilot Program. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institute of Mental Health or the National Institute on Drug Abuse.

Abstract

During pregnancy, a woman's emotions can have longstanding implications for both her own and her child's health. Within-person emotional concordance refers to the simultaneous measurement of emotional responses across multiple levels of analysis. This method may provide insight into how pregnant women experience emotions in response to stress. We enrolled 162 pregnant women and assessed concordance through autonomic physiology (electrodermal activity [EDA], respiratory sinus arrhythmia [RSA]), and coded behavior (Prosocial, Flight, Displacement) during the Trier Social Stress Test–Speech. We used multilevel models to examine behavioral-physiological concordance and whether self-reported emotion dysregulation moderated these effects. Participants exhibited EDA-Prosocial concordance, suggesting that prosocial behavior may be a marker of stress. Emotion dysregulation did not moderate concordance. These findings provide novel information about behavioral coping to stress in pregnancy. Given the importance of observed behavior in the maintenance and treatment of psychopathology, these findings may provide a launchpad for future perinatal intervention research.

Keywords: concordance, pregnancy, electrodermal activity, respiratory sinus arrhythmia, emotion dysregulation

Behavioral and physiological stress responses:

Within-person concordance during pregnancy

Pregnancy is a critical time for supporting maternal mental health. Prenatal maternal psychopathology may affect a developing child's long-term outcomes through influences on the intrauterine environment (Conradt, Adkins, Crowell, Monk, & Kobor, 2018; Davis et al., 2007; Doyle & Cicchetti, 2018; Guerri, 1998; Laplante et al., 2004; Lester et al., 2011; Liu et al., 2010; Lupien, McEwen, Gunnar, & Heim, 2009; Monk et al., 2011; Monk & Hane, 2016), referred to as fetal programming. Fetal programming may help explain some origins of maladaptive development over the first years of life (Wadhwa, Buss, Entringer, & Swanson, 2009). For instance, stress-exposed fetuses are more likely to develop anxiety later in life (see Rakers et al., in press). In addition to the developing child, women may also be "programmed" by pregnancy (Glynn, Howland, & Fox, 2018). Research to date has focused heavily on child outcomes but fewer studies have examined the emotional, behavioral, and physiological experiences of pregnant women.

During the perinatal period, women experience numerous physiological changes due to enhanced biobehavioral plasticity, most of which serve to prepare for child bearing and parenting (Glynn et al., 2018). For instance, pregnant women experience remarkable shifts in neuroendocrine activity over the course of gestation, including heightened cardiac output, blood pressure, and autonomic activation (see Christian, 2012; Torgersen & Curran, 2006). There is also an increase in the functional connectivity between areas of the brain associated with attachment and sensitivity (see also Glynn et al., 2018). Many of these changes are adaptive in the shift to parenthood (e.g., corresponding changes in white and gray matter appear to facilitate mother-child attachment capacity; Hoekzema et al., 2017). However, some women may be more sensitive to the physiological and hormonal changes of pregnancy and subsequently may be at increased risk for psychopathology, such as postpartum depression and suicidality (Glynn et al., 2018). Despite this risk, mental health problems are underdiagnosed during pregnancy (e.g., Carter & Kostaras, 2005). Failing to account for prenatal risk factors may make perinatal women (and their developing children) more vulnerable. To better identify and treat the mental health concerns of pregnant women, we need to have a better grasp of the various factors that may underlie maternal mental health problems during this sensitive time.

Emotions may provide a window into mechanisms underlying prenatal mental health risk. The relations between emotion dynamics and health are highly complex. Nevertheless, evidence indicates that flexible emotional responsivity and regulation denote health, particularly when buoyed by more positive than negative affect (e.g., Kashdan & Rottenberg, 2010; Koval & Kuppens, 2012; Stellar et al., 2015). On the other hand, strong, volatile negative emotional experiences appear to be related to numerous psychological disorders (e.g., Aldao & Nolen-Hoeksema, 2010; Beauchaine, 2015a, 2015b; Beauchaine & Zisner, 2017; Crowell, Vlisides-Henry, & Kaliush, 2020). Given that complex emotions can change rapidly in response to stimuli, it makes sense that affective well-being is best understood as an emergent, dynamic, and multifaceted construct (Coan, 2010). Indeed, many classical emotion theorists have argued that it is crucial to examine human emotions as *coordinated responsivity* across measurements, with respect to meeting contextual demands (see e.g., Darwin, 1872; Ekman, 1973, 1992; James, 1884). By understanding how emotions function prenatally through multivariate (i.e., with more than one construct-specific variable) and dynamic assessment, we might ultimately improve our ability to detect and treat mental health concerns during pregnancy, bolstering well-being of peripartum women and infants.

Within-person concordance: A multivariate marker of emotional health

Within-person concordance (herein, *concordance*) is best understood as coherent responding across an individual's physiology, behavior, and/or cognitive levels of emotion to meet environmental demands (Feldman Barrett, 2006; Fischer & Roseman, 2007; Friedman, Stephens, & Thayer, 2014; Gross, 2015; Hollenstein & Lanteigne, 2014; Lang, 1994; Lazarus, 1991; Quigley & Feldman Barrett, 2014). For instance, perceiving a significant threat will likely prompt intense fear- and arousal-based physiology and behavior (e.g., increased heart rate and sweat, freezing behavior), all of which may ultimately help the organism recruit sufficient resources to engage in a fight-flight response (Cannon, 1932; James, 1894). The result is a *functional concordant response* across multiple facets of fear (Levenson, 1994). Depending on the emotion at play and the respective markers, concordance can also be either positive or negative. Positive concordance is when emotional markers move in the same direction to meet demands, and negative is when markers move in opposing directions (see e.g., Crowell et al., 2014).

Despite decades of theorizing about emotional concordance, this phenomenon has proven challenging to measure. One reason could be that laboratory stimuli used to evoke emotional responsivity often do not prompt strong affect to observe concordance (Butler, Gross, & Barnard, 2014; Hollenstein & Lanteigne, 2014). If emotions function to motivate behavior such that an organism can act to meet contextual demands, it would make sense that the most evocative stimuli should prompt the most visible concordance (e.g., intense fear prompts observable fight-flight; Friedman et al., 2014; Stemmler, 2004). For instance, individuals with phobias tend to experience more concordance to fear-eliciting stimuli than non-phobic controls (Schaefer, Larson, Davidson, & Coan, 2014). In addition to evocative stimuli, more recent research suggests that concordance may also be moderated by individual differences, such as biological sex (Rattel, Mauss, Liedlgruber, & Wilhelm, 2020). However, little research has been done to examine how other individual differences might be related to concordance and emotion dynamics. For instance, it stands to reason that the more individuals struggle to regulate their emotions, the less their emotion markers might cohere in response to a stimulus.

Key Constructs

Little is known about *emotional responsivity* during pregnancy, as dynamic emotional assessments require multivariate measurement (Coan, 2010). We examine minute-to-minute behavioral-physiological concordance in a large sample of pregnant women—a group for whom there are potentially critical, downstream implications of intense emotion (e.g., on postpartum psychopathology or fetal neurodevelopment; Ostlund et al., 2019). Studying concordance could provide a novel window into the emotional and mental health of pregnant women, as no prior research has examined concordance during pregnancy. The primary goal of this study is to utilize a validated stress-inducing paradigm (Trier Social Stress Test, TSST; Kirschbaum, Pirke, & Hellhammer, 1993) to examine concordance between measures of psychophysiology and observed behavior across prosocial- and stress-based emotions. We also explore how concordance is affected by individual differences in self-reported emotion dysregulation, a transdiagnostic marker of psychopathology risk (i.e., a risk factor that spans multiple diagnostic criteria). Moreover, we examine stress responsivity during a well-validated stress task, in the context of pregnancy. Very few studies have examined the effects of the TSST on pregnant women's stress outcomes (e.g., Deligiannidis et al., 2016; Klinkenberg et al., 2009), and to our knowledge none of these peer-reviewed studies has employed coded behavior. Thus, our study contributes novel information about basic stress responsivity in pregnant women.

Autonomic-behavioral responsivity. Coding observed behavior, and its moment-by-moment association with autonomic physiology, provides one way to assess emotional activity in response to a powerful social stressor. This type of concordance assessment seems to provide unique insight into how individuals express strong affect (e.g., Butler et al., 2014; Crowell et al., 2014). For instance, the TSST is a widely used stress-inducing paradigm that prompts feelings of arousal and anxiety (for a review, see Allen, Kennedy, Cryan, Dinan, & Clarke, 2014). However, researchers have also found that women may respond to social stress somewhat uniquely. Villada and colleagues (2014) found that, during the TSST, women primarily expressed anxious and prosocial (or affiliative) behavior. This finding supports a growing body of evidence that stress can prompt mixed biobehavioral responses in women, both positive (e.g., affiliative) and negative (e.g., anxiety, fear; see Het & Wolf, 2012; Rattel et al., 2020; Taylor et al., 2000).

The behavioral coding scheme used by Villada et al. (2014), the Ethological Coding System for Interview (Troisi, 1999), allows for quantification of stress-management behavior. This scheme contains summary scores for Prosocial (affiliative behaviors, such as smiling), Flight (avoidant/withdrawn anxious behavior, such as avoiding eye contact), and Displacement behavior (overt signs of anxious distress, such as fidgeting). The ECSI has proven highly effective for measuring behavioral coping in response to the TSST (e.g., Bellagambi et al., 2018; Lam et al., 2009; Mohiyeddini, Bauer, & Semple, 2013; Sgoifo et al., 2003; Villada et al., 2014). Prior to this study, the ECSI has not been used to quantify concordance, let alone in the context of pregnancy. However, psychophysiological evidence and theory suggest that coded Prosocial, Flight, and Displacement should associate clearly with specific facets of autonomic activity (see Dawson, Schell, & Filion, 2017; Porges, 2001, 2007).

Respiratory sinus arrhythmia (RSA) is a marker of parasympathetic vagal tone and health

(Billman, 2011), in addition to being a robust index of emotion dysregulation (Beauchaine, 2001, 2015a, 2015b; Beauchaine & Thayer, 2015). Polyvagal Theory (Porges, 2007) provides a framework for understanding associations between RSA and these constructs. Due to vagal nerve innervation of the heart, beat-to-beat variability in heart rate is known to reflect dynamic changes in parasympathetic tone. RSA also associates with prosocial and approach behavior (e.g., Cui et al., 2015; Stifter & Corey, 2001), likely because social motivation is mediated by parasympathetic activity (Porges, 2001). Thus, vagal activation, and in turn higher RSA, is associated with well-being, positive emotion, and prosocial behavior (most clearly in adults). Vagal withdrawal, and lower RSA, in response to threat associates with fight-flight behavior, especially when there is also coordinated sympathetic nervous system responding (Beauchaine & Thayer, 2015; Porges, 2003). During a social stressor like the TSST, we would expect RSA to be positively concordant with ECSI Prosocial behaviors and negatively concordant with Flight and Displacement.

Electrodermal activity (EDA) is a measure of sympathetically-mediated eccrine sweat gland permeability. EDA is typically quantified through changes in electrical potential across the outer layers of skin, typically on the palm of the hand or sole of the foot (Dawson et al., 2017). Nonspecific skin conductance responses during a stress task are a robust measure of sympathetic activity, fight-flight motivation, arousal, fear, and anxiety (Beauchaine, 2001; Cuthbert, Bradley, & Lang, 1996; Dawson et al., 2017; Lang, Greenwald, Bradley, & Hamm, 1993; Fowles, 1988; Schaefer et al., 2014; Wallin, 1981; Witvliet & Vrana, 1995). The sympathetic nervous system is also known to mediate short-term social activity and affiliative behavior (e.g., meeting someone new can prompt EDA; Schwartz & Shapiro, 1973). EDA may be positively concordant with ECSI Flight, Displacement, and Prosocial behaviors in pregnant women. However, very little concordance research has been conducted with pregnant women, a fact that is further complicated by the changes that occur throughout pregnancy.

There are numerous physiological changes that occur throughout pregnancy. In general, over the course of gestation, stress system activity (via the HPA axis and sympathetic nervous system) increases and parasympathetic activity decreases (see Christian, 2012; Kuo, Chen, Yang, Lo, & Tsai, 2000; Lindsay & Nieman, 2005). There is also some evidence that EDA and RSA reactivity become more blunted during pregnancy (DiPietro, Mendelson, Williams, & Costigan, 2012), which may serve to protect the fetus from exposure to extreme fluctuations in physiological stress (Christian, 2012). For these reasons, it is somewhat unclear the extent to which it is even possible to detect concordant responsivity in pregnant women. This is why one of our overarching goals was to confirm the ability to effectively measure concordance with respect to key individual differences.

Emotion dysregulation and concordance. Emotion regulation, or the ability to regulate one's emotions in response to the environment and individual goals, is associated with mental health and well-being (e.g., Beauchaine, 2015a; Gross, 2015). Difficulties with emotion regulation are defining features of numerous forms of psychopathology, including anxiety and depression (e.g., Folk, Zeman, Poon, & Dallaire, 2014), bipolar disorder (e.g., Green, Cahill, & Malhi, 2007), and borderline personality disorder (e.g., Crowell et al., 2012). These difficulties, often called *emotion dysregulation*, can be thought of as a pattern of experienced and expressed affect that tends to be too intense or labile, interfering with goals and interpersonal behavior (Beauchaine & Crowell, 2020; Crowell et al., 2020; Gratz & Roemer, 2004). Emotion dysregulation interacts with contextual factors to shape health and behaviors across the lifespan. (Crowell, Puzia, & Yaptangco, 2015).

If concordance serves as a marker of emotional functioning in response to a distressing task, those who are highly emotionally dysregulated might show unique patterns of concordance. For instance, individual differences in prenatal maternal emotion dysregulation appear to moderate RSA reactivity to an infant crying (Lin et al., 2019). Crowell and colleagues (2014) examined both between- and within-person concordance in adolescent-mother dyads. They found that adolescents with depression and their mothers exhibited higher levels of within-person negative concordance between RSA and aversive behaviors, with lower RSA corresponding with higher aversiveness minute-by-minute. In contrast, typical controls did not show a concordant pattern, suggesting that concordance of emotional responses may be affected by psychopathology and emotion dysregulation.

On the other hand, other researchers found that engaging in other regulatory strategies, such as emotional suppression, may *reduce* concordance (Brown et al., in press; Butler et al., 2014; Dan-Glauser & Gross, 2013). However, it is worth noting that attenuation of concordance via suppression may actually be a marker of effective regulatory capacity. In some contexts, it can be better to mute behavioral responsivity despite strong emotion (e.g., when trying to manage feelings of anger when in a discussion with a close other; Crowell et al., 2014). Thus, there are mixed findings regarding emotion dysregulation and concordance, though there is still relatively little research. No studies to our knowledge have examined how individual differences in broadband emotion dysregulation (i.e., with state- and trait-like qualities) moderates concordance patterns, as most have focused on diagnostic groups or a specific regulatory strategy (e.g., emotional suppression).

Hypotheses

In this study, we examine behavioral-physiological concordance over the course of the TSST

Speech task in a sample of pregnant women, and aims were pre-registered on the Open Science Framework (see also Supplementary Material). To test for concordance, we use random intercept multilevel models, testing whether physiology associates with minute-by-minute behavior. We hypothesize the following patterns over the course of the stressor.

(1) We expect concordance in the positive direction (i.e., as physiological activity increases/decreases, so does behavioral activity) for the following behavior-physiology pairs:

+ Prosocial behaviors ~ RSA (H1a)
+ Prosocial behaviors ~ EDA (H1b)
+ Flight behaviors ~ EDA (H1c)
+ Displacement behaviors ~ EDA (H1d)

(2) We expect concordance in the negative direction (i.e., as physiological activity *decreases or increases,* behavioral activity *moves in the opposite direction*) for the following pairs:

- Flight behaviors ~ RSA (H2a)
- Displacement behaviors ~ RSA (H2b)

We also pre-registered exploratory analyses of how individual differences in self-reported emotion dysregulation moderate concordance. Finally, we test the interaction of emotion dysregulation and physiology on behavior for each of the above hypotheses (termed H3a-d and H4a-b, respectively). Given the dearth of research on emotion dysregulation moderating concordance, we did not make predictions about emotion dysregulation effects.

Method

Participants

We recruited 162 third-trimester pregnant women via the Difficulties in Emotion Regulation Scale (DERS; Gratz & Roemer, 2004), in a manner where those with both high and low self-reported DERS scores were oversampled. This approach yielded a uniform distribution of DERS scores. Additional inclusion criteria included age 18-40, at least 26 weeks gestation, and singleton pregnancy. Exclusion criteria were a diagnosis of gestational diabetes or preeclampsia and self-reported illicit substance use during pregnancy. Women were recruited from obstetrics and gynecology clinics. They were approached by study staff with details about the project and, if they consented, were asked to complete the DERS. If women met additional inclusion criteria, they were scheduled for a laboratory visit. Mean age of the 162 participants was 29 (*SD* = 5.2), 54% identified as non-Hispanic White, 9% Asian, 4% Black/African American, 4% American or Alaskan Native, 4% Hawaiian or Pacific Islander, 6% multiracial, and 27% of all women identified as Hispanic/Latina (see Lin et al., 2019). On average, there was a lag of about 12.5 days between completion of the DERS and the laboratory visit. We have described our sampling strategy and measurement distribution elsewhere (see Lin et al., 2019; Ostlund et al., 2019). All procedures were approved by the University of Utah and Intermountain Healthcare System Institutional Review Boards.

Measures

Respiratory sinus arrhythmia. Respiratory sinus arrhythmia (RSA) is an index of parasympathetic tone, measured through beat-to-beat variability in heart rate variability (HRV). RSA can provide an index of prosocial and approach-related affect. MindWare HRV software (MindWare Technologies Ltd., Gahanna, OH, USA; version 3.1) was used to collect and analyze psychophysiological data. Electrocardiography (ECG) sensors were placed using a standard three spot-electrode configuration (i.e., right clavicle and lowest left rib; Qu, Zhang, Webster, & Tompkins, 1986). RSA was collected continuously, scored in 30-second epochs, and averaged across each minute of the Speech. Scored values outside the expected range (i.e., 2–10) were double-checked by advanced graduate students and a senior author and were removed if necessary. Epochs with fewer than 30 seconds of usable ECG data were considered missing. RSA values were run through outlier checks, and participants whose data were flagged were examined an additional time to check for scoring errors and either corrected or considered missing. Four participants' RSA data were missing because of technical errors or unreliable signals, or due to being too distressed to complete the Speech task.

Electrodermal activity. Electrodermal activity (EDA) is a measure of sympathetically-mediated eccrine sweat gland permeability, providing an index of fight-flight responsivity and affective withdrawal. To gather and analyze EDA, we used MindWare EDA software (MindWare Technologies Ltd., Gahanna, OH, USA; version 3.1). Two GSC electrodes with 0.5% NaCl solution were attached by trained research assistants to the thenar and hypothenar eminences of each participant's nondominant hand. EDA was collected continuously, binned into 30-second epochs, and scored as the number of nonspecific responses ≥ 0.05 microsiemens (see Dawson et al., 2017). Data were cleaned and processed by trained research assistants and summed across two epochs to yield a total number of nonspecific responses per minute. Five participants' EDA data were missing because of technical errors or unreliable signals or because the participant was too distressed to complete the Speech task.

Coded Stress Behavior. Behavior was coded using the Ethological Coding System for Interviews (ECSI; Troisi, 1999) during the 5-minute Trier Social Stress Test Speech (TSST; Kirschbaum et al., 1993). The TSST Speech task is a highly effective stress-inducing paradigm that has been used for coding ECSI behaviors (e.g., Bellagambi et al., 2018; Lam et al., 2009; Villada et al., 2014). The ECSI is a well-validated scheme for quantifying ethologically-derived behaviors in interview-like situations (Troisi, 1999) such as the Speech task. Prosocial, Flight, and Displacement ECSI summary scores were used in this study. Prosocial behaviors are those that seek to maintain positive social contact through affiliation and submission (e.g., smiling). Flight and Displacement behaviors help an individual disconnect from a stressor. Flight refers to sensory withdrawal (e.g., looking down), whereas Displacement is defined as the shifting of one's sensory to another stimulus (e.g., touching one's face; see Troisi, 1999). Prosocial has eight behavior codes, Flight has five, and Displacement has nine. The Flight "Crouch" behavior was excluded *a priori* because women were asked to stay in view of the camera.

Four research assistants, blind to hypotheses and objectives, were trained on the ECSI. Coders were recruited via convenience sampling; one from an undergraduate course and three who were seeking research experience. To bolster transparency, coders provided written informed consent with respect to sharing their self-reported characteristics: 2 identified as male, 2 as female; 2 White/Caucasian, 1 Indian, 1 Black/African American; 2 were age 18-25, 2 were age 40-50; 3 were undergraduates, 1 was a paid lab technician (in a different lab). None of the four coders reported having prior observational coding experience. Coders trained for approximately 10 hours per week until ratings were considered reliable (procedure discussed below), altogether approximately four weeks. The training schedule consisted of the following procedures. First, coders read the ECSI coding scheme (Troisi, 1999) and discussed questions and concerns with the lead author. Second, coders trained on the ECSI using videos from an unrelated study and additional mock TSST Speech videos. Third, the team met once per week to resolve discrepancies between coders. During training, coders were assigned four to six videos per week with complete overlap until 20 videos were coded.

Of 162 participants, 145 had videos that could be used for coding. Seventeen videos could not be coded because of recording errors (e.g., camera was not turned on, video quality was poor/out of focus). Coders used one-zero time sampling coding for each behavior within 15-

second intervals over the 5-minute Speech, an approach that saves time while maintaining scheme fidelity and validity (Martin & Bateson, 1993; see e.g., Mohiyeddini et al., 2013; Sgoifo et al., 2003; Troisi, 1999). That is, each behavior was coded as either present (one) or absent (zero) within each 15-second segment. Coders were instructed to watch each participant video recording in its entirety (without accelerating or decelerating) exactly twice for each summary score (i.e., Prosocial, Flight, and Displacement). Two coders were assigned to code videos with respect to each summary score. To compute a participant's score per minute, one-zero values were summed across all behavior codes.

We assessed coder agreement both qualitatively (by comparing raw, time-sampled codes) and with inter-rater reliability (IRR). IRR was calculated with intra-class correlation coefficients (ICCs) across minute-level codes (Hallgren, 2012). Specifically, agreement between two raters was calculated using a two-way mixed, absolute, single-measures ICC (McGraw & Wong, 1996). Of the 145 videos, 22.8% (33) were double-coded for ICC. All ICCs were in the "good" range (Cicchetti, 1994) and were as follows [95% confidence intervals]: Prosocial = 0.62 [0.36-0.77]; Flight = 0.65 [0.55-0.73]; Displacement = 0.75 [0.66-0.81].[2] Only the Prosocial confidence interval crosses into the "unacceptable" range.

Emotion dysregulation. Emotion dysregulation was measured using the Difficulties in Emotion Regulation Scale (DERS; Gratz & Roemer, 2004). The DERS has 36 items (e.g., "When I'm upset, my emotions feel overwhelming"), each with 1 (*almost never*) to 5 (*almost always*) Likert options. The measure has six subscales: nonacceptance of emotions, difficulty with goal-directed behavior, impulsivity, lack of emotional awareness, limited access to emotion regulation strategies, and poor emotional clarity. We used the DERS total score (a sum total of

---

[2] We did not calculate internal consistency for minute-level summary scores because each behavior was a count variable, so codes did not have measurement homogeneity (see Streiner, 2003).

all 36 items, after reverse-scoring) as our measure of interest, a broadband index of emotion regulation problems, which had strong internal consistency ($\alpha = 0.96$). The DERS also has strong test-retest reliability ($\rho = .88$; Gratz & Roemer, 2004).

Covariates: Psychotropic medication. We used dummy-coded psychotropic medications as a covariate in all models because psychotropic medications were correlated with our outcome variables in this sample (see Results and OSF pre-registration). Participants self-reported all medications they were taking. The lead author gathered these responses and coded reported medication (or lack thereof) as psychotropic (1) or not (0). Note that altogether, only 38.9% of our sample reported currently taking a prescription medication, including psychotropics (most commonly antidepressants). Other reported prescriptions included medications for thyroid, anti-nausea, acid reflux, blood pressure, and asthma-related concerns, and participants were excluded if they reported currently taking illicit drugs. For the purposes of physiological data collection, participants were also required not to take stimulants, antihistamines, and beta blockers on the day of data collection (see Lin et al., 2019).[3]

Procedure

Participants who met inclusion criteria scheduled a visit to the laboratory. They then provided written informed consent about the larger study, which involved a psychophysiological assessment (including EDA and RSA), additional questionnaire data, and a series of clinical interviews. Women then began a 10-minute baseline, followed by the TSST which includes a 3-minute preparatory period. They were told to use this time to prepare a speech for a panel of "behavioral coding experts" (research assistants in lab coats). Next, participants gave the 5-

[3] We also included third-trimester body mass index (BMI) as an additional covariate in our models. We do not include this measure in the text because we did not pre-register the use of BMI. However, as noted in the Results and Supplementary Material, inclusion of BMI had no impact on significance level or concordance patterns.

minute Speech on their qualifications for a job of their choice while the research assistants observed with neutral expressions. Research assistants were also instructed to not give any verbal or nonverbal feedback throughout the Speech. Women were told to speak for the entire time. If they stopped, research assistants instructed them to continue. This was followed by 5-minute Mathematics and 10-minute Recovery tasks (not relevant to the current study). Participants then completed additional portions of the larger study and were debriefed and compensated ($60).

Analyses

Missing data. DERS responses were imputed via simple mean imputation to calculate total DERS scores. This was done because item-level responses were missing at less than 5%. We used a different approach to handle other missing data. Total DERS scores were missing at about 1%, and minute-level RSA, EDA, and coded behavior were missing at greater frequencies, with Displacement being the greatest (about 25% missingness). To account for this missingness, total DERS, within-person physiology and behavior, and cross-level interaction terms were imputed via multilevel multiple imputation using the R package *mice* (v.3.6.0; Van Buuren & Groothuis-Oudshoorn, 2011). Altogether, 40 imputed datasets were created using 5 iterations. Estimates were pooled across multilevel modeling on these imputed datasets.

Concordance models. To examine behavioral-physiological concordance, we created a series of multilevel models because we conceptualized concordance as minute-to-minute associations between physiology and behavior across the TSST Speech. Multilevel modeling allows us to account for individual differences via random effects, and these models have previously been used effectively for modeling concordance (e.g., Crowell et al., 2014). Multilevel models were created using R (version 3.6.1; R Core Team, 2019) with the *lme4* package (v.1.1-21; Bates, Mächler, Bolker, & Walker, 2015). We also corrected for multiple comparisons using the Benjamini-Hochberg correction, with a 5% false detection rate and 8 tests (per dependent variable).

The following multilevel models accounted for concordance, with group-mean centered physiology and a random intercept predicting uncentered behavior (H1a-d; H2a-b).

Level-1: $\text{Behavior}_{ij} = \beta_{0j} + \beta_1{*}(\text{Physiology}_{ij} - \overline{\text{Physiology}_j}) + r_{ij}$

Level-2: $\beta_{0j} = \gamma_{00} + u_{0j}$

Next, we ran multilevel models that included grand-mean centered DERS score as a Level-2 predictor of behavior. We then added a cross-level interaction between grand-mean centered DERS and group-mean centered physiology (H3a-d; H4a-b).

Level-1: $\text{Behavior}_{ij} = \beta_{0j} + \beta_1{*}(\text{Physiology}_{ij} - \overline{\text{Physiology}_j}) + \beta_2{*}((\text{Physiology}_{ij} - \overline{\text{Physiology}_j}){*}(\text{DERS}_j - \overline{\text{DERS}})) + r_{ij}$

Level-2: $\beta_{0j} = \gamma_{00} + \gamma_{01}{*}(\text{DERS}_j - \overline{\text{DERS}}) + u_{0j}$

Results

Descriptive Statistics and Correlations

Raw descriptive statistics are presented in Table 1. Data were within expected range and followed relatively normal distributions. For detailed demographic data on this sample, see Lin et al. (2019) and Ostlund et al. (2019). Correlations among mean values for primary variables of interest are displayed in Table 1. We ran correlations with dummy-coded psychotropic medication and found that medication usage was associated with both prosocial and flight behavior during the Speech, further confirming that it may be important to control for this variable in our concordance models. We also created spaghetti plots for all participants (with a random 10% highlighted for clarity) to emphasize unique trajectories across the stressor across each parameter. On a minute-by-minute basis, there appears to be a fair degree of variability in trajectory over the task. However, the overall trajectory, from start to finish, appears to be fairly similar across participants (Figures 1-2). Average plots across parameters were also created (see Supplementary Material).

Table 1

Correlations	1.	2.	3.	4.	5.	6.	7.
1. DERS	—						
2. RSA	-.09	—					
3. EDA	.02	-.09	—				
4. Prosocial	-.12	.01	.11	—			
5. Flight	-.03	.01	.06	$.20^{*}$	—		
6. Displacement	.16	-.06	.15	.06	-.002	—	
7. Psychotropic Medication	.15	-.12	.09	$.19^{*}$	$.31^{***}$	.11	—
n	160	158	157	145	145	123	28
(% of *N* = 162)	(98.8)	(97.5)	(96.9)	(89.5)	(89.5)	(75.9)	(17.3)
Mean	79.90	5.46	12.07	8.64	7.10	2.95	
Standard deviation	73.00	5.56	12.20	2.89	1.86	1.73	
Min	36	1.10	3.40	1.40	1.60	0.00	
Max	155	7.85	23.20	16.60	11.60	8.60	

Note. Correlations are between raw values. $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$. EDA, Prosocial, Flight, and Displacement are minute-level average values over the course of the Speech task. Psychotropic Medication: *n* = number of participants reporting current use of psychotropic medication.

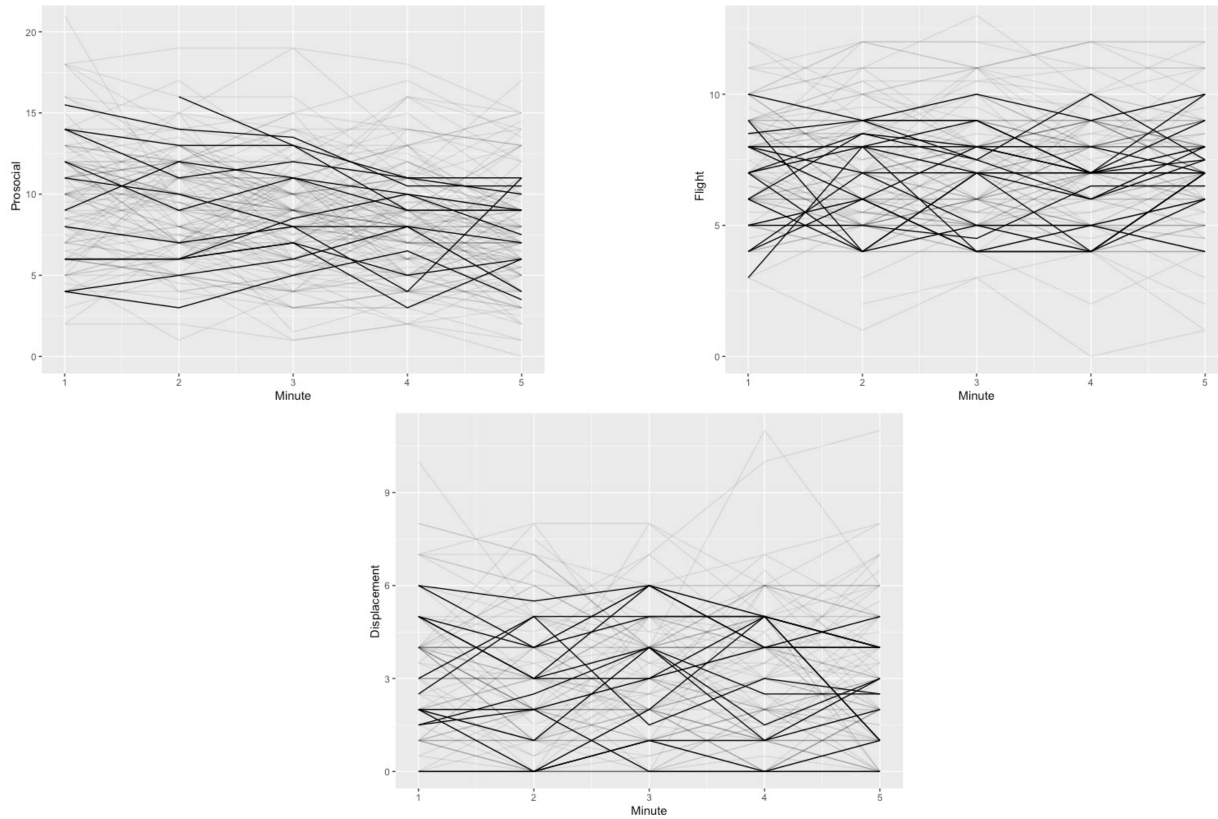

Figure 1. Spaghetti plots for the three behavior codes: Prosocial (top left), Flight (top right), and Displacement (bottom middle). Each line represents a unique participant. Black lines indicate a random 10% of participants that are highlighted for clarity.

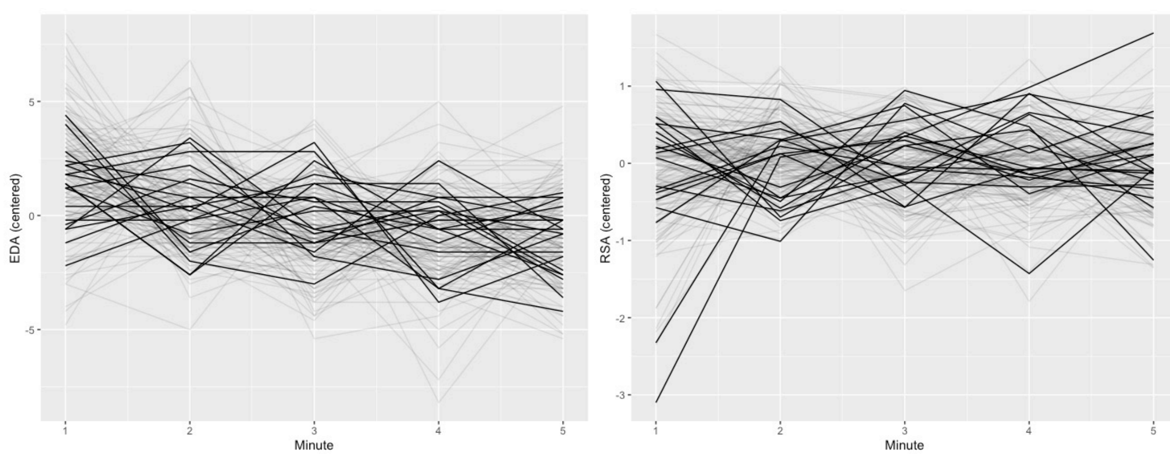

Figure 2. Spaghetti plots for the two physiological measures (both group-mean centered): EDA (left) and RSA (right). Each line represents a unique participant. The black lines indicate a

random 10% of participants that are highlighted for clarity.

Behavior–Physiology Concordance Models

Out of eight tested models, two had significant concordance effects (Table 2). We hypothesized concordance in the positive direction (i.e., physiology and behavior increase or decrease together) for Prosocial-RSA, Prosocial-EDA, Flight-EDA, and Displacement-EDA. First, though we did not find concordance for prosocial behavior with respect to RSA ($p > .10$), we found concordance in the expected direction with EDA ($b = 0.15$, $p < .001$; see Fig. 3). To further illustrate this finding, we created plots to compare participants with relatively high and low concordance (Fig. 4). Second, Flight and EDA were concordant ($b = 0.04$, $p = .03$; Fig. 3). However, the Flight-EDA concordance effect was non-significant after correcting for multiple comparisons. There was no concordance for displacement and EDA ($p > .10$). We also hypothesized negative concordance (opposite movement) for the following behavior-physiology pairs: Flight-RSA; Displacement-RSA. There was marginal concordance for Flight-RSA, albeit in the opposite direction than expected ($b = 0.13$, $p = .08$), indicating that the two may actually move together over the course of the Speech. Finally, the concordance effects for Displacement and RSA were not significant (ps > .10). After Benjamini-Hochberg corrections for multiple comparisons, marginal effects were nonsignificant.

Table 2
Multilevel Model Results

	Dependent Variable								
	Prosocial			Flight			Displacement		
Parameter	*B*	SE *B*	*β*	*B*	SE *B*	*β*	*B*	SE *B*	*β*
Intercept by model									
EDA	8.51***	0.26	32.2	6.89***	0.16	42.5	2.93***	0.18	16.7
EDA × DERS	8.52***	0.26	32.2	6.91***	0.16	42.4	2.90***	0.17	16.7
Concordance: Level-1									
EDA	0.15***	0.04	4.18	0.04*a	0.02	2.12	0.04	0.03	1.37
Concordance: Interactions									
EDA	0.15***	0.04	3.99	0.04*a	0.02	2.05	0.03	0.03	1.30
DERS	-0.02†a	0.01	-1.86	-0.01	0.01	-0.94	0.01	0.01	1.39
EDA × DERS	-0.001	0.001	-1.04	-0.001	0.001	-1.53	-0.001	0.001	-1.01
Intercept by model									
RSA	8.42***	0.27	31.5	6.89***	0.16	42.9	2.89***	0.18	16.4
RSA × DERS	8.43***	0.27	31.3	6.91***	0.16	42.7	2.86***	0.17	16.5
Concordance: Level-1									
RSA	0.12	0.15	0.78	0.13†a	0.08	1.73	0.04	0.11	0.36
Concordance: Interactions									
RSA	0.12	0.15	0.76	0.13†a	0.08	1.69	0.04	0.10	0.41
DERS	-0.01	0.01	-1.57	-0.01	0.01	-0.98	0.01	0.01	1.57
RSA × DERS	-0.001	0.01	-0.21	-0.002	0.002	-0.83	-0.01†a	0.004	-1.74

Note. Models were run with and without dummy coded psychotropic medication included as a Level-2 predictor. Significance levels were unchanged without this variable included, so only models with psychotropic medication are listed here for brevity. We also included BMI as a Level-2 predictor; significance levels were also unchanged with this variable included (thus, results are not reported here).

† $p < .10$; * $p < .05$; ** $p < .01$; *** $p < .001$

a Non-significant after Benjamini-Hochberg correction for multiple comparisons

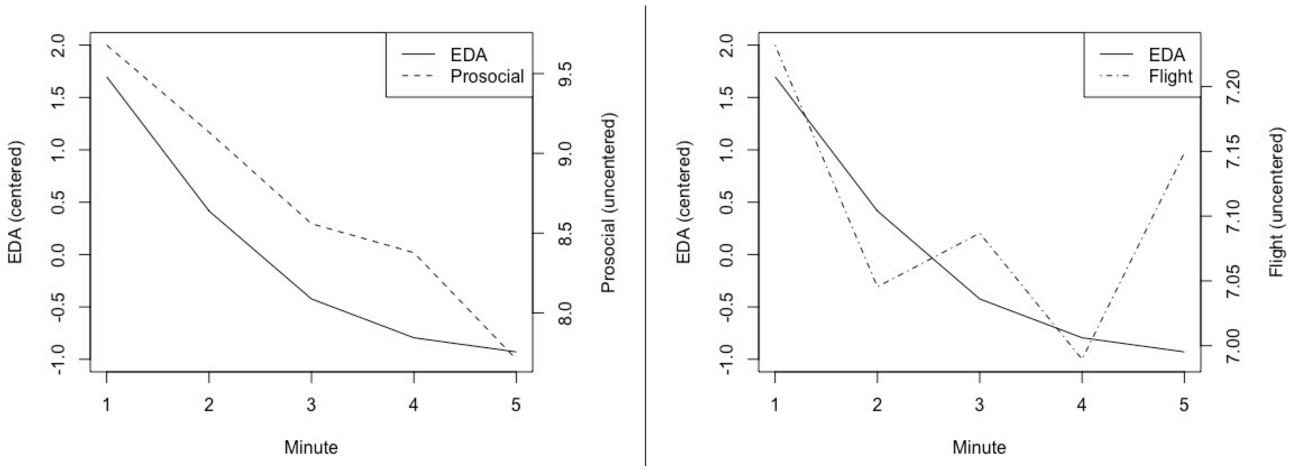

Figure 3. The two significant concordance patterns: group-mean centered EDA and Prosocial behaviors (left) and between EDA and Flight behaviors (right). Here, values represent averages across all participants, solely for plotting purposes. Though both have significant positive concordance, one can see that the concordance patterns are quite different. EDA and Prosocial behaviors move together consistently over the Speech, whereas EDA and Flight appear concordant across some minutes and then discordant others.

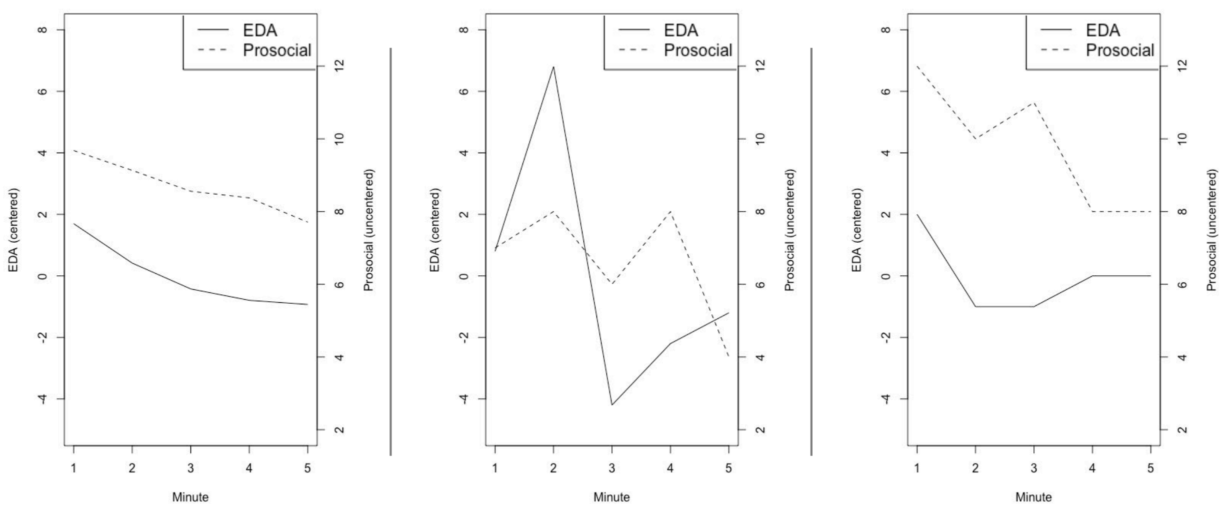

Figure 4. Examples of various degrees of EDA-Prosocial concordance. The patterns depicted are: average overall EDA-Prosocial concordance across all participants (left), an example participant with relatively high concordance (center), and an example participant with relatively low concordance (right).

Exploring Emotion Dysregulation as Concordance Moderator

Finally, we explored if DERS moderated concordance via interactions with physiology, so we included DERS × Physiology interaction terms. No significant interaction effects emerged, though there was a marginal interaction effect of RSA and DERS on Displacement (b = -0.01, p = .08). However, our correction for multiple comparisons renders this affect null.

Discussion

We examined a large sample of third-trimester pregnant women undergoing the Speech portion of the Trier Social Stress Test (TSST), and expected to find behavioral-physiological minute-by-minute concordance. We also examined the extent to which individual differences in emotion dysregulation moderated concordance effects. We found two significant concordance patterns, both in the hypothesized positive direction. Across the Speech, EDA was concordant with Prosocial behaviors, and we found a clear lack of concordance amongst all other behavior-physiology pairs (i.e., Prosocial-RSA; Flight-RSA; Displacement-EDA; Displacement-RSA). Though we did initially find Flight-EDA concordance, this effect was null after correcting for multiple comparisons, suggesting that it should be interpreted with extreme caution and should be replicated in future studies.

Findings suggest that short-term, moderately stressful situations may prompt pregnant women to experience concordant affiliation/arousal and potentially anxious avoidance. Our findings also align with Villada and colleagues (2014), who found that, during the TSST Speech, non-pregnant women exhibited mostly ECSI Flight and Prosocial behaviors. The authors reasoned that their findings were consistent with Taylor and colleagues' (2000) Tend-and-Befriend Theory, such that women cope adaptively to stress by balancing Flight (or anxious avoidance) and Prosocial (or affiliative) behavior. Given that concordance indicates strongly experienced emotion across multivariate markers (Hollenstein & Lanteigne, 2014), our findings may in turn extend the Tend-and-Befriend Theory to the prenatal period.

Our results also provide new information about prenatal maternal autonomic nervous system responsivity. For instance, DiPietro et al. (2012) showed that both RSA and EDA reactivity dampen during pregnancy. We found at least one EDA-related concordance pattern, which suggests that EDA reactivity was at least detectable enough to align with behavior. Our significant findings may indicate that, in spite of a more limited autonomic range, pregnant women still express affiliative (Prosocial) emotional responsivity to stress, associated specifically with sympathetic nervous system activity. In other words, sufficient stressors may be able to “override” some of the natural dampening that is placed on sympathetic activity while pregnant, which could have neurodevelopmental implications for the developing child and for women’s mental health (Doyle & Cicchetti, 2018).

To our knowledge, this is the first study to apply coded behavior-physiology concordance models in the context of pregnancy. The patterns we observed in stress responsivity over the TSST represent novel contributions to the literature. We found that, when faced with a brief and relatively intense social stressor, pregnant women may display relatively constant Flight (or avoidance) behaviors over time. On the other hand, some participants displayed virtually no Displacement behavior, whereas others used Displacement heavily in response to the task. Finally, there was incredible range in the number of Prosocial behaviors displayed across the task; some women were less Prosocial by the end of the task, though many others were relatively constant (see Figures 1, 3, and 4). With respect to physiology findings, we found that many pregnant women had constant RSA over the Speech, though there was a great deal of change within the first minute of the task. EDA declined modestly for most women over the course of the task (Figure 2). Given what is known about the extent to which a pregnant woman’s behaviors and physiology can affect her developing fetus and her own postnatal mental health, we believe that these findings represent a crucial step in better understanding perinatal stress responsivity across multiple levels of analysis (Doyle & Cicchetti, 2018; Glynn et al., 2018). Though there has been research on subjective stress appraisal and physiology during pregnancy (e.g., Deligiannidis et al., 2016; Klinkenberg et al., 2009), to our knowledge this is the first study to examine prenatal women's coded behavior in response to stress.

These findings also have the potential to help inform future treatment and prevention efforts. For instance, our results suggest that there may be numerous similarities in terms of how the autonomic nervous system and related emotions function in pregnancy relative to non-pregnancy. Though we cannot directly compare results to non-pregnant samples, obstetricians might be able to use this knowledge to generalize aspects of female mental and physical health more broadly to perinatal women. These results could also indicate that strong sympathetic responses to stress may be prominent in pregnancy. Medical providers and mental health practitioners can use this information to identify pregnant women who may be showing signs of concordant sympathetic activity and provide quick interventions (e.g., mindfulness and regulatory skills) to manage distress and protect women and the developing fetus from long-term consequences.

It is worth noting that the strong downward trend in EDA and Prosocial behavior may be explained (at least in part) by a physiological habituation response. Indeed, there is a fairly strong body of research demonstrating that EDA typically declines over the course of social stressors due to an attenuation of sympathetic tone (see Dawson et al., 2017). On the one hand, this could indicate habituation to the stressor, whereby sympathetic activity declines in conjunction with affiliation efforts. On the other hand, if there were a strong habituation response over time, one would also expect to find consistent downward trends across physiological and behavioral markers. As depicted in Figure 4, not all participants with high concordance had consistent downward trends in EDA or Prosocial behavior. Further, this was not the case for our primary variables of interest, as well as peripheral physiological measures, such as heart rate and electrodermal tonic activity, all of which showed relative stability over the task (see Supplementary Material).

Models with a lack of concordance included RSA and Displacement behavior. These null findings could suggest that participants did not experience strong enough emotions with respect to these pairs of markers. For instance, RSA is associated with social approach motivation (e.g., Cui et al., 2015), which is why we expected Prosocial-RSA positive concordance. We also anticipated negative concordance for Displacement-RSA and Flight-RSA, as these types of behaviors should align with vagal withdrawal during a stressor (Porges, 2001, 2003, 2007). These null findings may suggest that the parasympathetic/cardiovascular dampening that occurs during pregnancy limited the ability for us to detect any respective concordance patterns. The discordant Displacement-EDA finding is puzzling, though this could simply be due to a possible floor effect and skew for the Displacement variable (see Table 1 for descriptive statistics). It is possible that concordance might have emerged if more women were displaying Displacement behavior. Finally, discordance results could simply indicate effective emotional responsivity to a social stressor (Brown et al., in press). It is possible that, among the sample of women we observed, many modulated their behavior in response to the stressor enough to make concordance impossible to detect.

With respect to the exploratory DERS moderation models, we also did not find significant effects. Even the marginal negative effect of DERS × RSA on Displacement behavior was null after correcting for multiple comparisons. Future studies with larger samples and more observations per person should explore the extent to which state- and trait-level emotion dysregulation moderates concordance patterns (e.g., with random slopes). In general, more research needs to be conducted to explain how individual differences in regulatory tendencies can change concordance dynamics (see Brown et al., in press).

Limitations and Future Directions

This study had numerous strengths. First, our aims and analytic plan were pre-registered. Pre-registration is viewed as a foundational component to scientific rigor and reproducibility (Munafò et al., 2017), thus increasing confidence in our approach. We also recruited a large sample of pregnant women across a relatively uniform distribution of self-reported emotion dysregulation, oversampling high- and low-scorers, and asked these women to complete a well-validated social stressor. Analytically, we utilized multilevel models that accounted for interaction effects and measured concordance across multivariate behavioral and autonomic markers. This analytic plan explains why we were able to find concordance even though no significant correlations emerged between these same variables.

Advantages withstanding, our results should still be interpreted with appropriate caution. First, the concordance effect for Flight was null after multiple comparison corrections, meaning that this finding should be treated as tenuous at most, pending replication. There are also numerous limitations to the examination of minute-by-minute concordance in terms of developing understanding of fine-grained emotional responsivity. This analytic and methodological approach was chosen for the current study because our goal was to use a similar design to Crowell and colleagues (2014), who found within- and between-person behavioral-physiological concordance in mother-teen dyads using minute-level segments. Minute-long bins also allowed us to capture more of the variance in behaviors, which were computed via 0-1 coding in 15-second segments (per coding scheme recommendations; Troisi, 1999). If total bins were only 30 seconds long, this would have severely limited the range captured in summary scores. Indeed, our raw data confirm that few participants exhibited every possible Prosocial behavior in a given 15-second segment. By binning across four 15-second segments, we were able to capture a greater range in Prosocial scores, which likely made it more feasible for our models to detect concordance effects.

Concordance is often defined relatively simply, i.e., as the phenomenon when two emotion-related measures move together (Hollenstein & Lanteigne, 2014), though others have more recently taken more rigorous approaches to concordance (e.g., Brown et al., in press). Our use of level-level analyses (i.e., without a focus on change scores or autoregressive paths) may have limited our ability to detect micro-level changes in physiological and behavior. For instance, cross-lagged autoregressive or change-based models with shorter bins can allow researchers to examine fine-grained emotion dynamics (e.g., Randall, Post, Reed, & Butler, 2013). Due to the novelty of our approach with this population, we did not believe we could articulate a priori, theoretically-driven reasoning for lagged or change-based modeling. This prompted us to pre-register a classic concordance approach (i.e., minute-by-minute associations). Other approaches may be helpful for enriching understanding of perinatal emotion going forward.

Though we were able to find a marginal interaction effect, null results (after correcting for multiple comparisons) indicate we were underpowered to detect cross-level interactions. Anticipated power also limited us from pre-registering the use of random slopes, which can lead to biased estimates with few observations per person. Spaghetti plots highlight that there may be a fair degree of variability in minute-by-minute trajectories, though the overall trajectory was more or less comparable across people. It is possible that with a large sample of pregnant women with more observations per individual, random slopes could be calculated and concordance might be detected.

Additionally, though we used a relatively robust missing data approach, the amount of missing Displacement data we imputed (about 25%) were large enough to have had a significant impact on our ability to find valid and reliable effects. Moreover, Flight and Displacement also had relatively limited range, especially Displacement, which had a notable skew. Finally, though the TSST has been well-validated as a stress-inducing task, a recent review found that there are inconsistencies in how the TSST protocol is applied from study-to-study (Linares, Charron, Ouimet, Labelle, & Plamondon, 2020). The replicability of TSST-based studies is an important topic and future research should continue to validate the effectiveness of this paradigm.

Despite the novelty of these findings, these are still many questions to be answered. We still do not know the extent to which these findings will generalize to perinatal populations more broadly, let alone to other women. Our study design was limited by our decision not to include a control group (i.e., a comparison group of non-pregnant women). This potentially limits the generalizability of our findings, as we are unable to determine how our findings directly compare to non-pregnant women. Though there are a number of studies focusing on stress responsivity in non-pregnant samples (e.g., Alley, Diamond, Lipschitz, & Grewen, 2020; Dumas et al., 2012; Villada et al., 2014), to our knowledge no other studies have used a similar approach to behavioral coding and concordance analyses during pregnancy. One strength of our study is also a potential limitation—our recruitment strategy. By recruiting across a range of emotion dysregulation scores (i.e., a non-random sample), we improved power to find emotion dysregulated-related effects, though our findings may not generalize to the larger population.

Lastly, our study design allowed us to explore the extent to which concordance could be found in a sample of pregnant women—not necessarily to determine the function of concordance. Depending on numerous factors (e.g., context, individual differences), concordance (or lack thereof) may be an adaptive response to stress (Brown et al., in press). One can generate numerous hypotheses about the function of our concordance findings, though it is impossible for us to determine at this stage the extent to which our findings indicate deleterious outcomes for mother or child. Future research should examine how concordance or discordance predicts other mental health factors, as well as birth- and delivery-related outcomes.

Future research can also examine how concordance is associated with perinatal mental health and infant developmental outcomes. It will also be important for researchers to consider prenatal maternal stress responsivity across contexts. For instance, the TSST Speech is likely not representative of day-to-day prenatal stress experiences. Researchers could use more ecologically-valid methods to extend emotion research to the real world (e.g., digital phenotyping; ecological momentary assessment; Insel, 2017; Walsh, Basu,, & Monk, 2015).

Given a brief social stressor, we found that women expressed concordant behavioral-physiological responsivity in terms of anxious withdrawal and affiliative arousal. We also found marginal evidence that women who generally struggled to regulate their emotions may have had a more concordant anxious responsivity to a stressor. These findings add to the field's extant and growing knowledge of prenatal maternal emotional functioning and mental health. In fact, this may be the first study to describe temporal changes in coded behavior across a controlled social stressor in pregnant women. Given the importance of a multiple-levels-of-analysis approach to perinatal stress (Doyle & Cicchetti, 2018), these findings may serve as a launchpad for helping future researchers understanding the multifaceted nature of perinatal mental health. As we continue to build on concordance research, we ultimately move closer to a more rigorous understanding of emotion itself, improving our ability to help infants and families.

References

Abrams, R. M., & Gerhardt, K. J. (2000). The acoustic environment and physiological responses of the fetus. *Journal of Perinatology, 20*, S31-S36. https://doi.org/10.1038/sj.jp.7200445

Aldao, A., & Nolen-Hoeksema, S. (2010). Specificity of cognitive emotion regulation strategies: A transdiagnostic examination. *Behaviour Research and Therapy, 48*, 974-983. https://doi.org/10.1016/j.brat.2010.06.002

Allen, A. P., Kennedy, P. J., Cryan, J. F., Dinan, T. G., & Clarke, G. (2014). Biological and psychological markers of stress in humans: focus on the Trier Social Stress Test. *Neuroscience and Biobehavioral Reviews*, *38*, 94-124. http://dx.doi.org/10.1016/j.neubiorev.2013.11.005

Alley, J., Diamond, L. M., Lipschitz, D. L., & Grewen, K. (2020). Women's Cortisol Stress Responsivity, Sexual Arousability, and Sexual History. *Archives of Sexual Behavior, 49,* 1489-1503. https://doi.org/10.1007/s10508-019-01585-x

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software, 67*, 1-48. https://doi.org/10.18637/jss.v067.i01

Beauchaine, T. (2001). Vagal tone, development, and Gray's motivational theory: Toward an integrated model of autonomic nervous system functioning in psychopathology. *Development and Psychopathology, 13*, 183-214. https://doi.org/10.1017/s0954579401002012

Beauchaine, T. P. (2015a). Future directions in emotion dysregulation and youth psychopathology. *Journal of Clinical Child and Adolescent Psychology, 44*, 875-896. https://doi.org/10.1080/15374416.2015.1038827

Beauchaine, T. P. (2015b). Respiratory sinus arrhythmia: A transdiagnostic biomarker of emotion dysregulation and psychopathology. *Current Opinion in Psychology, 3*, 43-

47. https://doi.org/10.1016/j.copsyc.2015.01.017

Beauchaine, T.P., & Crowell, S.E. (Eds.). (2020). *Oxford handbook of emotion dysregulation*. New York, NY: Oxford.

Beauchaine, T. P., & Thayer, J. F. (2015). Heart rate variability as a transdiagnostic biomarker of psychopathology. *International Journal of Psychophysiology, 98*, 338-350. https://doi.org/10.1016/j.ijpsycho.2015.08.004

Beauchaine, T. P., & Zisner, A. (2017). Motivation, emotion regulation, and the latent structure of psychopathology: An integrative and convergent historical perspective. *International Journal of Psychophysiology, 117*, 108-111. https://doi.org/10.1016/j.ijpsycho.2016.12.014

Bellagambi, F. G., Degano, I., Ghimenti, S., Lomonaco, T., Dini, V., Romanelli, M., … Di Francesco, F. (2018). Determination of salivary α-amylase and cortisol in psoriatic subjects undergoing the Trier Social Stress Test. *Microchemical Journal, 136*, 177-184. https://doi.org/10.1016/j.microc.2017.04.033

Berntson, G. G., Quigley, K. S., & Lozano, D. L. (2017). Cardiovascular psychophysiology. In J. Cacioppo, L. G. Tassinari, & G. G. Berntson (Eds.), *Handbook of psychophysiology* (4th ed., pp. 182-216). New York: Cambridge University Press.

Billman, G. E. (2011). Heart rate variability–A historical perspective. *Frontiers in Physiology, 2*. https://doi.org/10.3389/fphys.2011.00086

Brown, C. L., Van Doren, N., Ford, B. Q., Mauss, I. B., Sze, J. W., & Levenson, R. W. (in press). Coherence between subjective experience and physiology in emotion: Individual differences and implications for well-being. *Emotion*. https://doi.org/10.1037/emo0000579

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. https://doi.org/10.1016/j.biopsycho.2013.09.003

Cannon W. B. (1932). *The wisdom of the body*. New York: Norton. https://doi.org/10.1097/00000441-193212000-00028

Carter, D., & Kostaras, X. (2005). Psychiatric disorders in pregnancy. *British Columbia Medical Journal, 47*, 96-99.

Christian, L. M. (2012). Physiological reactivity to psychological stress in human pregnancy: Current knowledge and future directions. *Progress in Neurobiology, 99*, 106-116. https://doi.org/10.1016/j.pneurobio.2012.07.003

Cicchetti, D. V. (1994). Guidelines, criteria, and rules of thumb for evaluating normed and standardized assessment instruments in psychology. *Psychological Assessment, 6*, 284-290. https://doi.org/10.1037/1040-3590.6.4.284

Coan, J. A. (2010). Emergent ghosts of the emotion machine. *Emotion Review, 2*, 274-285. https://doi.org/10.1177/1754073910361978

Conradt, E., Adkins, D. E., Crowell, S. E., Monk, C., & Kobor, M. S. (2018). An epigenetic pathway approach to investigating associations between prenatal exposure to maternal mood disorder and newborn neurobehavior. *Development and Psychopathology, 30*, 881-890. https://doi.org/10.1017/S0954579418000688

Crowell, S. E., Baucom, B. R., Yaptangco, M., Bride, D., Hsiao, R., McCauley, E., & Beauchaine, T. P. (2014). Emotion dysregulation and dyadic conflict in depressed and typical adolescents: Evaluating concordance across psychophysiological and observational measures. *Biological Psychology, 98*, 50-58. https://doi.org/10.1016/j.biopsycho.2014.02.009

Crowell, S. E., Beauchaine, T. P., Hsiao, R. C., Vasilev, C. A., Yaptangco, M., Linehan, M. M., & McCauley, E. (2012). Differentiating adolescent self-injury from adolescent depression:

Possible implications for borderline personality development. *Journal of Abnormal Child Psychology, 40*, 45-57. https://doi.org/10.1007/s10802-011-9578-3

Crowell, S. E., Puzia, M. E., & Yaptangco, M. (2015). The ontogeny of chronic distress: Emotion dysregulation across the life span and its implications for psychological and physical health. *Current Opinion in Psychology*, *3*, 91-99. https://doi.org/10.1016/j.copsyc.2015.03.023

Crowell, S. E., Vlisides-Henry, R. D., & Kaliush, P. R. (2020). Emotion generation and regulation as multilevel transdiagnostic constructs. In T. P. Beauchaine & S. E. Crowell (Eds.), *Oxford handbook of emotion dysregulation*. New York, NY: Oxford.

Cui, L., Morris, A. S., Harrist, A. W., Larzelere, R. E., Criss, M. M., & Houltberg, B. J. (2015). Adolescent RSA responses during an anger discussion task: Relations to emotion regulation and adjustment. *Emotion, 15*, 360-372. https://doi.org/10.1037/emo0000040

Cuthbert, B. N., Bradley, M. M., & Lang, P. J. (1996). Probing picture perception: Activation and emotion. *Psychophysiology, 33*, 103-111. https://doi.org/10.1111/j.1469-8986.1996.tb02114.x

Dan-Glauser, E. S., & Gross, J. J. (2013). Emotion regulation and emotion coherence: Evidence for strategy-specific effects. *Emotion, 13*, 832-842. https://doi.org/10.1037/a0032672

Darwin, C. (1872). *The expression of emotion in man and animals.* New York: D. Appleton & Co. https://doi.org/10.1037/10001-000

Davis, E. P., Snidman, N., Wadhwa, P. D., Glynn, L. M., Schetter, C. D., & Sandman, C. A. (2004). Prenatal maternal anxiety and depression predict negative behavioral reactivity in infancy. *Infancy, 6*, 319-331. https://doi.org/10.1207/s15327078in0603_1

Dawson, M. E., Schell, A. M., & Filion, D. L. (2017). The electrodermal system. In J. Cacioppo,

L. G. Tassinary, & G. G. Berntson (Eds.), *The handbook of psychophysiology* (4th ed., pp. 159-181). New York: Cambridge University Press.

Del Giudice, M. (2012). Fetal programming by maternal stress: Insights from a conflict perspective. *Psychoneuroendocrinology, 37*, 1614-1629. https://doi.org/10.1016/j.psyneuen.2012.05.014

Deligiannidis, K. M., Kroll-Desrosiers, A. R., Svenson, A., Jaitly, N., Barton, B. A., Hall, J. E., & Rothschild, A. J. (2016). Cortisol response to the Trier Social Stress Test in pregnant women at risk for postpartum depression. *Archives of Women's Mental Health*, *19*, 789-797. https://doi.org/10.1007/s00737-016-0615-7

DiPietro, J. A., Mendelson, T., Williams, E. L., & Costigan, K. A. (2012). Physiological blunting during pregnancy extends to induced relaxation. *Biological Psychology, 89*, 14-20. https://doi.org/10.1016/j.biopsycho.2011.07.005

Doyle, C., & Cicchetti, D. (2018). Future directions in prenatal stress research: Challenges and opportunities related to advancing our understanding of prenatal developmental origins of risk for psychopathology. *Development and Psychopathology, 30*, 721-724. https://doi.org/10.1017/s095457941800069x

Dumas, J. A., Albert, K. M., Naylor, M. R., Sites, C. K., Benkelfat, C., & Newhouse, P. A. (2012). The effects of age and estrogen on stress responsivity in older women. *The American Journal of Geriatric Psychiatry*, *20*, 734-743. https://doi.org/10.1097/JGP.0b013e31825c0a14

Ekman, P. (1973). *Darwin and facial expression: A century of research in review*. Los Angeles: Academic Press.

Ekman, P. (1992). An argument for basic emotions. *Cognition & Emotion, 6*, 169-200.

Feldman Barrett, L. (2006). Solving the emotion paradox: Categorization and the experience of emotion. *Personality and Social Psychology Review, 10*, 20-46. https://doi.org/10.1207/s15327957pspr1001_2

Fischer, A. H., & Roseman, I. J. (2007). Beat them or ban them: The characteristics and social functions of anger and contempt. *Journal of Personality and Social Psychology, 93*, 103-115. https://doi.org/10.1037/0022-3514.93.1.103

Folk, J. B., Zeman, J. L., Poon, J. A., & Dallaire, D. H. (2014). A longitudinal examination of emotion regulation: Pathways to anxiety and depressive symptoms in urban minority youth. *Child and Adolescent Mental Health, 19*, 243-250. https://doi.org/10.1111/camh.12058

Fowles, D. C. (1988). Psychophysiology and psychopathology: A motivational approach. *Psychophysiology, 25*, 373-391. https://doi.org/10.1111/j.1469-8986.1988.tb01873.x

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. https://doi.org/10.1016/j.biopsycho.2013.12.006

Gable, S. L., Reis, H. T., Impett, E. A., & Asher, E. R. (2004). What do you do when things go right? The intrapersonal and interpersonal benefits of sharing positive events. *Journal of Personality and Social Psychology, 87*, 228-245. https://doi.org/10.1037/0022-3514.87.2.228

Glover, V. (2011). Prenatal stress and the origins of psychopathology: An evolutionary perspective. *Journal of Child Psychology and Psychiatry, 52*, 356-367. https://doi.org/10.1111/j.1469-7610.2011.02371.x

Glynn, L. M., Howland, M. A., & Fox, M. (2018). Maternal programming: Application of a developmental psychopathology perspective. *Development and Psychopathology, 30*, 905-

919. https://doi.org/10.1017/S0954579418000524

Gratz, K. L., & Roemer, L. (2004). Multidimensional assessment of emotion regulation: Development, factor structure, and initial validation of the Difficulties in Emotion Regulation Scale. *Journal of Psychopathology and Behavioral Assessment, 26*, 41-54.

Green, M. J., Cahill, C. M., & Malhi, G. S. (2007). The cognitive and neurophysiological basis of emotion dysregulation in bipolar disorder. *Journal of Affective Disorders, 103*, 29-42. https://doi.org/10.1016/j.jad.2007.01.024

Gross, J. J. (2015). Emotion regulation: Current status and future prospects. *Psychological Inquiry, 26*, 1-26. http://dx.doi.org/10.1080/1047840X.2014.940781

Guerri, C. (1998). Neuroanatomical and neurophysiological mechanisms involved in central nervous system dysfunctions induced by prenatal alcohol exposure. *Alcoholism: Clinical and Experimental Research, 22*, 304-312. https://doi.org/10.1111/j.1530-0277.1998.tb03653.x

Hallgren, K. A. (2012). Computing inter-rater reliability for observational data: An overview and tutorial. *Tutorials in Quantitative Methods for Psychology, 8*, 23-34. https://doi.org/10.20982/tqmp.08.1.p023

Het, S., & Wolf, O. T. (2007). Mood changes in response to psychosocial stress in healthy young women: Effects of pretreatment with cortisol. *Behavioral Neuroscience*, *121*, 11-20. http://doi.org/10.1037/0735-7044.121.1.11

Hoekzema, E., Barba-Müller, E., Pozzobon, C., Picado, M., Lucco, F., García-García, D., … Vilarroya, O. (2017). Pregnancy leads to long-lasting changes in human brain structure. *Nature Neuroscience, 20*, 287-296. https://doi.org/10.1038/nn.4458

Hollenstein, T., & Lanteigne, D. (2014). Models and methods of emotional concordance. *Biological Psychology, 98*, 1-5. https://doi.org/10.1016/j.biopsycho.2013.12.012

Insel, T. R. (2017). Digital phenotyping: Technology for a new science of behavior. *Journal of the American Medical Association, 318*, 1215-1216. https://doi.org/10.1001/jama.2017.11295

James, W. (1884). What is an emotion? *Mind, 34*, 188-205. https://doi.org/10.1093/mind/os-ix.34.188

Kashdan, T. B., & Rottenberg, J. (2010). Psychological flexibility as a fundamental aspect of health. *Clinical Psychology Review, 30*, 865-878. https://doi.org/10.1016/j.cpr.2010.03.001

Kirschbaum, C., Pirke, K. M., & Hellhammer, D. H. (1993). The "Trier Social Stress Test"–A tool for investigating psychobiological stress responses in a laboratory setting. *Neuropsychobiology, 28*, 76-81. https://doi.org/10.1159/000119004

Klinkenberg, A. V., Nater, U. M., Nierop, A. D. A., Bratsikas, A., Zimmermann, R., & Ehlert, U. (2009). Heart rate variability changes in pregnant and non-pregnant women during standardized psychosocial stress. *Acta Obstetricia et Gynecologica Scandinavica, 88*, 77-82.

Kok, B. E., Coffey, K. A., Cohn, M. A., Catalino, L. I., Vacharkulksemsuk, T., Algoe, S. B., … Fredrickson, B. L. (2013). How positive emotions build physical health: Perceived positive social connections account for the upward spiral between positive emotions and vagal tone. *Psychological Science, 24*, 1123-1132. https://doi.org/10.1177/0956797612470827

Koval, P., & Kuppens, P. (2012). Changing emotion dynamics: Individual differences in the effect of anticipatory social stress on emotional inertia. *Emotion*, *12*, 256-267.

Kuo, C. D., Chen, G. Y., Yang, M. J., Lo, H. M., & Tsai, Y. S. (2000). Biphasic changes in autonomic nervous activity during pregnancy. *British Journal of Anaesthesia, 84*, 323-329. https://doi.org/10.1093/oxfordjournals.bja.a013433

Lam, S., Dickerson, S. S., Zoccola, P. M., & Zaldivar, F. (2009). Emotion regulation and cortisol reactivity to a social-evaluative speech task. *Psychoneuroendocrinology, 34*, 1355-1362. https://doi.org/10.1016/j.psyneuen.2009.04.006

Lang, P. J. (1994). The varieties of emotional experience: a meditation on James-Lange theory. *Psychological Review, 101*, 211-221. https://doi.org/10.1037/0033-295x.101.2.211

Lang, P. J., Greenwald, M. K., Bradley, M. M., & Hamm, A. O. (1993). Looking at pictures: Affective, facial, visceral, and behavioral reactions. *Psychophysiology, 30*, 261-273. https://doi.org/10.1111/j.1469-8986.1993.tb03352.x

Laplante, D. P., Barr, R. G., Brunet, A., Du Fort, G. G., Meaney, M. L., Saucier, J. F., … King, S. (2004). Stress during pregnancy affects general intellectual and language functioning in human toddlers. *Pediatric Research, 56*, 400-410. https://doi.org/10.1203/01.pdr.0000136281.34035.44

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

Lester, B. M., Miller, R. J., Hawes, K., Salisbury, A., Bigsby, R., Sullivan, M. C., & Padbury, J. F. (2011). Infant neurobehavioral development. *Seminars in Perinatology, 35*, 8-19. https://doi.org/10.1053/j.semperi.2010.10.003

Levenson, R. W. (1994). Human emotion: A functional view. *The nature of emotion: Fundamental questions* (pp. 123-126).

Lin, B., Kaliush, P. R., Conradt, E., Terrell, S., Neff, D., Allen, A. K., … Crowell, S. E. (2019). Intergenerational transmission of emotion dysregulation: Part I. Psychopathology, self-injury, and parasympathetic responsivity among pregnant women. *Development and Psychopathology, 31*, 817-831. https://doi.org/10.1017/s0954579419000336

Linares, N. N., Charron, V., Ouimet, A. J., Labelle, P. R., & Plamondon, H. (2020). A systematic review of the Trier Social Stress Test methodology: Issues in promoting study comparison and replicable research. *Neurobiology of Stress, 13*, 100235.

Lindsay, J. R., & Nieman, L. K. (2005). The hypothalamic-pituitary-adrenal axis in pregnancy: Challenges in disease detection and treatment. *Endocrine Reviews, 26*, 775-799. https://doi.org/10.1210/er.2004-0025

Liu, J., Bann, C., Lester, B., Tronick, E., Das, A., Lagasse, L., … Bada, H. (2010). Neonatal neurobehavior predicts medical and behavioral outcome. *Pediatrics, 125*, e90-e98. https://doi.org/10.1542/peds.2009-0204

Lupien, S. J., McEwen, B. S., Gunnar, M. R., & Heim, C. (2009). Effects of stress throughout the lifespan on the brain, behaviour and cognition. *Nature Reviews Neuroscience, 10*, 434-445. https://doi.org/10.1038/nrn2639

Martin, P., & Bateson, P. (1993). *Measuring behaviour: An introductory guide* (2nd ed.). New York, NY: Cambridge University Press.

McGraw, K. O., & Wong, S. P. (1996). Forming inferences about some intraclass correlation coefficients. *Psychological Methods, 1*, 30-46. https://doi.org/10.1037/1082-989x.1.1.30

Mohiyeddini, C., Bauer, S., & Semple, S. (2013). Displacement behaviour is associated with reduced stress levels among men but not women. *PLoS one, 8*, 1-9. https://doi.org/10.1371/journal.pone.0056355

Monk, C., Fifer, W. P., Myers, M. M., Bagiella, E., Duong, J. K., Chen, I. S., … Altincatal, A. (2011). Effects of maternal breathing rate, psychiatric status, and cortisol on fetal heart rate. *Developmental Psychobiology, 53*, 221-233. https://doi.org/10.1002/dev.20513

Monk, C., & Hane, A. A. (2016). Fetal and infant neurobehavioral development: Basic processes and environmental influences. In A. Wenzel (Ed.), *The Oxford handbook of perinatal psychology.* New York: Oxford University Press.

Munafò, M. R., Nosek, B. A., Bishop, D. V., Button, K. S., Chambers, C. D., Du Sert, N. P., … Ioannidis, J. P. (2017). A manifesto for reproducible science. *Nature Human Behaviour, 1*, 0021. https://doi.org/10.1038/s41562-016-0021

Ostlund, B. D., Vlisides-Henry, R. D., Crowell, S. E., Raby, K. L., Terrell, S., Brown, M. A., … Conradt, E. (2019). Intergenerational transmission of emotion dysregulation: Part II. Developmental origins of newborn neurobehavior. *Development and Psychopathology, 31*, 831-845. https://doi.org/10.1017/s0954579419000440

Porges, S. W. (2001). The polyvagal theory: Phylogenetic substrates of a social nervous system. *International Journal of Psychophysiology, 42*, 123-146. https://doi.org/10.1016/s0167-8760(01)00162-3

Porges, S. W. (2003). Social engagement and attachment: A phylogenetic perspective. *Annals of the New York Academy of Sciences, 1008*, 31-47. https://doi.org/10.1196/annals.1301.004

Porges, S. W. (2007). The polyvagal perspective. *Biological Psychology, 74*, 116-143. https://doi.org/10.1016/j.biopsycho.2006.06.009

Qu, M., Zhang, Y., Webster, J. G., & Tompkins, W. J. (1986). Motion artifact from spot and band electrodes during impedance cardiography. *IEEE Transactions on Biomedical Engineering, 33*, 1029-1036. https://doi.org/10.1109/tbme.1986.325869

Quigley, K. S., & Barrett, L. F. (2014). Is there consistency and specificity of autonomic changes during emotional episodes? Guidance from the Conceptual Act Theory and psychophysiology. *Biological Psychology, 98*, 82-94. https://doi.org/10.1016/j.biopsycho.2013.12.013

R Core Team (2019). R: A language and environment for statistical computing [Computer software]. Vienna, Austria: R Foundation for Statistical Computing. Retrieved from https://www.R-project.org/.

Randall, A. K., Post, J. H., Reed, R. G., & Butler, E. A. (2013). Cooperating with your romantic partner: Associations with interpersonal emotion coordination. *Journal of Social and Personal Relationships, 30*, 1072-1095. https://doi.org/10.1177/0265407513481864

Rakers, F., Rupprecht, S., Dreiling, M., Bergmeier, C., Witte, O. W., & Schwab, M. (in press). Transfer of maternal psychosocial stress to the fetus. *Neuroscience and Biobehavioral Review*. https://doi.org/10.1016/j.neubiorev.2017.02.019

Rattel, J. A., Mauss, I. B., Liedlgruber, M., & Wilhelm, F. H. (2020). Sex differences in emotional concordance. *Biological Psychology, 151*, 1-12. https://doi.org/10.1016/j.biopsycho.2020.107845

Schaefer, H. S., Larson, C. L., Davidson, R. J., & Coan, J. A. (2014). Brain, body, and cognition: Neural, physiological and self-report correlates of phobic and normative fear. *Biological Psychology, 98*, 59-69. https://doi.org/10.1016/j.biopsycho.2013.12.011

Schwartz, G. E., & Shapiro, D. (1973). Social psychophysiology. In W. F. Prokasy, & D. C. Raskin (Eds.), *Electrodermal activity in psychological research* (pp. 377-416). New York: Academic Press.

Sgoifo, A., Braglia, F., Costoli, T., Musso, E., Meerlo, P., Ceresini, G., & Troisi, A. (2003). Cardiac autonomic reactivity and salivary cortisol in men and women exposed to social stressors: Relationship with individual ethological profile. *Neuroscience and Biobehavioral Reviews, 27*, 179-188. https://doi.org/10.1016/s0149-7634(03)00019-8

Stellar, J. E., John-Henderson, N., Anderson, C. L., Gordon, A. M., McNeil, G. D., & Keltner, D. (2015). Positive affect and markers of inflammation: Discrete positive emotions predict lower levels of inflammatory cytokines. *Emotion, 15*, 129-133.

https://doi.org/10.1037/emo0000033

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.

Stifter, C. A., & Corey, J. M. (2001). Vagal regulation and observed social behavior in infancy. *Social Development, 10*, 189-201. https://doi.org/10.1111/1467-9507.00158

Streiner, D. L. (2003). Starting at the beginning: An introduction to coefficient alpha and internal consistency. *Journal of Personality Assessment, 80*, 99-103. https://doi.org/10.1207/s15327752jpa8001_18

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

Troisi, A. (1999). Ethological research in clinical psychiatry: The study of nonverbal behavior during interviews. *Neuroscience and Biobehavioral Reviews, 23*, 905-913. https://doi.org/10.1016/s0149-7634(99)00024-x

Van Buuren, S., & Groothuis-Oudshoorn, K. (2011). Mice: Multivariate imputation by chained equations in R. *Journal of Statistical Software, 45*, 1-68. https://doi.org/10.18637/jss.v045.i03

Villada, C., Hidalgo, V., Almela, M., Mastorci, F., Sgoifo, A., & Salvador, A. (2014). Coping with an acute psychosocial challenge: Behavioral and physiological responses in young women. *PloS ONE, 9*. https://doi.org/10.1371/journal.pone.0114640

Wadhwa, P. D., Buss, C., Entringer, S., & Swanson, J. M. (2009). Developmental origins of health and disease: Brief history of the approach and current focus on epigenetic mechanisms. *Seminars in Reproductive Medicine, 27*, 358-368. https://doi.org/10.1055/s-

0029-1237424

Wallin, B. G. (1981). Sympathetic nerve activity underlying electrodermal and cardiovascular reactions in man. *Psychophysiology, 18*, 470-476. https://doi.org/10.1111/j.1469-8986.1981.tb02483.x

Walsh, K., Basu, A., & Monk, C. (2015). The role of sexual abuse and dysfunctional attitudes in perceived stress and negative mood in pregnant adolescents: An ecological momentary assessment study. *Journal of Pediatric and Adolescent Gynecology, 28*, 327-332. https://doi.org/10.1016/j.jpag.2014.09.012

Walsh, K., McCormack, C. A., Webster, R., Pinto, A., Lee, S., Feng, T., … Werner, E. A. (2019). Maternal prenatal stress phenotypes associate with fetal neurodevelopment and birth outcomes. *Proceedings of the National Academy of Sciences, 116*, 23996-24005. https://doi.org/10.1073/pnas.1905890116

Witvliet, C. V. O., & Vrana, S. R. (1995). Psychophysiological responses as indices of affective dimensions. *Psychophysiology, 32*, 436-443. https://doi.org/10.1111/j.1469-8986.1995.tb02094.x