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Social support buffers the effects of maternal prenatal stress on infants' unpredictability

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ABSTRACT

Objective: Exposure to stress in pregnancy has been shown to affect fetal development with short- and long-term physiological and behavioral consequences for the offspring. Although social support is known to lower perceived stress, no prior study has investigated the buffering role of social support in the context of prenatal stress effects on infant temperament. The aim of this study was to examine interactive effects of prenatal stress and social support on several dimensions of infant temperament at 9 months postpartum.

Study design: A total of 272 mothers completed the Perceived Stress Scale and the Perceived Social Support Scale in the 3rd trimester of pregnancy. Infant temperament was assessed by mothers at 9 months postpartum using the Infant Characteristics Questionnaire. Linear regression models were performed to assess the effects of perceived stress, social support, and their interaction on infant temperament.

Results: Prenatal stress interacted with social support, such that prenatal stress increased infant unpredictability when social support was below -0.5 SD.

Conclusions: Prenatal stress was found to be a risk factor for infant temperamental unpredictability when combined with low social support perceived by the mother during pregnancy. Support of others, not previously examined in this context, can reduce the impact of prenatal stress.

1. Introduction

Exposure to environmental factors can alter maternal physiology in a manner that results in "programming" effects on the fetus, with physiological and behavioral consequences for offspring. Fetal programming is understood in terms of adaptation to the prenatal environment, with the course of development altered in a manner that shapes outcomes after birth and into adulthood. Although mechanisms involved in this *in utero* programming are not yet fully understood, related work has contributed to the growing multi-disciplinary field addressing Developmental Origins of Health and Disease (DOHaD) [1], with several studies having examined fetal programming effects associated with prenatal exposure to maternal stress.

In DOHaD research, operationalizations of stress have included traumatic events (e.g., exposure to interpersonal violence or natural disasters), physiological stress reactivity (e.g., cortisol concentrations), symptoms of anxiety and depression, and psychosocial stress (daily hassles/stressful events). The latter set of effects is particularly important, given the prevalence of environmental stress: for example, a recent community-based study indicated that about 30% of pregnant women reported some type of stress (e.g., job strain) in their daily lives [2]. Perceived environmental stress during pregnancy has been shown to impact perinatal outcomes, including birth weight, as well as child behavioral phenotypes, including temperament later in infancy [3–5].

Behavioral effects of *in utero* stress exposure have often been examined in animal models [6]. Although behavioral outcomes have not been typically framed as temperament *per se*, but rather discussed in terms of stress reactivity, susceptibility to anxiety, or impulsivity, these characteristics are consistent with the overarching theoretical framework defining temperament as early appearing individual differences in reactivity and regulation, which are constitutionally based and subject to influences of environmental factors and maturation [7]. In human

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research, a preponderance of evidence suggests associations between prenatal stress exposure and high levels of largely overlapping temperament attributes associated with expressions of negative emotions [8–14]. Early manifestations of temperament are not only important as key components of social-emotional development, but are also significant as markers of risk for later symptoms of psychopathology [15,16].

To date, the majority of studies linking prenatal maternal stress to offspring temperament have relied on nonspecific measures assessing broad constructs such as "negative affectivity" or "difficulty". This is problematic, as temperament is multifaceted, with different aspects of individual differences associated with distinct physiological underpinnings and patterns of adjustment. A primary goal of the current study was to provide a more detailed perspective of infant temperament attributes affected by *in utero* environmental stress exposure. Our focus was on fine-grained elements of temperament perceived as "difficult" by parents. Factor analyses of the instrument used in the current study, the Infant Characteristics Questionnaire [17], revealed four dimensions: Fussy/Difficult (e.g., how much does your baby cry and fuss in general?), Unadaptable (e.g., how does your baby typically respond to a new person?), Dull (e.g., how much does your baby enjoy playing with you?), and Unpredictable (e.g., how consistent is your baby in sticking to his/her eating routine?). Results of prior investigations lead to expectations that high prenatal stress would translate into infants being perceived as fussy, unadaptable, dull and/or unpredictable, but offered scant rationale regarding which of these dimensions are most closely linked to maternal stress.

A second organizing goal was to test the proposal that social support may moderate the effects of prenatal stress. Social support is likely to influence inter-generational transmission of risk, playing a protective function with respect to disruption of HPA axis functioning, as well as other potential mechanisms (e.g., nutrition and inflammation related pathways) [18]. Although not adequately examined to date, existing evidence suggests that higher levels of social support can buffer offspring with respect to stress-related fetal programming. For example, Stapleton et al. [19] reported that mothers who perceived stronger support from their partners during pregnancy experienced less emotional distress postpartum (controlling for earlier distress), and their infants exhibited less fear reactivity. Support from a broader social network appears to also enhance maternal and child adjustment postpartum [20]. For example, prenatally depressed women assigned weekly group social support sessions demonstrated marked reductions in depression and anxiety, as well as decreased cortisol reactivity [21]. Importantly, low levels of perceived social support after childbirth predicted infant negative affectivity at 6 months of age, after accounting for pre- and postpartum depressive symptoms, and infant temperament measured at 3 months [22].

In sum, exposure to psychosocial stress during pregnancy has been shown to influence offspring reactivity and regulation [23], but prior studies have examined broad aspects of temperament, rather than more discrete dimensions of difficulty. Furthermore, social support appears to buffer the effects of perceived stress on other outcomes [24]; however, the potential modulation of prenatal stress effects on infant temperament by social support remains unexplored. The present study was designed to address these gaps. We hypothesized that higher perceived stress would be associated with a more challenging infant temperament profile, including higher levels of fussiness, unadaptability, dullness, and/or unpredictability, an effect that would be moderated by social support, buffering the offspring from manifesting "difficult" temperament. In addition, as prenatal stress has been found to be associated with stress experienced in the postpartum period [25], with some studies indicating that postnatal environments, rather than prenatal stress *per se*, affects child outcomes [26], we included maternal perceived stress in the postnatal period as a control variable in our analyses.

2. Material and methods

2.1. Procedure

The data were collected between 2013 and 2014 in five maternity hospitals (Havlíčkův Brod, Jihlava, Třebíč, Pelhřimov, Nové Město na Moravě) within a larger project investigating the perinatal determinants of maternal well-being and child development [27,28]. Pregnant women were approached during their prenatal medical check-ups at maternity hospitals and invited to participate in the study. The data used in this study were collected via in person, online or mail distributed questionnaires administered in the 3rd trimester of pregnancy and 9 months postpartum. At baseline, women completed a questionnaire about their sociodemographic background. In the 3rd trimester of pregnancy, they completed the Perceived Stress Scale (PSS) [29] and Perceived Social Support Scale (PSSS) [30]. Nine months postpartum, participants completed the PSS again along with the Infant Characteristics Questionnaire (ICQ) [17]. Data related to maternal health status in pregnancy and perinatal outcomes were extracted from medical records. All women signed an informed consent form before participating in the study, after the research was explained to them.

2.2. Participants

A total of 713 women completed the questionnaires in pregnancy and had data from medical records available. Out of those women, 307 took part in the survey at 9 months postpartum. We excluded women with multiple pregnancy ($n = 5$) and those who had missing data on key study variables (PSS, PSSS, ICQ) ($n = 30$) (see flow-chart in Fig. 1). The final sample thus consisted of 272 women. Characteristics of the final sample and of the women who did not respond to postpartum instruments at 9 months are shown in Table 1. Women who opted out of the 9-month follow-up were more likely to have attained a lower education level and were less often married.

2.3. Measures

2.3.1. Maternal perceived stress in the 3rd trimester of pregnancy and 9 months postpartum

The Perceived Stress Scale (PSS) [29] is a 10-item self-report inventory to assess the degree to which situations in daily life are perceived as stressful. Each item is rated on a 5-point scale ranging from 0 to 4. The total score may thus range from 0 to 40, with higher scores reflecting higher levels of perceived stress. The PSS has previously been used in a population of pregnant and postpartum women [31–33]. The internal consistency was evaluated using McDonald's ω coefficient with values of 0.86 and 0.88 in the 3rd trimester of pregnancy and at 9 months postpartum, respectively (Table 2).

2.3.2. Maternal social support in the 3rd trimester of pregnancy

The Perceived Social Support Scale (PSSS) [30,34] is a 12-item self-report questionnaire assessing perceived social support from family, friends and significant others. Each item is rated on a 7-point scale ranging from 1 to 7. The total score may thus range from 12 to 84, with higher scores indicating higher social support. The PSSS has previously been used with pregnant women [35]. The internal consistency coefficient (McDonald's ω) was 0.92 (Table 2).

2.3.3. Infant temperament 9 months postpartum

Infant temperament was reported by mothers on the Infant Characteristics Questionnaire (ICQ) [17]. The ICQ was developed as a tool to screen infant difficultness. It consists of four dimensions: Fussy/Difficult, Unadaptable, Dull, and Unpredictable. Each item is rated on a 7-point scale, where all item scores combine to form a single score, with higher scores indicating more difficult temperament. The original version of the ICQ contains 24 items. Based on a factor analysis reported

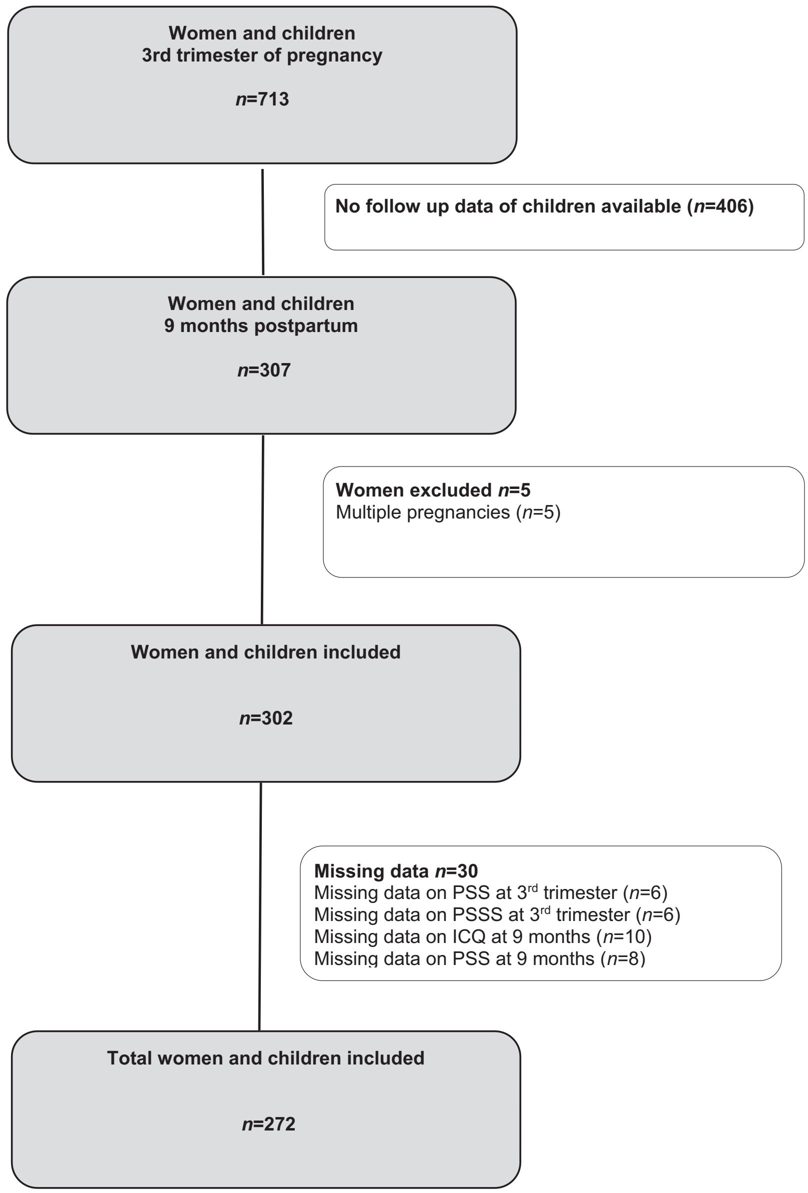

Fig. 1. Flow-chart of participants.

by the authors [17], only 16 items were used in this study. The ICQ version used in this study included five items from the Fussy/Difficult dimension, four from Unadaptable, three from Dull, and four from Unpredictable. The internal consistency coefficient (McDonald's ω) was 0.86 for the overall ICQ and 0.84, 0.80, 0.48 and 0.79 for the ICQ subscales Fussy/Difficult, Unadaptable, Dull, and Unpredictable, respectively (Table 2).

2.4. Statistical analyses

Multiple linear regressions were performed to assess the effects of PSS, PSSS and their interaction on infant temperament. Simple slope tests were performed to aid the interpretation of significant interactions. The analyses were adjusted for maternal age, marital status, educational level, child's sex, gestational age at birth and perceived stress (PSS) at nine months postpartum. We opted to statistically control for these variables because of existing research indicating links with maternal perceived stress during pregnancy, as well as infant outcomes [36,37], and to provide a more conservative test of anticipated effects in the case of postpartum psychosocial stress. Moreover, to account for potential effects of perinatal factors, we created an extended model, adding the following covariates: pregnancy complications (hypertension, diabetes), parity, induction of labor (synthetic oxytocin, prostaglandins), intrapartum analgesia/anesthesia (epidural/spinal; other analgesia/anesthesia), mode of delivery, Apgar score at 5 min, birth weight. The first model with a limited number of covariates was also fitted with quadratic effect of stress in pregnancy to account for possible non-linear effects of prenatal stress evidenced by several previous studies [38–40]. The variable "mode of delivery" was coded as 1 for vaginal and 0 for other modes. Marital status was recoded with 1 for married and 0 for other types. All raw data files are available from the OSF database: https://osf.io/7wmb3/.

3. Results

3.1. Sample characteristics

Characteristics of the mother-infant pairs are shown in Table 1. The mean maternal age was 30 years (SD = 3.83). Out of 272 women who completed the ICQ nine months postpartum, 72% were married, 40%

Table 1
Characteristics of the sample.

	Final sample		Women who dropped out of the study		Comparison *p*-value*
	N = 272		*N* = 441		
Age, years, SD	30.46	3.83	30.21	4.45	0.4420
Education, n (%)					**0.0320**
Elementary	0	0%	8	1.18%	
Vocational	19	6.98%	39	8.84%	
Secondary	143	52.57%	243	55.10%	
University	108	39.70%	139	31.51%	
Missing	2	0.73%	5	0.11%	
Parity, n (%)					0.3467
primipara	138	50.74%	212	48.07%	
multipara	134	49.26%	229	51.93%	
Marital status, n (%)					**0.0194**
single	73	26.84%	124	28.12%	
married	195	71.69%	287	65.08%	
divorced	3	1.10%	24	5.44%	
widowed	0	0%	1	0.23%	
missing	1	0.37%	9	1.13%	
Delivery type, n (%)					0.4318
spontaneous	178	65.44%	288	66.06%	
emergency CS	55	20.22%	74	16.97%	
planned CS	39	14.34%	74	16.97%	
instrumental	0	0%	0	0%	
Child sex, n (%)					0.0641
boy	153	56.25%	214	48.538%	
girl	119	43.75%	222	50.34%	
missing	0	0%	1	1.13%	
Gestational diabetes, n (%)	23	8.46%	31	7.033%	0.5611
Hypertension, n (%)	20	7.35%	27	6.12%	0.5393
Induction of labor, n (%)	61	22.42%	109	25.00%	0.2370
Analgesia epidural/ spinal	79	29.04%	133	30.64%	0.6738
Analgesia other, n (%)	45	16.54%	62	14.22%	0.4803
Gestational age, weeks, SD	39.53	1.21	39.45	1.33	0.4301
Apgar score at 5 min, n (%)					0.3021
10	176	64.71%	307	69.62%	
9–7	94	34.55%	125	28.34%	
< 7	1	0.37%	2	0.45%	
missing	1	0.37%	2	1.59%	
Birth weight, grams, SD	3450.07	487.59	3429.54	493.27	0.5882

* Welchs *t*-test for age, birth weight, chi-square test for education, marital status, mode of delivery, Fisher's exact test for the rest.

had a university degree and 65% had spontaneous vaginal birth, while 14% delivered via planned and 20% via emergency CS. The numbers of primiparous and multiparous women were approximately even. There were more boys (153, 56%) than girls (119, 44%) in the sample.

3.2. The effects of perceived stress and social support in pregnancy on infant temperament

There were no main effects of prenatal stress or social support in pregnancy on infant temperament (overall ICQ score or ICQ subscales) in the model adjusted for maternal age, marital status, educational level, infant's sex, gestational age at birth and perceived stress at nine months postpartum (Table S1, Supplementary material). Maternal perceived stress measured at nine months postpartum was the only significant predictor of infant temperament (overall ICQ score and the subscales Unadaptability and Dullness).

After including the interaction between prenatal stress and concurrently measured social support in the model (Table 3), a significant moderating effect of social support was observed on the association between prenatal stress and ICQ subscale Unpredictability ($b = -1.24$, $t[258] = -2.00$, $p = 0.045$). This interaction is visualized in Fig. 2. Simple slope tests used to probe the nature of this interaction revealed that the effect of prenatal stress on infant Unpredictability was only significant when social support scores in pregnancy ranged from −0.6 SD to -6.8 SD, while non-significant in the range of −0.5 SD to 1.0 SD (see Table 4). Thus, prenatal stress only increased infant's unpredictability when social support score was below −0.6 SD. No moderated effects of prenatal stress were revealed for overall difficulty or the remaining three ICQ subscales. The results remained the same after excluding maternal stress at 9 months postpartum from the model.

A possible nonlinear effect of stress was tested by introducing a quadratic term of stress, but there was no such effect detected for the ICQ or its subscales (see Table S2, Supplementary material). In addition, we controlled for an extended number of covariates to account for possible effects of maternal health problems in pregnancy and less favorable birth outcomes (see Table S3, Supplementary material). The effect of the interaction between prenatal stress and social support on infant Unpredictability remained significant after adjusting the model for those covariates. After stratifying the analyses by infant sex, the effects of PSS, PSSS and their interaction were no longer significant, probably due to a decreased number of observations.

4. Discussion

The aim of this study was to investigate the effects of prenatal stress on multiple aspects of difficult temperament at nine months of age and potential buffering effects of social support measured concurrently with perceived stress in pregnancy. We found no main effect of prenatal stress on infant overall temperament score or scores for the individual temperamental sub-dimensions, but, in line with our hypothesis, we found that prenatal stress interacted with social support, such that prenatal stress increased infant unpredictability provided that social support was low.

Table 2
Descriptive statistics for the PSS, PSSS, ICQ and its subscales.

Questionnaire	N	Mean	Median	SD	Min	Max	McDonald's ω
PSS in pregnancy	272	13.87	14	5.56	2	35	0.86
PSS at 9 months ppt.	272	13.7	14	5.89	1	31	0.88
PSSS in pregnancy	272	75.21	77	8.31	20	84	0.92
ICQ at 9 months ppt.	272	41.37	40.5	10.57	17	72	0.86
ICQ-Fussy/Difficult, 9 months ppt.	272	13.49	13	4.52	5	28	0.84
ICQ-Unadaptable, 9 months ppt.	272	9.45	9	3.85	4	21	0.8
ICQ-Dull, 9 months ppt.	272	8.84	9	2.08	3	15	0.48
ICQ-Unpredictable, 9 months ppt.	272	9.43	9	3.47	4	20	0.79

ppt. = postpartum.

Table 3
Associations between prenatal stress (PSS), social support (PSSS) and their interaction with infant temperament at 9 months postpartum (ICQ and its subscales).

Dependent variable	ICQ				Fussiness				Unadaptability				Dullness				Unpredictability			
	Est.	Std. Err.	Std. Est.	Pr(>|t|)	Est.	Std. Err.	Std. Est.	Pr(>|t|)	Est.	Std. Err.	Std. Est.	Pr(>|t|)	Est.	Std. Err.	Std. Est.	Pr(>|t|)	Est.	Std. Err.	Std. Est.	Pr(>|t|)
(Intercept)	16.444	30.123	0	0.586	12.045	12.856	0	0.35	−0.062	10.497	0	0.995	12.383	5.998	0	0.04	−4.462	9.82	0	0.65
Stress in pregnancy (PSS)	1.799	1.211	0.947	0.139	0.741	0.503	0.914	0.142	−0.01	0.417	−0.014	0.981	0.114	0.234	0.303	0.628	0.818	0.388	1.322	**0.036***
Social support in pregnancy (PSSS)	0.371	0.243	0.298	0.128	0.154	0.102	0.287	0.133	0.001	0.084	0.002	0.991	0.013	0.048	0.053	0.781	0.152	0.078	0.369	0.052
PSS:PSSS	−0.024	0.016	−0.944	0.135	−0.011	0.007	−0.975	0.111	0.001	0.005	0.081	0.891	−0.002	0.003	−0.356	0.563	−0.01	0.005	−1.241	**0.045***
Stress at 9 months (PSS)	0.451	0.126	0.253	**<0.001*****	0.165	0.053	0.217	**0.002***	0.206	0.044	0.315	**<0.001*****	0.029	0.025	0.081	0.254	0.06	0.041	0.104	0.143
Maternal age	0.005	0.18	0.002	0.978	−0.016	0.076	−0.014	0.831	0.015	0.061	0.015	0.807	−0.019	0.035	−0.035	0.585	0.025	0.057	0.028	0.667
Marital status	1.174	1.565	0.05	0.454	0.884	0.648	0.088	0.174	−0.098	0.53	−0.011	0.853	−0.035	0.306	−0.008	0.909	0.177	0.501	0.023	0.725
Maternal education	−0.215	0.603	−0.023	0.721	−0.079	0.251	−0.02	0.755	−0.362	0.206	−0.105	0.081	0.14	0.117	0.076	0.233	0.331	0.195	0.108	0.09
Child sex	−1.271	1.335	−0.06	0.342	−0.592	0.561	−0.065	0.292	−0.044	0.46	−0.006	0.923	−0.353	0.264	−0.084	0.182	−0.394	0.435	−0.057	0.367
Gestational age at birth	−0.233	0.556	−0.026	0.675	−0.288	0.238	−0.075	0.226	0.169	0.197	0.051	0.391	−0.109	0.112	−0.061	0.333	−0.019	0.184	−0.007	0.917
Observations	249				262				266				264				261			
R^2	0.076				0.067				0.131				0.030				0.050			
Adjusted R^2	0.042				0.033				0.104				-0.004				0.015			
Residual Std. Error	10.27 (df = 239)				4.426 (df = 252)				3.662 (df = 256)				2.088 (df = 254)				3.423 (df = 251)			
F Statistic	2.207* (df = 9; 239) (p = 0.022)				2.02* (df = 9; 252) (p = 0.037)				4.277** (df = 98; 256) (p < 0.001)				0.876 (df = 9; 264) (p = 0.547)				1.452 (df = 9; 251) (p = 0.166)			

Note: *p**p***p < 0.001; adjusted for sociodemographic characteristics, gestational age at birth and perceived stress at 9 months postpartum; PSS:PSSS – interaction between PSS and PSSS. Est. = Estimate, Std. Err. = Standard Error, Std. Est. = Standardized Estimate.

The finding that there are no main or interaction effects of prenatal stress on overall difficulty or three of the four sub-dimensions is surprising, as substantial evidence points to the link between prenatal stress and infant "difficult temperament" or negative affectivity [8,9,12,13,41]. On the other hand, several previous studies reported no association between prenatal stress and infant temperament [42,43] or negative affectivity [22]. It is possible that our results are due to generally low levels of perceived stress in our community, non-clinical sample, so that we were not able to detect potential effects of high levels of stress on infants' emotionality, social responsiveness, or reactions to novelty. Alternatively, different types of stress may have differential effects, with infants' emotional response being more closely linked to mothers' mental state (i.e., their self-reported anxiety) than their perceptions of how stressful they find daily life events [43].

We did observe a combined effect of high prenatal stress and low social support on infant unpredictability, i.e. behavioral manifestations related to maternal assessment of how easy or difficult it is to predict the infant's needs. The processes underlying this specific finding are elusive. One class of possibilities are biological. Frequent experiences of unmodulated stress, through effects on the HPA axis or other physiological systems, may influence development of neural structures associated with regulation of state, leading to disorganization in the infant's behaviors related to sleep, nutrition and comfort-seeking. Another class of mechanisms are behavioral. It may be the case that mothers who experience high levels of daily life stress during pregnancy subsequently face challenges in establishing routines of child rearing that allow their infants to develop predictable patterns of activity. A third possibility concerns the nature of the measurement. In contrast to the Fussy-Difficult and Unadaptable subscales, which focus solely on infant behavior, some items on the Unpredictable subscale additionally reflect parent's ability to understand their infants' signals (e.g., "How easy or difficult is it for you to know what's bothering your baby when he/she cries or fusses?"). It may be the case that mothers who perceive both a great deal of stress and a lack of social support during pregnancy may also experience uncertainty regarding their interactions with their offspring and more difficulties interpreting their infants' cues.

Our finding that maternal prenatal stress had a negative effect on an aspect of infant temperament when combined with low social support is in line with general research on the role of social support in coping with stress, evidencing that social support can protect against a wide variety of detrimental effects of stress, including physical and mental health problems or alcohol abuse [44]. It also indicates that women vulnerable because of lacking social safety nets may be more susceptible to the effects of prenatal stress. However, although social support (more specifically, support from the partner) in pregnancy has been found to enhance maternal well-being in the postpartum period and positively affect infant temperament [19], only a few studies employed measures of social support in the context of prenatal stress. Examining combined effects of prenatal stressful life events and social support on the early behavioral symptoms of attention-deficit hyperactivity disorder (ADHD), Zhu et al. [20] found that boys whose mothers experienced severe stressful life events during pregnancy were at a higher risk of ADHD symptoms, a risk that increased significantly if the mother reported very low social support. Zande and Sebre [22] observed that maternal depressive symptoms in pregnancy predicted infant negative affectivity at three months postpartum, but this effect was no longer significant for infant negative affectivity measured at six months postpartum in analysis adjusted for postnatal social support, maternal postnatal depressive symptoms and infant negative affectivity at three months postpartum.

The current study is unique in evaluating whether there is a combined effect of prenatal stress and prenatally assessed social support, providing an important extension of previous findings. The strengths of this study include a prospective design, multi-centric data collection (women were recruited in 5 maternity hospitals) and controlling for maternal health status in pregnancy and perinatal outcomes, variables

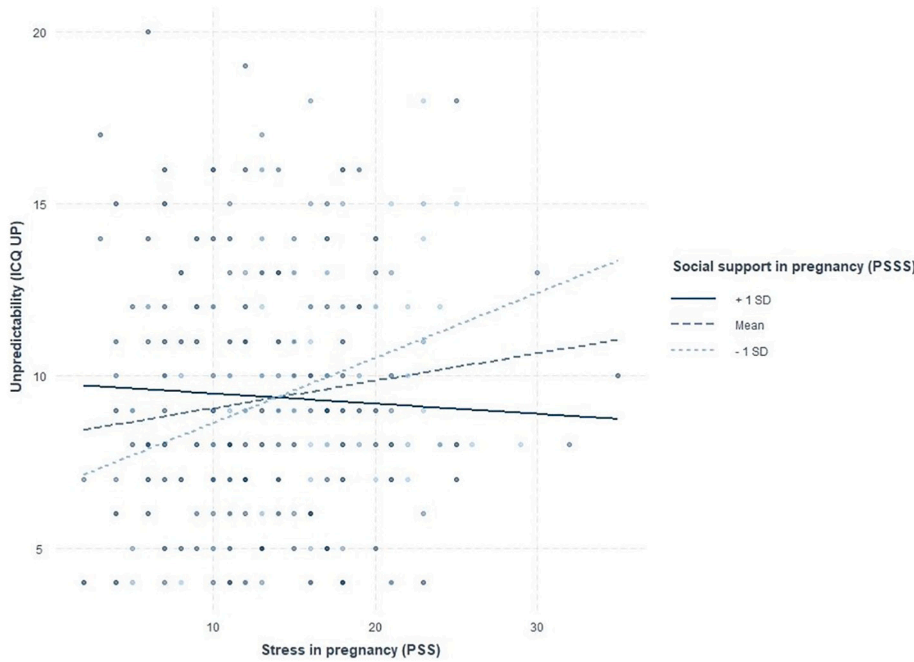

Fig. 2. Interaction between prenatal stress (PSS) and social support (PSSS) in their effect on infant unpredictability (ICQ).

Table 4
Simple slope analysis of interaction between prenatal stress (PSS) and social support (PSSS) in their effect on infant unpredictability (ICQ).

Social support	It's Z score	Slope of prental stress (std. error)	It's Z score	p-Value	Sig. symbol
21.18	−6.5	0.60 (0.28)	2.14	**0.041**	*
25.34	−6	0.56 (0.26)	2.15	**0.041**	*
29.49	−5.5	0.52 (0.24)	2.17	**0.040**	*
33.65	−5	0.47 (0.22)	2.14	**0.041**	*
37.81	−4.5	0.43 (0.20)	2.15	**0.041**	*
41.96	−4	0.39 (0.18)	2.17	**0.040**	*
46.12	−3.5	0.34 (0.16)	2.13	**0.042**	*
50.28	−3	0.30 (0.14)	2.14	**0.041**	*
54.43	−2.5	0.26 (0.12)	2.17	**0.040**	*
58.59	−2	0.22 (0.10)	2.20	**0.039**	*
62.74	−1.5	0.17 (0.08)	2.13	**0.042**	*
66.90	−1	0.13 (0.06)	2.17	**0.040**	*
70.23	−0.6	0.10 (0.05)	2.00	**0.048**	*
71.06	−0.5	0.09 (0.05)	1.80	0.061	#
75.21	0	0.05 (0.04)	1.25	0.131	ns
79.37	0.5	0.00 (0.05)	0.00	0.525	ns
83.53	1	−0.04 (0.06)	−0.80	0.237	ns

Note: ns $p > 0.1$, # $p > 0.05$, * $p < 0.05$, ** $p < 0.01$,*** $p < 0.001$.

that could be related to both prenatal stress and infant behaviors. Moreover, we controlled for the effects of postnatal stress (9 months postpartum), which enabled us to report results unique to prenatal stress. Several limitations of the present study must, however, be addressed. First, infant temperament was assessed by mothers, such that it is hard to disentangle the evaluation of infant temperament *per se* and maternal views of it. Nevertheless, this is a limitation that applies to the majority of the studies on the link between prenatal stress and infant temperament [5]. Moreover, there is a consensus in the field that parent ratings reflect actual infant behavior, and are not solely measures of observer bias [7,45].

Another limitation is the low reliability of the ICQ Dull subscale, which lowers the probability of detecting effects concerning this variable. Also, our study is based on a non-clinical sample of White, European women, which can limit generalizability of our findings to clinical or more diverse populations. Last but not least, it is important to note that the effect on infant unpredictability has been derived from inter-individual rather than intra-individual variability, suggesting that assumptions about positive effects of increasing social support or decreasing prenatal stress on infant behaviors on an individual level must be made with caution, as we can only state that mothers experiencing lower levels of stress and higher levels of social support tended to rate their children as more predictable.

The emotional and social context of pregnancy may shape fetal, infant and family development through multiple mechanisms. Future studies should clarify the processes associated with the current findings, considering relevant biological (e.g., cortisol levels) and psychological (e.g., parenting) contributors. The most salient clinical implications of the current study concern the importance of social support for preventing potential negative implications of maternal stress. Policy and practices that enhance the likelihood that pregnant women receive assistance in coping with distressing circumstances hold promise for benefitting both parents and their children.

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Ethics statement

All procedures performed were in accordance with the ethical standards of the institutional Ethics Committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

This research project was approved by the Ethics Committee of the Jihlava Hospital, which is responsible for the Vysočina Region where the study took place.

Informed consent was obtained from all individual participants included in the study.

CRediT authorship contribution statement

LT: Conceptualization; Funding acquisition; Data collection; Investigation; Methodology; Project administration; Writing- original draft; Writing - review & editing.

JŠ: Data curation; Formal analysis; Methodology; Writing - review & editing.

MG: Conceptualization; Methodology; Writing- original draft; Writing - review & editing.

SPP: Conceptualization; Methodology; Writing- original draft; Writing - review & editing.

CM: Conceptualization; Methodology; Writing - review & editing; Supervision

Declaration of competing interest

The authors declare no conflict of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.earlhumdev.2021.105352.

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