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Post-Natal Maternal Mood Provides Evidence for the Psychic Pain Hypothesis

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## Abstract

We tested predictions derived from the psychic pain hypothesis according to which depressive symptoms after delivery signal to a mother that she is suffering or has suffered a fitness loss. The predictions were tested on a range of mild emotional states, i.e. moods, which allowed us to assess whether the consequences of unfavorable maternal conditions are limited to depressive mood or include other negative and positive moods. In a longitudinal study of 150 women, we measured positive and negative moods twice: during the last trimester of pregnancy and one to three months after delivery. As an index of infant quality, we used mean of Apgar scores measured at one and five minutes after delivery, and as an index of maternal circumstances we used perceived family social support. Supporting the psychic pain hypothesis, after controlling for mothers' moods before delivery, Apgar score and perceived family social support as well as their interaction predicted mothers' negative moods after delivery, especially depressive mood and rejection. Additionally, mothers' depressive mood was sensitive to subtle signs of lower infant health. Perceived family social support and Apgar score were weaker predictors of mothers' positive moods after delivery. Theoretical and practical implication of these results are discussed.

*Key words:* psychic pain hypothesis, Apgar score, perceived family social support, moods, depression

### Public Significance Statements

The present longitudinal study supported the psychic pain hypothesis for post-natal maternal mood. The results showed that mother's negative post-natal mood, especially depression, is associated with low offspring quality (Apgar score) and unfavorable maternal circumstances (lower family social support). These results suggest the potential universality of the psychic pain hypothesis, and the need for social policies aimed at enhancing well-being and mental health of mothers in unfavorable perinatal circumstances.

## Introduction

### Postpartum Depression and Depressive Mood

Many women are prone to depressive mood after delivery of a child. Up to 80% of women report postpartum blues within the first 7-10 days after delivery (Henshaw, Foreman, & Cox, 2004). Postpartum blues refers to a transient mood disturbance characterized by mood swings, anxiety, tearfulness, irritability, and insomnia that usually resolve within a few days without intervention (O'Hara & McCabe, 2013). Postpartum blues are distinguished from postpartum depression (PPD). PPD refers to an episode of major depressive disorder that begins within four weeks after delivery and lasts for several weeks or months (O'Hara & McCabe, 2013), with an estimated prevalence of 10-15% (Gavin et al., 2005).

PPD symptoms may have short-term and long-term health implications for children, although they are generally small to modest (e.g. Kingston & Tough, 2014), and could be mediated by later maternal depression (e.g. Closa-Monasterolo et al., 2017). The children of mothers with PPD have problems in cognitive, social, and emotional development, and are at a higher risk for anxiety disorders and major depression (Goodman et al., 2011). These effects are observed from infancy to adolescence (Murray et al., 2011) and are linked to maternal depression through multiple genetic, neurobiological, and social pathways (Goodman et al., 2011). Risk factors for PPD include younger maternal age, lower socioeconomic status, poorer health, unwanted pregnancy, obstetrical stressors, maternal depression before and during pregnancy, low self-esteem, perceived lack of social support, difficult infant temperament, and poor infant health (Hagen, 1999, 2002; O'Hara & McCabe, 2013; Wang, Wu, Anderson, & Florence, 2011; Yim, Tanner Stapleton, Guardino, Hahn-Holbrook, & Dunkel Schetter, 2015).

## **Evolutionary Explanation of Postpartum Depressive Symptoms and PPD**

A leading evolutionary account of minor postpartum depressive symptoms is the psychic pain hypothesis, which contends that psychological pain is analogous to physical pain (Hagen, 1999, 2011). However, this hypothesis does not account well for the most detrimental symptoms of PPD, such as a loss of interest in most or all activities, weight loss, hypersomnia, psychomotor retardation, fatigue, loss of energy, and suicidal ideation; these symptoms are better accounted for by the bargaining hypothesis (Hagen, 1999, 2002). The focus of the current study is on minor postpartum depressive symptoms and, therefore, was designed as a test of the psychic pain hypothesis. According to this hypothesis, depressive symptoms signal to a mother that she is suffering or has suffered a fitness loss, which then motivates her to assess whether to invest in or defect from childrearing, including disinvesting in offspring with poorer prospects for survival and reproduction (Hagen, 1999; Thornhill & Furlow, 1998). This defection hypothesis for postpartum symptoms of depression generates several predictions. First, when an infant requires more investment than usual, a mother will evaluate its viability (e.g., health) before she invests. Second, when a child requires more investment than usual, a mother will assess how much others (father or family) will invest before investing herself. Taken together, poor infant viability and lack of social support will predict mothers' sad or depressed mood (Hagen, 1999).

Consistent with these predictions, problems with pregnancy, delivery, and infant health, and perceived lack of social support correlate with postpartum depressive symptoms. These results have been obtained for both maternal self-reported symptoms and clinical diagnosis (Hagen, 1999), and have been corroborated in meta-analyses of data from Western cultures (e.g. Yim et al., 2015), and in investigations in non-Western cultures (Hagen & Barrett, 2007).

## The Present Research

Although empirical evidence noted above provides convergent evidence consistent with the psychic pain hypothesis, few empirical studies have directly tested its predictions (e.g., Hagen, & Barret, 2007; Myers, Burger, & Johns, 2016). Appropriate tests of the psychic pain hypothesis for postpartum depressive symptoms should simultaneously investigate both sets of hypothesized etiological conditions - offspring quality and maternal circumstances. Most previous research has addressed only one of these sets of conditions. The present research uses Apgar score as a measure of offspring quality and perceived social support as a measure of maternal circumstances.

Apgar score measured at 1 and 5 minutes after delivery provides a reliable index of infant quality (Apgar, 1953) that can be secured quickly and without interfering with infant care by observing five signs: heart rate, respiratory effort, muscle tone, reflex irritability, and color, each of which is given a score of 0, 1, or 2 (Apgar, 1953). Infants with lower Apgar scores (i.e. less than 7) are at greater risk of neonatal and infant mortality (Casey, McIntire, & Leveno, 2001; Iliodromiti, Mackay, Smith, Pell, & Nelson, 2014), neurologic disability and low cognitive function (Ehrenstein et al., 2009), neonatal intracranial hemorrhage, cerebral palsy, mental retardation, and epilepsy (Ehrenstein et al., 2006; Moster, Lie, Irgens, Bjerkedal, & Markestad, 2001; Thorngren-Jerneck & Herbst, 2001). Research documents an association between low 5-minute Apgar score (i.e. less than 7) and greater risk of motor and developmental impairments at school age, including symptoms of attention deficit (Moster, Lie, & Markestad, 2002) and speech and language problems (Krebs, Langhoff-Roos, & Thorngren-Jerneck, 2001).

The importance of social support as a resource for maternal mental health following childbirth has been documented in studies that showed its effectiveness in helping mothers cope

with psychological stressors in the postpartum period (Cutrona, & Troutman, 1986; Collins, Dunkel-Schetter, Lobel, & Scrimshaw, 1993). Low or inconsistent levels of social support strongly predict postpartum depressive symptoms and PPD (Howell, Mora, & Leventhal, 2006; Reid & Taylor, 2015), and dissatisfaction with social support increases the risk for subclinical as well as clinical maternal depression during the postpartum period (Beck, 2001; Boury, Larkin, & Krummel, 2004). Family and partner social support are among the most important predictors of PPD across ethnic/racial groups (Negron, Martin, Almog, Balbierz, & Howell, 2013; O'Hara & Swain, 1996; Robertson, Grace, Wallington, & Stewart, 2004). In the mental health literature, measures of *perceived* social support are the most frequently used (Cohen, Gottlieb, & Underwood, 2000) because the effects of perceived support are stronger predictors of mental health than other measures (e.g., objective assessments of support; Thoits, 2011). Simultaneous investigation of both relevant factors (i.e. infant quality and maternal circumstances) for the development of postpartum depressive symptoms affords investigation not only of their main effects but also their interaction. Although the psychic pain hypothesis suggests additive effects of infant quality and maternal circumstances on postpartum depressive symptoms, it is also plausible to expect their multiplicative effect. Consistent with the stress buffering hypothesis (Cohen & Wills, 1985), we might expect a more beneficial effect of perceived family social support on mothers' negative mood in more stressful circumstances, i.e. when Apgar score is lower. On the other hand, when Apgar score is higher, social support may not exert an effect on mothers' negative moods.

In the present study, we investigated mild emotional states (i.e. moods), and this provided several advantages for tests of the psychic pain hypothesis. One prediction derived from this hypothesis states that PPD symptom levels should be proportionate to maternal conditions such

as infant health and access to resources (Hagen & Thornhill, 2017). Therefore, extremely unfavorable maternal conditions are expected to result in PPD, whereas less unfavorable maternal conditions are expected to result in emotional states of lower intensity such as minor depressive symptoms and low mood. Unlike specific emotions, mood is more inclusive and encompassing (Watson, 2000), allowing us to test whether the consequences of unfavorable maternal conditions are limited to depressive mood or also affect other specific negative and positive moods.

In summary, the aim of this longitudinal study was to explore the effects of Apgar score as an index of offspring quality and perceived family social support as an index of maternal circumstances, as well as their interaction, on mothers' postpartum positive and negative moods and their components, controlling for mothers' levels of the same moods before delivery. In accord with the psychic pain hypothesis, we expected that lower infant quality and unfavorable maternal circumstances would predict negative mood in mothers after delivery, with the strongest effects for depression and depression-like moods. Along with the main effects of Apgar score and perceived family social support, we expected their interaction, i.e. low infant quality would affect mothers' depression and depression-like moods more when social support is low.

## **Method**

### **Participants and Procedure**

Participants were comprised of a convenience sample of healthy women without prior history of depression, examined at two measurement points. The first measurement point (Time 1) was during the last trimester of pregnancy ( $M = 29.19$ ;  $SD = 3.84$  weeks of gestation), and the second measurement point (Time 2) was at an average of 47.85 ( $SD = 14.24$ ) days after delivery.

A total of 167 pregnant women without previous history of depression residing in Rijeka, Croatia and its immediate surroundings participated at Time 1. Seventeen women dropped out before the second measurement, resulting in a total of 150 women participants. The reasons for attrition included women's change of residence, death of a child, and lack of interest in further participation. Participants ages ranged from 17 to 41 years ( $M = 28.01$ ;  $SD = 4.77$ ). Almost three-quarters of the sample (70.7%) were primiparous, and 82.2% reported no pregnancy complications. The majority had secondary education (58.7%), were employed (70.7%), and married (85.6%).

At Time 1 women were approached by research assistants individually in a doctor's office or were given questionnaires in groups during childbirth education classes. At Time 2 questionnaires were administered individually in participants' homes. Along with other questionnaires that were a part of a larger project, the Perceived Family Social Support scale was administered only at Time 1, and the Mood Scale was administered at Times 1 and 2. Data on the medical status of mothers before and after delivery and their children were secured from medical records. Participation in the study was voluntary and not rewarded. Women signed statements of informed consent for participation and for researcher access to their selected medical records before completing the questionnaires. This study was performed in accordance with the Declaration of Helsinki of the World Medical Association and approved by the Institutional Review Board of the Clinical Hospital Rijeka, and Faculty of Humanities and Social Sciences, University of Rijeka, Croatia.

## Measures

### *Mood Scale*

We administered the Mood Scale, which consisted of 40 items (Kardum & Bezinović, 1992) assessing two higher-order mood factors, positive mood and negative mood. The positive mood factor indexes the positive emotional states of happiness (e.g., happy, cheerful), acceptance (e.g., social, tolerant), and activation (e.g., active, efficacious), and the negative mood factor indexes the negative emotional states of depression (e.g., sad, depressed), anger (e.g., angry, irritable), fear (e.g., afraid, scared), and rejection (e.g., rejected, isolated). In this study, we investigated the two higher-order factors of positive and negative mood in addition to the seven lower-level dimensions. The Mood Scale is an adjective-type scale and the number of items for each dimension varies from four to eight. Participants responded to each item using a five-point scale (0 = *felt not at all*, 4 = *felt very much*). At Time 1 participants rated their usual mood during pregnancy, and at Time 2 participants rated their usual mood after delivery. All dimensions have satisfactory internal consistency coefficients (Cronbach's  $\alpha$  ranged from .72 for rejection at Time 1 to .87 for depressive mood at Time 2). Correlations between mood dimensions at Times 1 and 2 are presented in Table S1 in Supplementary online material.

### *Perceived Family Social Support Scale*

Perceived family social support was measured by a translated and adapted version of one subscale of the Social Support Appraisals Scale (SS-A; Vaux et al., 1986). This scale measures social support as an appraisal of the extent to which the individual believes she is loved by, esteemed by, and involved with her family (e.g., "My family cares a lot about me"). It consists of eight items, and Cronbach's  $\alpha$  reliability coefficient for this study was .86.

### *Apgar Scores*

Apgar scores were recorded at one and five minutes after delivery. Apgar score at the fifth minute after delivery ( $M = 9.54$ ;  $SD = 0.82$ ) was higher than the score at the first minute after delivery ( $M = 8.98$ ;  $SD = 1.16$ ) ( $t = 8.03$ ;  $p < .001$ ). The correlation between the two scores was  $.68$  ( $p < .001$ ). To obtain a more reliable measure of infants' viability, the mean of the Apgar scores measured at one and five minutes after delivery ( $M = 9.26$ ;  $SD = 0.91$ ; range from 4 to 10) was used in subsequent analyses. Mean Apgar score did not correlate with perceived family support ( $r = .15$ ;  $p > .05$ ).

## **Results**

First, we investigated differences in the higher-level positive and negative mood factors and their lower-level dimensions before and after delivery (Table 1).

Table 1

*Means and Standard Deviations of Mood Dimensions Measured Before Delivery (Time 1) and After Delivery (Time 2)*

MOODS	TIME 1		TIME 2		<i>t</i> -test	Cohen's <i>d</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
Negative mood	37.01	11.38	32.15	11.05	4.79***	0.43
Depression	11.59	4.21	10.75	4.56	2.05*	0.19
Rejection	7.35	2.72	7.07	2.84	1.05	0.10
Anger	9.53	3.60	8.80	3.27	2.35*	0.21
Fear	8.58	3.34	7.39	3.35	3.68***	0.35
Positive mood	75.29	10.28	75.23	10.81	0.06	0.01
Joy	32.07	4.31	32.82	4.48	1.77	0.17
Acceptance	18.83	3.15	18.76	3.14	0.24	0.02
Activation	24.17	4.51	23.67	4.69	1.17	0.11

\*  $p < .05$ ; \*\*  $p < .01$ ; \*\*\*  $p < .001$ .

All dimensions of negative mood except rejection were lower after delivery, whereas there were no changes in the dimensions of positive mood. Correlations between mood dimensions measured before and after delivery and mood dimensions with perceived social support and Apgar score are presented in Table 2.

Table 2

*Correlations Between Moods Dimensions Measured Before Delivery (Time 1) and After Delivery (Time 2) and Mood Dimensions with Perceived Social Support and Apgar Score*

Moods	Mood T1 - Mood T2	Mood T1- Social Support	Mood T2 - Social Support	Mood T1 - Apgar	Mood T2 - Apgar
Negative mood	.44**	-.18	-.29**	-.05	-.13
Depression	.37**	-.12	-.30**	-.06	-.30**
Rejection	.32**	-.24**	-.33**	-.03	-.23*
Anger	.42**	-.16	-.24**	-.01	-.09
Fear	.33**	-.11	-.15	-.07	-.20
Positive mood	.37**	.25**	.19	.01	-.02
Joy	.34**	.24**	.20	.00	.00
Acceptance	.29**	.25**	.05	.01	.02
Activation	.39**	.14	.04	.02	-.01

\*  $p < .01$ ; \*\*  $p < .001$

The same mood dimensions before and after delivery correlated moderately positively. Perceived family social support positively correlated with almost all positive mood dimensions before delivery and negatively with negative mood dimensions after delivery. Apgar score did not correlate with any mood dimension before delivery, but as predicted, correlated negatively with depression and rejection after delivery.

Next, we performed hierarchical linear regression analyses on negative and positive mood dimensions after delivery (Time 2). In the first step of the analyses we controlled for each

mood measured at Time 1. In the second step we entered perceived family social support and mean Apgar score, and in the third step we entered the interaction term for perceived family social support and mean Apgar score. The results for negative mood are presented in Table 3, and the results for positive mood are presented in Table 4.

Table 3

*The Results of Hierarchical Linear Regression Analyses with Negative Mood and Associated Dimensions as Criteria*

Predictors	Depression	Rejection	Anger	Fear	Negative mood
<i>Step 1</i>					
Mood – T1	.35***	.33***	.41***	.32***	.43***
$R^2$	.12***	.11***	.16***	.10***	.18***
<i>Step 2</i>					
Mood – T1	.31***	.28***	.39***	.31***	.40***
Social support	-.22**	-.23**	-.18*	-.07	-.21**
Apgar	-.24**	-.18*	-.08	-.14	-.09
$R^2$	.24***	.21***	.20***	.13***	.23***
$\Delta R^2$	.12***	.10***	.04*	.03	.05*
<i>Step 3</i>					
Mood – T1	.28***	.26***	.40***	.29***	.40***
Social support	-.21**	-.22**	-.17*	-.06	-.21**
Apgar	-.19*	-.11	-.06	-.06	-.09
Social support*Apgar	.16*	.23**	-.12	.23**	-.00
$R^2$	.26***	.25***	.21***	.18***	.23***
$\Delta R^2$	.02*	.05**	.01	.05**	.00

\*  $p < .05$ ; \*\*  $p < .01$ ; \*\*\*  $p < .001$ ; beta weights are presented

As predicted, negative mood assessments measured before delivery predicted the same moods after delivery. After controlling for the same mood, perceived family social support negatively predicted all measures of negative mood except fear, whereas Apgar score negatively predicted only depression. The interaction between perceived family social support and Apgar score predicted depression, rejection, and fear. The interaction plot showing depressive mood in mothers who have different levels of perceived family social support and children with higher (one standard deviation above mean) and lower (one standard deviation below mean) Apgar scores is presented in Figure 1.

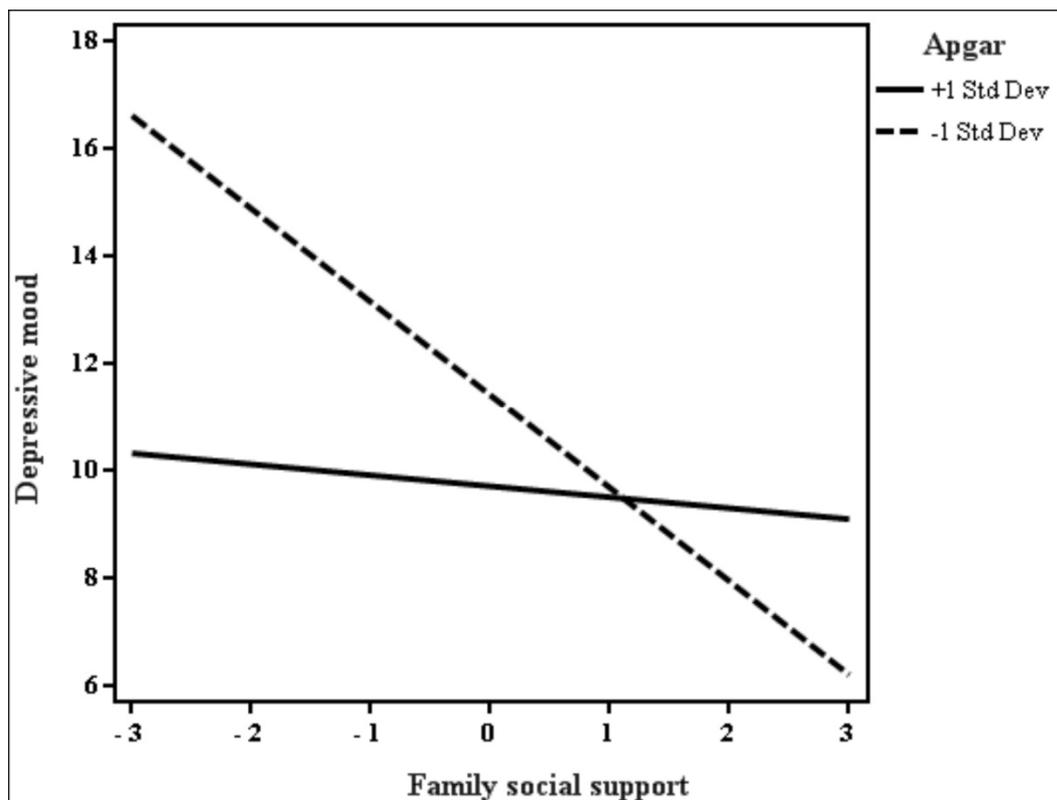


Figure 1. Interaction between perceived family social support and Apgar score on participants' depression.

Simple slope analysis shows that depression in participants whose children had lower Apgar scores increased as their perceived family social support decreased ( $b = -0.97$ ;  $p < .01$ ),

whereas depression in participants whose children had higher Apgar scores was low regardless of their perceived family social support ( $b = -0.20; p > .05$ ). Similar results were obtained when rejection and fear were analyzed. Rejection in participants whose children had lower Apgar scores increased as their perceived family social support decreased ( $b = -1.30; p < .001$ ), whereas rejection in women whose children had higher Apgar scores was low regardless of their perceived family social support ( $b = -0.17; p > .05$ ). Similarly, fear in participants whose children had lower Apgar scores increased as their perceived family social support decreased ( $b = -0.95; p < .01$ ), whereas fear in women whose children had higher Apgar scores was low regardless of their perceived family social support ( $b = 0.41; p > .05$ ).

Table 4

*The Results of Hierarchical Linear Regression Analyses with Positive Mood and Associated Dimensions as Criteria*

Predictors	Joy	Acceptance	Activation	Positive mood
<i>Step 1</i>				
Mood – T1	.34***	.27***	.34***	.33***
$R^2$	.11***	.08***	.12***	.11***
<i>Step 2</i>				
Mood – T1	.31***	.28**	.34***	.31***
Social support	.15	-.02	.01	.15
Apgar	-.07	-.04	-.06	-.11
$R^2$	.13***	.08*	.12***	.14***
$\Delta R^2$	.02	.00	.00	.03
<i>Step 3</i>				
Mood – T1	.32***	.31***	.39***	.34***
Social support	.15	-.01	.02	.15
Apgar	-.03	-.00	.01	-.04
Social support*Apgar	.14	.14	.23**	.20*
$R^2$	.15***	.09*	.16***	.17***
$\Delta R^2$	.02	.01	.04**	.03*

\*  $p < .05$ ; \*\*  $p < .01$ ; \*\*\*  $p < .001$ ; beta weights are presented

All positive moods measured before delivery predicted the same moods after delivery. After controlling for the same mood, perceived family social support and Apgar score did not predict participants' positive mood measures. The interaction between perceived family social support and Apgar score predicted participants' activation and overall positive mood. The interaction plot showing activation in mothers who have different levels of perceived family social support and children with higher (one standard deviation above mean) and lower (one standard deviation below mean) Apgar scores is presented in Figure 2.

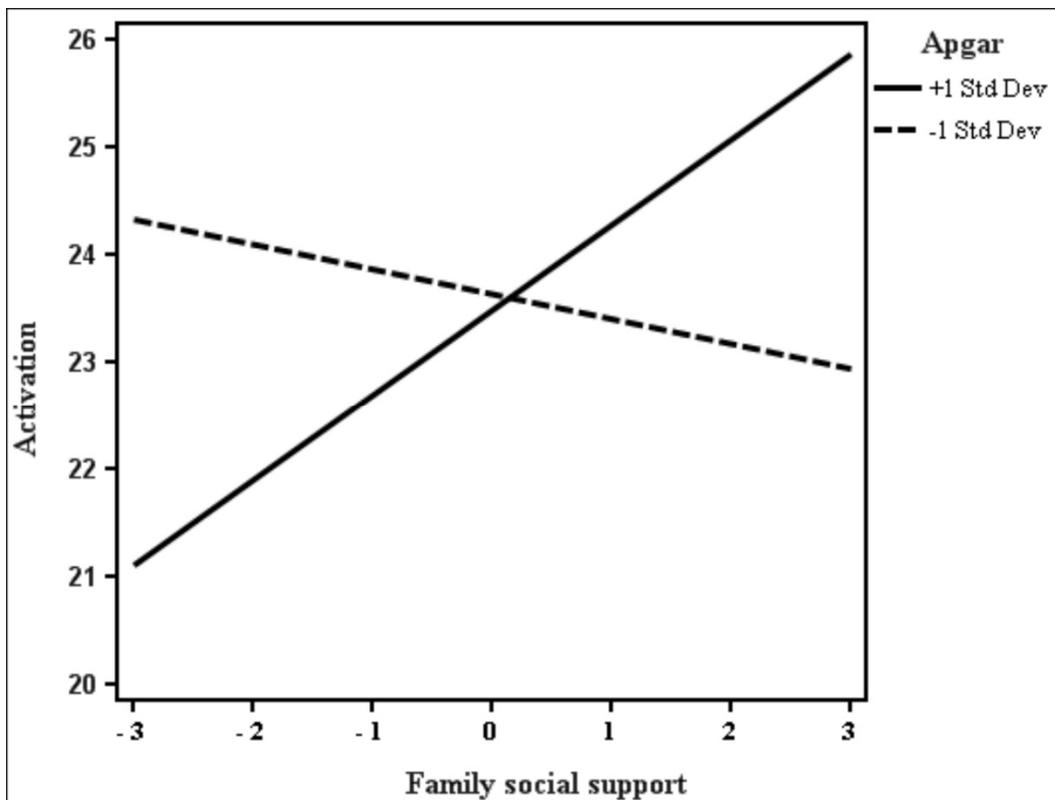


Figure 2. Interaction between perceived family social support and Apgar score on participants' activation.

Activation in participants whose children had higher Apgar scores increased as their perceived family social support increases ( $b = 0.79$ ;  $p = .06$ ), whereas activation in women

whose children had lower Apgar scores was the same regardless of perceived family social support ( $b = -0.23$ ;  $p > .05$ ). Similarly, in participants whose children had higher Apgar scores overall positive mood increased as their perceived family social support increased ( $b = 3.76$ ;  $p < .01$ ), whereas overall positive mood in participants whose children had lower Apgar scores was the same regardless of their perceived family social support ( $b = 1.50$ ;  $p > .05$ ).<sup>1</sup>

### Discussion

Guided by the psychic pain hypothesis, we tested whether lower infant quality measured by Apgar score and unfavorable maternal circumstances measured by perceived family social support predict mothers' mood after delivery. We predicted that lower infant quality and unfavorable maternal circumstances would have the strongest effects on depression and depression-like moods. We also predicted their interaction, i.e. that low infant quality would affect mothers' depression and depression-like moods more when social support was low.

The results mostly supported the predictions. After controlling for mothers' mood before delivery, Apgar score and perceived family social support as well as their interaction strongly predicted mothers' negative mood dimensions after delivery, especially depressive mood and rejection. Lower Apgar score predicted only higher depressive mood (Table 3), suggesting that lower infant quality exerted a specific effect on mothers' mood. Additionally, mothers' depressed mood seems to be sensitive to subtle signs of lower infant quality, considering that 90% of infants in this study had mean Apgar score above 7. On the other hand, lower perceived family social support exerted a more generalized effect on mothers' negative moods, i.e. it predicted higher scores on all negative mood dimensions except fear. We can hypothesize that

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<sup>1</sup> When controlling for sociodemographic variables (e.g., age, education), variables related to mothers' health (e.g., chronic illnesses, complications during pregnancy and during and after childbirth) and variables related to infants' health (e.g., illnesses, days in hospital after delivery), we obtained results similar to those presented in Tables 3 and 4.

these effects of lower perceived family social support reflect mothers' emotional states related to their potential loss (e.g., depression and rejection), but also those that reflect their feelings of personal endangerment or attempts to control and increase social support (e.g., anger).

As predicted, along with the main effects, we found interactions between mean Apgar score and perceived family social support on mothers' negative moods including depression, rejection, and fear. All interactions predicted mothers' negative moods in the same manner, i.e. negative moods in mothers whose children had lower Apgar scores were of lower intensity when they perceived higher family social support, whereas mothers whose children had higher Apgar scores had the same low intensity levels of negative moods regardless of their perceived family social support (see Figure 1). Therefore, although lower perceived family social support may have intensified the effects of a stressful experience (lower Apgar score) on mothers' negative mood, higher perceived social support may have acted as a buffer against these negative effects. When stress was low (i.e. higher Apgar score), social support did not have an effect on mothers' negative moods, which is in accordance with the stress buffering hypothesis. The results obtained for depressive and other negative moods are important in the context of the evidence supporting the conclusion that maternal perinatal depressive mood may be associated with consequences for the infant, parents, and the interaction between them. For example, maternal depressive mood is associated with infant temperamental difficulty during the first year after birth (Britton, 2011), more parenting stress, more daily hassles, and less marital harmony (Gelfand, Teti, & Radin Fox, 1992), as well as with more maternal punishment and rejection toward their children (MacEwen & Barling, 1991). Additionally, maternal postpartum depressed mood may continue long after childbirth and can eventually develop into PPD (Ozdemir, Ergin,

Selimoglu, & Bilgel, 2005). Therefore, social policies aimed at enhancing well-being and mental health of mothers in unfavorable perinatal circumstances are warranted.

Perceived family social support and Apgar score were considerably weaker predictors of mothers' positive moods than negative moods. After controlling for the same positive mood before delivery, only the interaction between Apgar score and perceived family social support predicted mothers' activation and overall positive mood. Activation and overall positive mood in mothers whose children had higher Apgar scores were higher as their perceived family social support was higher, but mothers whose children had lower Apgar scores had the same levels of these moods regardless of perceived family social support (see Figure 2). Therefore, the effects of unfavorable maternal conditions are mainly limited to negative moods, especially depressive mood, and do not generalize to positive moods. These results could be interpreted as additional support for the psychic pain hypothesis, which focuses on depressive symptomatology and not on the symptoms of low positive mood. They are also in accordance with the conceptualization of mood structure in terms of two independent dimensions of Positive Affect and Negative Affect (Watson & Tellegen, 1985). Both dimensions are parts of wider biobehavioral systems – approach motivation, elicited by appetitive stimuli (i.e., positive hedonic stimuli, reward cues, signals of safety), and avoidance motivation elicited by aversive stimuli (i.e., negative hedonic stimuli, threat cues, punishment) (Larsen & Augustine, 2008). In this context, we might consider mothers' depressive symptoms a domain-specific mechanism, one part of general avoidance system activated in unfavorable maternal conditions. On the other hand, the approach system seems to be less sensitive to maternal conditions and, therefore, better infant health together with favorable social circumstances have to be present to improve mothers' mood. One fruitful line of

research might be investigating the development of postpartum depressive symptomatology and PPD in the context of approach and avoidance systems and corresponding emotional states.

The strengths of the current research are in its longitudinal design, which allowed us to control for mothers' moods before delivery, and assessment of a wide range of emotional states, not only depressive mood, which afforded nuanced insights into maternal mood after delivery. The results of the current research are consistent with the psychic pain hypothesis of maternal depressive moods, and indicated that the effects of unfavorable maternal conditions are limited to negative moods, especially depressive ones. Additionally, the fact that support for the psychic pain hypothesis obtained in a different, although Westernized, culture attests to the potential universal applicability of the hypothesis.

Several limitations of this study are noteworthy and might be addressed in future studies. First, to better assess the dynamics of maternal moods, research might employ multiple informants and multiple measurements, especially at timepoints further from delivery. By securing larger samples and multiple measurement points in assessments of mothers' moods and by including measures of PPD, we would be able to assess the extent to which postpartum depressive moods predict the onset of PPD. Additionally, other family members, and especially those who also suffer fitness losses (e.g., fathers) should be included as respondents in future research to gain insight into family dynamics related to infant health and environmental circumstances. Furthermore, in the present study we measured perceived family social support only once—during pregnancy. Although perceived social support is stable over time (Allemand, Schaffhuser, & Martin, 2015), life events such as delivery, problems in infant health, and other events not included in this study may affect perceptions of social support and, therefore, it would be informative to assess different types of social support before and after delivery. Future

research might also attempt to replicate the current results using other indices of infant development and health.

In conclusion, the psychic pain hypothesis was supported even when subtle unfavorable maternal conditions, operationalized as lower infant health and lower perceived family social support, were taken into account. These conditions increased post-natal maternal negative moods, but did not affect positive moods. Lower infant health increased only maternal depressive mood, whereas perceived family social support had more generalized effects on mothers' negative moods, and may act as a buffer in suboptimal infant health conditions.

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## Supplementary online material

Table S1

*Correlations Between Mood Dimensions at Time 1 and Time 2*

Variables	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. Depression	-	.72**	.74**	.62**	-.56**	-.27**	-.41**	.91**	-.51**
2. Rejection	.54**	-	.61**	.49**	-.43**	-.23*	-.34**	.79**	-.40**
3. Anger	.75**	.56**	-	.56**	-.48**	-.19	-.33**	.86**	-.43**
4. Fear	.63**	.46**	.48**	-	-.29**	-.13	-.30**	.77**	-.30**
5. Joy	-.45**	-.52**	-.38**	-.35**	-	.64**	.67**	-.57**	.89**
6. Acceptance	-.18	-.25*	-.14	-.20*	.52**	-	.63**	-.34**	.84**
7. Activation	-.28**	-.24*	-.16	-.24*	.57**	.58**	-	-.49**	.90**
8. Negative mood	.91**	.74**	.86**	.78**	-.51**	-.23*	-.38**	-	-.56**
9. Positive mood	-.38**	-.42**	-.28**	-.32**	.85**	.79**	.87**	-.41**	-

\* $p < .01$ ; \*\* $p < .001$ ; correlations between mood dimensions at Time 1 are presented below the diagonal, and correlations between mood dimensions at Time 2 above the diagonal