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ORIGINAL ARTICLE

Maternal anxiety from pregnancy to 2 years postpartum: transactional patterns of maternal early adversity and child temperament

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Abstract The aims of this study were to examine the anxiety trajectories of women from pregnancy to 2 years postpartum and to assess the influence of their early life experiences and the temperament of the child on these trajectories. We evaluated state anxiety (State-Trait Anxiety Inventory) at pregnancy and 3, 6, 12, 18, and 24 months postpartum and determined its course as a function of self-reported early adverse experiences (Childhood Trauma Questionnaire) and the temperament of the child at 18 months (Early Child Behavior Questionnaire). Based on growth curve modeling, we found that anxiety followed a general U-shape pattern from gestation to 2 years postpartum, which was modified by early life experience of women. Greater early adversity was associated with higher gestational anxiety, followed by a marked decrease once the baby was born, and subsequent increase during the later postpartum period. The temperament of the child also modulated anxiety trajectories. Thus, mothers of children high in negative affectivity and who also experienced greater early adversity had elevated and flat anxiety trajectories, while child extraversion was associated with increasing anxiety courses approaching 2 years postpartum. These results show that maternal anxiety dynamically changes through the postpartum period with a course that is affected by previous and current experiences.

Keywords State anxiety · Pregnancy · Postpartum · Early adversity · Child temperament

Introduction

Mothers undergo remarkable physiological and psychological changes around parturition that influence the emergent

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relationship with their babies. New mothers experience considerable emotional lability during the first postpartum weeks, involving both positive and negative affect (Leckman et al. 1999; Lonstein 2007; Macbeth and Luine 2010). These fluctuations in the affective states of women may contribute to an elevated prevalence of anxiety and depressive disorders and a high incidence of comorbidity after childbirth compared to the general population (Austin et al. 2010; Correia and Linhares 2007; Ross and McLean 2006; Vesga-Lopez et al. 2008). Conversely, a number of studies report a decrease of anxiety and depression symptoms from pregnancy to the postpartum period (Andersson et al. 2006; DiPietro et al. 2008; Figueiredo and Conde 2011a; Heron et al. 2004). This discrepancy may be due to the temporally dynamic nature of anxiety and the fact that most studies do not examine other variables that may affect its regulation. In order to address these inconsistencies, the current study contributes to the literature by (1) examining changes in state anxiety from pregnancy and throughout the first two postpartum years and (2) exploring trajectories of maternal anxiety as a function of both maternal early adverse life experiences and the temperament of the child.

Considerable research has focused on postpartum depression and its etiology; however, fewer studies have considered anxiety. Anxiety remains understudied in humans (Ross and McLean 2006) and in animal models (Lonstein 2007) and investigations often yield conflicting results. While anxiety disorders, especially generalized anxiety disorder, have been reported to be higher in postpartum women than in the general population (Britton 2008; Ross and McLean 2006; Wenzel et al. 2005), studies exploring subclinical symptoms of anxiety during pregnancy and the postpartum period yield discrepant results. Some studies find that anxiety symptoms increase after parturition (Britton 2008) or do not change (Leckman et al. 1999); however, several studies report a decrease of anxiety from pregnancy to the postpartum period (Andersson et al. 2006; Figueiredo and Conde 2011a, b; Heron et al. 2004; Madigan et al. 2014; van Bussel et al. 2009). This anxiety reduction after childbirth has been mainly attributed to mother-infant interaction, especially to breastfeeding (Heinrichs et al. 2001; Jonas et al. 2008; Macbeth and Luine 2010; Nissen et al. 1998). Discrepancies in the course of anxiety after childbirth between studies may be due to the postpartum time in which anxiety is evaluated. Thus, Figueiredo and Conde (2011b) observed that state anxiety dynamically changes during the postpartum period, remaining high during the first postpartum days compared to pregnancy, but decreasing by the third postpartum month. While most studies analyze women's anxiety during the first postpartum year (Britton 2008; Figueiredo and Conde 2011b; Leckman et al. 1999; Ross and McLean 2006), others consider maternal anxiety during the second postpartum year (DiPietro et al. 2008), at a time when maternal influences continue to impact the development of the child (Casalin et al. 2012; Putnam et al. 2006).

The variable patterns of postpartum anxiety observed across different investigations may reflect the fact that anxiety states are complex; they are temporally dynamic and multiply determined. Factors that affect women's anxiety include past events; current experiences; and a host of individual, social, and contextual variables such as socioeconomic status and social support (Correia and Linhares 2007; van Bussel et al. 2009; Vesga-Lopez et al. 2008), as well as physiology and genetics (Eley 1999; Macbeth and Luine 2010). Among these variables, early life experiences, especially negative ones, appear to profoundly impact the neurobiological development of individuals, including increasing reactivity to stress during adulthood (Chu et al. 2013; Dong et al. 2004; Heim and Nemeroff 2001; Ladd et al. 2000). During pregnancy, early life adversity is associated with high depression symptoms (Benedict et al. 1999; Records and Rice 2005) and increased risk of developing a general anxiety disorder (Buist et al. 2011; Lim et al. 2005) and of presenting pregnancy complications (Leeners et al. 2010). Also, during the postpartum period, a history of childhood trauma has been related to alterations in the psychological well-being of women, including an increase in anxiety and depression (Buist 1998; Buist and Janson 2001; Lang et al. 2006; Madigan et al. 2014). Long-term alterations in hypothalamus-pituitary-adrenal (HPA) axis activity as a function of early life stress may be related to this heightened psychological vulnerability of pregnant and post parturient women (Gonzalez et al. 2009; Lazinski et al. 2008; Lupien et al. 2009; Shea et al. 2007). Therefore, different trajectories of anxiety from pregnancy to the postpartum period could be expected in women with different adverse experiences early in life.

There is strong evidence indicating that maternal anxiety influences the development of the child (Bergman et al. 2007; Feldman et al. 2009; Glover et al. 2010; O'Donnell et al. 2013); less is known about the way in which the behavior of the child influences maternal affectivity. Difficult temperament of the infant has been related to higher levels of maternal anxiety during the postpartum period (McMahon et al. 2001; Mednick 1996; Miller et al. 1993), even as early as one postpartum month (Britton 2011). Gelfand and co-workers (1992) also reported that for both depressed and non-depressed mothers, a difficult infant temperament is positively associated with high parent-related stress. Hence, the emotional states of mothers and their children affect one another, making the direction of effects and causality difficult to establish. Consistent with these observations, most developmental theories emphasize the transactional and reciprocal nature of parent-child relationships (Belsky 1984; Sameroff 2010). That is, parental factors influence functioning of the child and the altered behavior of the child further drives parenting, and vice versa. For example, one longitudinal study demonstrated that maternal

negativity predicted increase in misbehavior in children, which in turn predicted a further increase in negative parenting (Zadeh et al. 2010). Similar transactional patterns have been observed in infancy, where difficult infant temperament contributes to maternal stress, which further exacerbates temperament in a number of domains, including domains of negative and positive affectivity (Pesonen et al. 2008).

Given the aforementioned bidirectional mechanisms of influence, it is likely that there will also be transactional patterns between trajectories of maternal anxiety and infant temperament as well. Moreover, it is possible that the influences of maternal anxiety on infant temperament begin during pregnancy, consistent with literature citing the effects of maternal intrauterine climate on the HPA axis of the developing fetus (e.g., O'Connor et al. 2002; O'Donnell et al. 2014).

Based on this evidence, we hypothesized that early life adversity of women and the temperament of the child will interact to shape the patterns of maternal anxiety from pregnancy and throughout the postpartum period. In order to test this, we (1) examined the trajectory of maternal anxiety across the peri- and postpartum periods, (2) explored this trajectory as a function of early adversity, and (3) assessed the transactional relationships between mothers and infants in terms of maternal anxiety and temperament of the child.

Methods

Participants

Participants came from the Maternal Adversity, Vulnerability and Neurodevelopment (MAVAN) Study. This longitudinal study follows two cohorts of mothers and children in Hamilton, Ontario and Montreal, Quebec, Canada. We examined the Hamilton, Ontario cohort for which 255 mothers had enrolled at the time of this report. While similar in most respects, the Montreal cohort did not, for the most part, include prenatal or 3-month postpartum measures and hence could not provide the needed anxiety measures for these time periods. Of the 255 Hamilton women, 51 subjects were lost to follow-up or excluded. Reasons include attrition between the recruitment visit and the 6-month postpartum follow-up (N=28), exclusion due to premature delivery (N=18), stillbirth or termination (N=3), or involvement of the Children's Aid Society (N=2). Ethnic descent of the resultant sample was mostly Caucasian (90 %), with 3 % (N=6) mixed ethnicity, 2 % (N=4) African, 1.5 % Hispanic (N=3), and 1 % East Indian (N=2), and the rest having unknown or unspecified ethnicity. This ethnic distribution is typical of the greater Hamilton region. Because we will be contrasting present results with results derived from measures taken on these same women on whom we also considered genetic moderators, in this paper we also did not include 45 women excluded from the genetic papers because of incomplete genotyping. Comparisons of most outcomes including and excluding these 45 women showed the same pattern of effects. Thus, the current study examined 159 mothers from the Hamilton cohort.

Ethics statement Written consent was obtained from each participant to participate in the MAVAN project prior to contacting and mothers received $25 compensation after each visit. The study was approved by the research ethics boards at St. Joseph's Healthcare Hamilton, Hamilton, ON and the University of Toronto, Toronto, ON.

Procedure

Women between the ages of 18–45 years were recruited during the second trimester of pregnancy (12–24 weeks). The participant pool was derived via referrals to the Women's Health Concerns Clinic and the Ultrasound Department at St. Joseph's Health Center, Hamilton, Ontario. Demographic information and early life adversity ratings (Child Trauma Questionnaire) were obtained during the initial visit at 12–24 weeks of pregnancy and questionnaires measuring infant temperament were administrated at the 3rd and the 18th months visits. Six repeated measures of maternal state anxiety were obtained during the pregnancy visit in addition to 3, 6, 12, 18, and 24 postpartum months.

Measures

Covariates As the number of children in family, child gender, household income (17 ordered categories ranging from "less than $5000" to "over $100,000" in Canadian dollars), maternal age (years), baby birth weight (kilograms), gestational age (weeks), and the duration of breastfeeding (in weeks) are factors that may influence the anxiety state of women (Bener et al. 2012; Figueiredo and Conde 2011b; Jonas et al. 2013; Mount et al. 2010; Sisk et al. 2006; Ystrom 2012), they were measured as control variables. Infant sex was coded so that female=0.5 and male=−0.5. Thus, the effect of the "female child" variable is the difference between females and males, though the variable was centered on zero so the growth parameters reflect the average for boys and girls.

Anxiety State anxiety of women was assessed by the State-Trait Anxiety Inventory, which consists of two subscales that measure the respective components of state and trait anxiety. State anxiety was selected for modeling, as it is more amenable to temporal fluctuation and less analogous to stable personality traits (Spielberger 2010) and its use has been validated in perinatal studies (Meades and Ayers 2011). Also, the state anxiety subscale was assessed at each time point whereas the trait subscale was assessed less frequently. The state anxiety questionnaire (STAI-S) is a self-report inventory that

contains 20 items measured on a 4-point scale (where 0=not at all and 4=very much) that assesses the global level of anxiety at that particular moment. The STAI-S has good reliability and sensitivity to change and has been well documented (Spielberger 2010).

Early adversity Early adversity was evaluated using the Childhood Trauma Questionnaire (CTQ), which is a 28-item self-report scale that screens for 5 types of maltreatment: emotional, physical, and sexual abuse and emotional and physical neglect (Bernstein et al. 1994). It quantifies the frequency of these experiences on a 5-point scale (from 0=never to 5=very often). The CTQ scores obtained during pregnancy correlated with the CTQ scores obtained at 24 months after birth (r= 0.915, $p \leq 0.001$). The CTQ has excellent psychometric properties (Bernstein et al. 1994). In the current investigation, the mean was taken across all scales and combined into a composite that ranged from 1 to 5. The average adversity score was 1.48 (SD=0.54, min=1.00, max=3.64). For modeling purposes, adversity was dichotomized at the 50th percentile (median=1.28) because the distribution was positively skewed, violating assumptions of univariate normality. That is, adversity was modeled as a dichotomous variable: "higher" (1) vs. "lower" (0).

Infant temperament Infant temperament was assessed at two ages: 3 and 18 months. Although there are laboratory-based observational procedures for assessing infant temperament, these are labor intensive and therefore not as widely used as parent report instruments (Gartstein and Marmion 2008).

Three months temperament of the baby was assessed by the Infant Behavior Questionnaire, Revised Version (IBQ, (Gartstein and Rothbart 2003)). This is a widely used parent-report measure of infant temperament consisting of items that represent 14 scales in which mothers were asked to rate the behavior of their babies on a 7-point Likert scale format ranging from "never" to "always". Factor analysis reveals three primary factors: (1) *negative affectivity*: including the subscales of sadness, distress to limitations, fear and falling reactivity; (2) *surgency/extraversion*, including approach, vocal reactivity, high intensity pleasure, smiling and laughter, activity level, and perceptual sensitivity; and (3) *orienting/regulation* containing the subscales low intensity pleasure, cuddliness/affiliation, duration of orienting, soothability and smiling and laughter (Gartstein and Rothbart 2003). This measure is well researched and has internal and external validity (Parade and Leerkes 2008).

Eighteen months temperament of the toddler was measured using the Early Childhood Behavior Questionnaire (ECBQ (Putnam et al. 2006)) at 18 months. The ECBQ is a questionnaire with a neurobiological developmental approach and consists of 201 items, in which mothers were asked to rate the behavior of their infant that occurs in an every-day context on a 7-point Likert scale format ranging from "never" to "always." The items are grouped into 18 subscales with 3 main factors as suggested by Putnam et al. (2006) and further validated by others (Casalin et al. 2012): (1) *negative affectivity*—containing the subscales discomfort, fear, motor activation, sadness, perceptual sensitivity, shyness, soothability, and frustration; higher scores indicate less emotionally stable infants; (2) *surgency/extraversion*—containing impulsivity, activity level, high-intensity pleasure, sociability, positive anticipation, and inhibitory control; higher scores are observed in infants with high activity levels and positive affect in response to stimulating situations; and (3) *effortful control*—including the subscales inhibitory control, attention shifting, low-intensity pleasure, cuddliness, and attention focusing; higher scores are seen in infants with good ability to regulate their own emotions. The ECBQ is well researched and has high internal and external validity (Casalin et al. 2012; Putnam et al. 2006).

Analysis

Latent growth curve modeling was used to examine trajectories of maternal anxiety from pregnancy to 2 years postpartum. Six repeated measures of maternal state anxiety (gestation and 3, 6, 12, 18, and 24 months postpartum) were modeled as a function of time, the aforementioned covariates, early maternal adversity (higher vs. lower), and infant temperament at 3 and 18 months. Three latent variables that describe trajectories of maternal anxiety were modeled: (1) the intercept, which is maternal anxiety during pregnancy; (2) the linear slope or linear rate of change in anxiety, which reflects linear change in anxiety over time; and (3) the quadratic slope or curved rate of change in anxiety, which reflects change in anxiety that takes on a "U" or inverted "U" shape.

Modeling took place in three steps. Model 1 was fit as an unconditional growth model, where only the intercept, linear slope, and curved slope were specified in order to determine the grand mean trajectory, or the trajectory of anxiety for all mothers irrespective of their early experiences and child temperament. In model 2, the effects of early adversity on trajectories of anxiety were examined while controlling for the covariates. Due to the large number of covariates examined, only significant terms for these covariates are reported. These models are tabled in unstandardized form in order to permit the examination of growth parameters in units of the outcome. Finally, in model 3, the transactional effects between peripartum maternal anxiety and child temperament were examined. The temperament of the child at 3 months (extraversion, negative affectivity, and orienting) and 18 months (extraversion, negative affectivity, and effortful control) were regressed onto the intercept. This was done in order to examine the impact of pregnancy anxiety on child temperament. Additionally, the linear and quadratic slopes were regressed onto

temperamental variables in order to determine the impact of temperament on trajectories of anxiety. Standardized results are presented graphically in order to highlight transactional processes and compare the size of effects. Model fit was evaluated using the chi-square test, comparative fit index (CFI), root mean square effort of approximation (RMSEA), and standardized root mean square residual (SRMR). Description and recommended use of these indices are available online (Kenny 2014) (see davidakenny.net/cm/fit.htm). Additionally, the hypothesized indirect effect from early adversity to pregnancy anxiety, to child temperament, and to change in maternal postnatal anxiety was tested using the delta method.

Missing data Recommended procedures for the analysis of data with missing values were followed (Graham 2009). Estimation maximization was used for descriptive statistics, while model fitting and hypothesis testing was conducted with the Full Information Maximum Likelihood (FIML) algorithm in MPlus (Muthén and Muthén 1998–2010). Thus, all 159 mothers were included in the analysis even when some data was missing. The 159 mothers provided 725 repeated measures of maternal anxiety out of a possible 954 (76 % complete, M=4.56, SD=1.70) responses. Simulation studies indicate that this estimate technique can convey accurate estimates despite missingness in samples as small as N=50 with 50 % missing data (Graham 2009). Moreover, Little's Missing Completely at Random (MCAR) test was conducted and was non-significant, indicating that missing values of study variables represent a random subset of cases and there was not a systematic or selective attrition pattern, χ^2 (834)=878.83, p=0.14.

Results

Changes in anxiety across the first 24 postpartum months in all women

Descriptive statistics are presented in Table 1 and fit indices for latent growth curve models are presented in Table 2. Model 1 indicates that the average maternal anxiety score during pregnancy is 35.72. There is a significant negative linear slope and a positive quadratic (curved) slope, indicating that the average trajectory of maternal anxiety is a U-shaped pattern (Table 3). The shape of this trajectory, however, is permitted to vary between persons, as indicated by the variances of the latent variables and their covariances. The significant intercept variance, slope variance, and quadratic variance indicate that there is significant between-mother variability in pregnancy anxiety levels and linear and curved change in anxiety. The significant and negative correlation between the intercept and linear slope indicates that mothers who have higher anxiety levels during pregnancy show a greater linear decrease in anxiety once their babies are born. However, there is also a positive correlation between the intercept and curved slope, indicating that mothers with higher anxiety levels during pregnancy also experience a greater U-shaped change (i.e., later increase in anxiety). Conversely, mothers with low anxiety levels during pregnancy tend to stay low across the postpartum period (i.e., flatter trajectory).

Table 1 Descriptive statistics

	M	SD	Min	Max
Birth weight (kg)	3.46	0.47	2.01	5.36
Maternal age	30.59	4.78	18.00	43.00
Income	13.60	3.35	3.00	17.00
Number of children	1.50	0.58	1.00	3.00
Breastfeeding (weeks)	26.70	16.16	0.00	56.00
Gestational age (weeks)	38.59	1.99	32.00	42.00
IBQ3m negative affectivity	3.55	0.41	2.61	5.55
IBQ3m extraversion	4.19	0.68	2.27	6.32
IBQ3m orienting	5.10	0.54	3.13	6.48
EBQ18m negative affectivity	3.09	0.37	2.19	4.03
EBQ18m extraversion	4.98	0.44	3.68	6.88
EBQ18m effortful control	4.45	0.46	2.70	5.79
Early adversity	–	–	0.00	1.00
Anxiety pregnancy	36.46	13.24	20.00	74.00
Anxiety 3m	33.06	9.23	20.00	62.00
Anxiety 6m	35.01	10.25	20.00	75.00
Anxiety 12m	35.47	9.29	20.00	66.00
Anxiety 18m	35.09	10.19	20.00	65.00
Anxiety 24m	37.74	11.41	20.00	69.00

Changes in anxiety across the first 24 postpartum months as a function of early adversity

In model 2, the main effects of early adversity were evaluated, while controlling for all covariates (i.e., the number of children in the family, birth weight, infant sex, household income, maternal age, gestational age, and weeks of breastfeeding).

Table 2 Fit indices for latent growth curve models

Statistic	Model 1 (unconditional)	Model 2 (adversity)	Model 3 (temperament)
χ^2	29.56**	68.08***	107.23**
df	12	35	72
RMSEA	0.10	0.08	0.06
CFI	0.94	0.90	0.90
SRMR	0.08	0.07	0.08

df degrees of freedom, *RMSEA* root mean square error of approximation, *CFI* comparative fit index, *SRMR* standardized root mean square residual

** p<0.01; *** p<0.001

Table 3 Unstandardized latent growth curve output examining trajectories of maternal anxiety from pregnancy to 2 years postpartum as a function of early adversity

	Model 1		Model 2[a]	
	Estimate	SE	Estimate	SE
Intercept	35.72***	1.02	30.86***	1.75
Early adversity			10.00***	1.85
Slope	−1.66*	0.73	0.44	1.34
Income			1.90*	0.80
Early adversity			−3.21*	1.42
Quadratic slope	0.40**	0.15	0.10	0.27
Income			−0.37*	0.17
Female			0.75*	0.31
Early adversity			0.38	0.29
Latent variances and covariances				
var(Int)	112.48***	22.48	89.75***	20.23
var(Slope)	32.64**	11.45	30.06**	11.04
var(Quad)	1.31**	0.44	1.18**	0.43
cov(Int/Slope)	−40.98**	14.62	−36.95**	13.76
cov(Int/Quad)	7.70**	2.66	7.51**	2.52
cov(Slope/Quad)	−6.32**	2.17	−5.81**	2.10

Int intercept, *Var* variance, *Cov* covariance, *Quad* quadratic

[a] Models 2 and 3 controlled for the effects of number of children in family, child gender, household income, maternal age, gestational age, weeks of breastfeeding, and child birth weight on the intercept, slope, and quadratic term. For purposes of presentation, only significant terms for these covariates are presented

* $p<0.05$; ** $p<0.01$; ***$p<0.001$

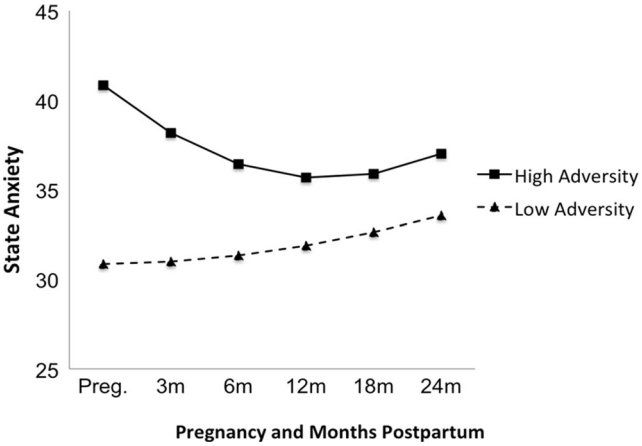

Fig. 1 Estimated maternal anxiety is presented from pregnancy to 24 postpartum months as a function of early adversity

Only significant covariates are presented in Table 3, though all independent variables in this step were forced into the model. There was a large and significant main effect of early adversity on the intercept (i.e., anxiety during pregnancy), whereby mothers who were above the median in terms of early life adversity had significantly higher anxiety scores during pregnancy. There was also a significant main effect of early adversity on the linear slope of anxiety, whereby mothers with greater early life adversity had a negative linear slope, versus the lower adversity group who had a flat slope of anxiety. Thus, mothers with higher levels of early adversity have higher levels of anxiety during pregnancy, though these levels decrease substantially once their babies are born. There was not a significant effect of early adversity on the quadratic or curved growth. However, the significant co-variances among growth parameters suggest that mothers who have high levels of anxiety during pregnancy also tend to show greater decreases (around 3 to 6 months) and subsequent increases as their children get older (approaching 2 years). Thus, the trajectory of maternal anxiety of women with higher levels of adversity is a tight U-shaped pattern. Conversely, for mothers with low levels of adversity, the trajectory of anxiety is linear and moderately increasing (see Fig. 1). Stated differently, the differential trajectories implied in the first model (i.e., high initial anxiety followed by a U-shaped pattern versus low stable anxiety) are largely explained by the impact of early adversity. For example, the main effect of adversity accounted for 20 % of the variance in the intercept [0.20=(112.48−89.75)/112.48], which is correlated with both linear and quadratic anxiety slopes. In other words, pregnancy anxiety levels, which are predicted by adversity, provide a great deal of information about the subsequent anxiety trajectory.

There were no significant effects of any of the covariates on anxiety during pregnancy. However, mothers with higher levels of income had flatter trajectories, as indicated by the positive association between income and anxiety slope (in the context of a grand mean anxiety slope that is negative), and the negative association between income and the quadratic term (in the context of a grand mean quadratic term that is positive). Finally, mothers with female children showed greater quadratic growth compared to mothers of male children. That is, mothers with female children tend to show somewhat greater increases in anxiety as they approach the two postpartum years.

Changes in maternal anxiety and the role of child temperament

Model 3 is presented as a path diagram in Fig. 2. There were no significant pathways between temperament at 3 months and any of the growth parameters in either direction. Additionally, these non-significant pathways substantially compromised model fit; therefore, they were dropped from the model. The resultant model fits the data well (see Table 2) and was retained as the final model. Higher maternal anxiety during pregnancy was associated with significantly greater negative affectivity of the child at 18 months. Additionally, there was a direct association between negative affectivity and the linear slope (in the context of a negative grand mean slope of

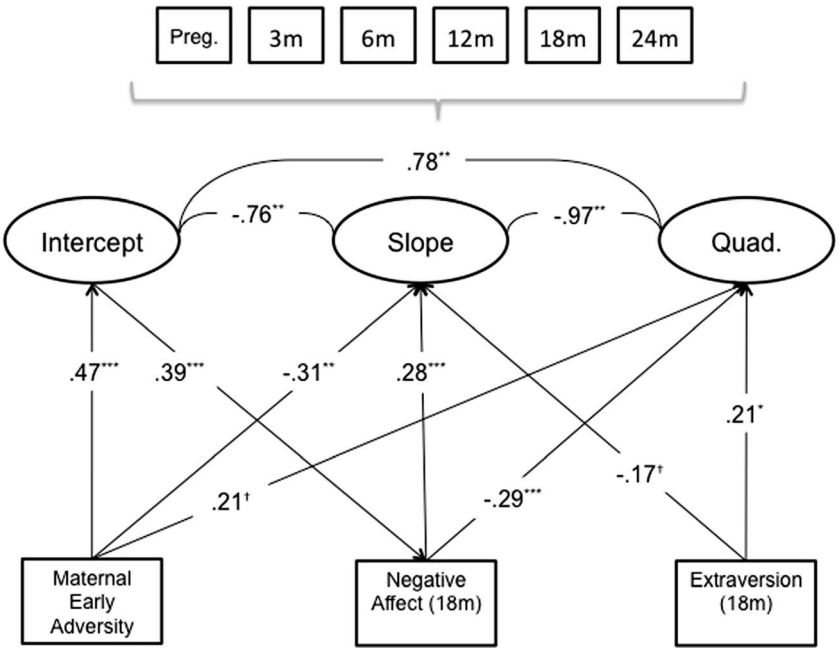

Fig. 2 Path model illustrating the transactional relationship between maternal early adversity, maternal anxiety during pregnancy, child temperament, and changes in postpartum maternal anxiety (model 3) *p<0.05; **p<0.01; ***p<0.001; † p<0.10

anxiety) and an inverse association between negative affectivity and the quadratic term (in the context of a grand mean quadratic that is positive or U-shaped). Taken together, this means that mothers with children who are more negatively affective at 18 months have postpartum trajectories that are elevated but flat. Also, there was a positive relationship between extraversion at 18 months and the quadratic upward slope in anxiety, suggesting that mothers with children who have high levels of extraversion exhibit greater curved increases in anxiety approaching 24 months postpartum.

Finally, the hypothesized transactional pathways were evaluated. Specifically, a pathway was expected that spanned from early adversity to anxiety during pregnancy, to difficult child temperament (only negative affectivity at 18 months was significantly predicted by anxiety during pregnancy), and to change in maternal anxiety (both linear and quadratic components). These effects were significant for both the linear slope (Z=2.12, p= 0.034) and the quadratic slope (Z=−1.98, p 0.047). In other words, mothers who experienced early adversity have higher levels of anxiety during pregnancy. This, in turn, is associated with the negative affectivity of the child, which is predictive of elevated and persistent trajectories of anxiety. While the indirect pathways linking early adversity to the intercept, to child temperament, and to linear and quadratic growth are significant, suggestive of mediation, the strength of these associations is moderate and it remains possible that a mother who experienced early adversity has a child with low negative affectivity. In order to explore this possibility, maternal trajectories are reported at high and low levels of early adversity of women and negative affectivity of the child, the latter of which is plotted one standard deviation above and below the mean (Fig. 3). In the context of high early adversity, high negative affectivity of the child was associated with trajectories that remain high from pregnancy and across the postpartum period. Conversely, in the context of low adversity, child with elevated negative affectivity was associated with trajectories that increase immediately after pregnancy and eventually level out.

Discussion

The present study shows variation in maternal anxiety over time—across pregnancy and the first two postpartum years—in addition to the influences of maternal early adversity and the temperament of the child. The U-shaped trajectory of state

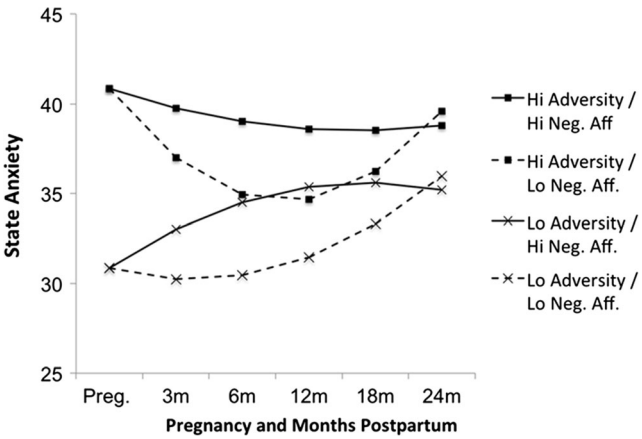

Fig. 3 Estimated maternal anxiety is presented from pregnancy to 24 months postpartum as a function of maternal early adversity and child negative affectivity at 18 months. *Hi Adversity* high adversity, *Lo Adversity* low adversity, *Hi Neg. Aff.* high negative affectivity, *Lo Neg. Aff.* low negative affectivity

anxiety from pregnancy to 2 years postpartum indicates that maternal anxiety dynamically changes through these periods. Across all women, the decline of anxiety after parturition suggests an anxiolytic effect of maternity during the early postpartum period. This result is consistent with previous studies reporting a reduction in anxiety from gestation to the first postpartum months in human mothers (Andersson et al. 2006; Figueiredo and Conde 2011a, b; Heron et al. 2004; Madigan et al. 2014; van Bussel et al. 2009) and with the relative reduction in anxiety-like behaviors in postpartum when compared to virgin rats (Agrati et al. 2008; Ferreira et al. 1989; Fleming and Luebke 1981; Lonstein 2005; Smith and Lonstein 2008). Indeed, anxiety during gestation in women has been associated with a number of social, environmental, and intrapersonal psychological variables (Da Costa et al. 1998; Roos et al. 2013; van Bussel et al. 2009), in addition to maternal-specific factors, including negative thoughts related to fetus health or the proximity of childbirth (Brockington et al. 2006). Once the child is born, its presence and the proximal contact with the mother likely promote feelings of well-being and improve maternal mood (Figueiredo and Conde 2011b; Leckman et al. 1999), which could explain the greater reduction of anxiety after delivery in those women with high gestational anxiety.

The positive effect of mother-infant interaction on the affective states of a woman (Lonstein 2007; Macbeth and Luine 2010) has been mainly attributed to lactation, as breastfeeding—in comparison to bottle-feeding—reduces the perception of stress and dysphoric symptoms and decreases anxiety and depressive symptoms (Henderson et al. 2003; Jonas et al. 2008, 2013; Nissen et al. 1998; Sibolboro-Mezzacappa and Katlin 2002). Conversely, in our study, the anxiety decline after parturition was not associated to breastfeeding, suggesting that mother-infant interaction per se also contributes to this affective change. In this sense, Heinrichs et al. (2001) showed that the physical interaction with the baby, either through breastfeeding or just holding, diminishes the state anxiety reported by 2 months postpartum mothers.

In contrast to the observed decrease in anxiety during early postpartum period, we observed a rise in anxiety during the second postpartum year. Similarly, DiPietro et al. (2008) reported that though state anxiety remained stable, maternal distress—assessed by a composite score of anxiety and depression—increased in primiparous women during this period. This augmentation in anxiety during the second postpartum year might be related to the development in the child of an increasing autonomy and sense of self and the expression of negativity in the child during the transition from infancy to childhood, which may pose new challenges and an increase in stress on parents (Aber et al. 1999; Crinc and Booth 1991; Van Zeijl et al. 2006). Thus, externalizing behaviors, such as non-compliance and hitting others, increase in children from 12 to 24-month-olds and this behavioral change is accompanied by an increase in parenting daily hassles (Van Zeijl et al. 2006). Similarly, Aber et al. (1999) reported that mothers' representation of their relationship with their children involves more anger at 28 than at 15 postpartum months, and this change positively correlates with parental daily hassles. In the present study, extraversion of the child at 18 months predicted the anxiety increase during the second postpartum year, pointing to a role of the behavior of the child in regulating the affective state of the mother. In addition to a possible effect on maternal anxiety of increasing parent-related stress from the first to the second postpartum year (Aber et al. 1999; Crinc and Booth 1991; Van Zeijl et al. 2006), other non-parenting hassles can augment mothers' stress, including economic demands. Indeed, we observed that mothers with higher family incomes tended to show a smaller increase in anxiety during the second postpartum year.

Early adverse experience moderation of maternal anxiety

The impact of early adversity on anxiety during pregnancy is consistent with several studies showing that early stressful experiences—including physical, psychological, or sexual abuse; family separations; and parental rejection—increase the probability of anxiety and depression later in life (Bifulco et al. 1992; Heim and Nemeroff 2001; Stein et al. 1996). Moreover, child abuse constitutes a risk factor for generalized anxiety during gestation (Buist et al. 2011; Lim et al. 2005), in addition to pregnancy complications (Leeners et al. 2010). In other species, simulated experimental models of neglect via disruption and deprivation of parental care increase anxiety and depressive-like behaviors during adulthood (Gilmer and McKinney 2003; Huot et al. 2001; Kraemer et al. 1984; Ladd et al. 2000; Loman and Gunnar 2010).

Different types of childhood trauma, including emotional neglect and physical, psychological, and sexual abuse, have been consistently shown to be associated with the development of anxiety disorders (Hovens et al. 2010; Kessler et al. 1997; Gibb et al. 2007; Kessler et al. 1997; Spinhoven et al. 2010; van Veen et al. 2013); however, recent literature indicates that each type of child trauma experience impacts different aspects of the psychological well-being of individuals (Spinhoven et al. 2010; van Veen et al. 2013). Although in the present study we did not discriminate among different types of trauma, our results are in accordance with those obtained by Madigan et al. (2014) showing a strong effect of parental neglect during childhood on the course of anxiety from pregnancy to the postpartum period. This study reports that anxiety symptoms decrease from pregnancy to 1 year postpartum in adolescent mothers and parental neglect (but not sexual or physical abuse) was associated with high gestational anxiety and a more pronounced decrease after childbirth. The similar anxiety profile in these two cohorts of

mothers, adolescent (Madigan et al. 2014) vs adult (present study), reveals a robust effect of early life stressful experiences on the course of anxiety during this particular reproductive and psychological period.

Evidence from human and rodent studies indicates that long-term alterations in the activity of the HPA axis as a consequence of these stressful experiences underlie the influence of early adversity on affectivity (Heim and Nemeroff 2001; Ladd et al. 2000; Lazinski et al. 2008; Meaney et al. 1996; Penza et al. 2003; Struber et al. 2014). Thus, glucocorticoids by acting on their central receptors modulate the function of several brain regions that integrate affective systems (Groeneweg et al. 2011; Struber et al. 2014). Interestingly, women who experienced child trauma (Gonzalez et al. 2009), and female rats exposed to early life social stress (Carini and Nephew 2013), show hypersecretion of basal glucocorticoids during the postpartum period. This alteration in HPA axis function during the postpartum period indirectly reveals a modified stress central system associated with early adversity, which may underlie increased anxiety in these women. Thus, early adversity seems to be related to a hyperresponsiveness of limbic circuits to negative cues (Dannlowski et al. 2012; Tottenham et al. 2011) that may promote anxiety (Dannlowski et al. 2012; Etkin et al. 2011; Loman and Gunnar 2010). Within this framework, it is possible to speculate that during pregnancy, when concerns related to fetal health and child delivery emerge, and during the second postpartum year, when parental-related stress increases, a greater reactivity to negative cues of those women experiencing early adversity heighten anxiety, leading to a more pronounced U-shaped trajectory of their anxiety.

Interaction between maternal anxiety and temperament of the child

The strong positive relationship found between gestational anxiety and negative affectivity of the child at 18 months of age agrees with studies reporting that maternal prenatal stress and anxiety are associated with an increase in negative affectivity and behavioral problems in the child, as well as with alterations in the activity of the HPA axis (Gutteling et al. 2005; O'Donnell et al. 2013). These early effects of the affectivity of the mother on the development of the child have been mainly attributed to direct fetus programming in the uterus (Lazinski et al. 2008; Van den Bergh et al. 2005). For instance, maternal anxiety during pregnancy can impact the child behavioral development by increasing maternal blood cortisol levels and other stress hormones. Maternal cortisol can cross over into the placenta by altering the 11β-HSD2 barrier enzyme, changing the fetal context, and contributing to the development of neurological formations that are associated with difficult temperament and behavior problems (O'Donnell et al. 2012). Besides an intrauterine effect, the affective state of the mother during gestation can also influence the child indirectly through alterations of the mother-infant interaction later during the postpartum period (Bergman et al. 2010; Glynn et al. 2007).

Interestingly, the present study shows a transactional pathway by which early life experiences of the mother predict negative affectivity of the child by modulating gestational anxiety. In turn, negative affectivity of the child impacts the maternal anxiety course later. This result agrees with several studies highlighting the interactive and dynamic nature of mother-infant interaction, and how this relationship imposes a cross-dependence between affective and cognitive processes in the infant and the mother (Feldman et al. 1999, 2009; O'Donnell et al. 2013; Sameroff 2010; Van den Bergh et al. 2005). In the same line, Bridgett and co-workers (Bridgett et al. 2009) found that maternal stress and depression influence infant negative emotions and regulatory capacity development, which in turn affects negative parenting during toddlerhood.

In addition to the influence of child's affectivity, extraversion at 18 months predicted the increase in maternal anxiety during the second postpartum year; a result that can be related to changes on ambulation and social engagement that occur during this period of child development (Evans and Porter 2009; Feldman et al. 2009; Gartstein and Rothbart 2003; Putnam et al. 2006; Rothbart and Ahadi 1994). It is possible that greater motor activity and impulsivity, reflected in the extraversion of the child, may lead to the display of more risk taking behaviors (Fagot 1978; Morrongiello and Dawber 1999), and this behavioral profile of toddlers may, in turn, augment demands on the mothers. Moreover, temperamental extraversion of toddlers also predicts externalizing behaviors as aggressiveness (Berdan et al. 2008; Mervielde et al. 2005; Rothbart et al. 2001). Both externalizing behaviors (Crinc and Booth 1991; Van Zeijl et al. 2006) and high activity level (McBride et al. 2002) of toddlers have been related to greater parental stress in the mothers. In the current study, this later rise in maternal anxiety was greater in mothers who had a female child. Accordingly, it has been reported that parents tend to respond more negatively (Fagot 1978) and perceive greater injury vulnerability, with large motor activity in girls than in boys (Morrongiello and Dawber 1999).

Overall, the reciprocal interactions between maternal and the child psychological functioning illustrate the dynamic co-regulation of physiological, cognitive, and affective process in the mother-infant dyad, in addition to the importance of contextual influences. Thus, it is important to conceptualize maternal peripartum and postpartum mental health in a systemic fashion, reflective of multiple historical and concurrent contextual and social influences.

Final remarks and limitations of the study

This report contributes to a series of papers based on the MAVAN sample in which we explore environmental and physiological factors that contribute to the affective state of the mother across the first five postpartum years (e.g., (Adedinsewo et al. 2014; Jonas et al. 2013; Mileva-Seitz et al. 2011, 2012, 2013). The current study examined variation in maternal anxiety during the first 2 years. We still do not know the extent to which prepregnancy anxiety contributes to the course of their later anxiety, the contributions to overall affective state of anxiety versus depression, and the role in the anxiety/depression trajectory of mothers' endocrine profile, especially of the HPA axis. These and other situational, physiologic, and historical influences have yet to be evaluated.

Three main limitations of the present study should be considered. Firstly, the possibility of a common method variance bias (Podsakoff et al. 2003) as a consequence of women responding on gestational anxiety and early adversity questionnaires at the same interview, as well as on 18 months maternal anxiety and ECBQ, encourage future studies employing multi-method assessment strategy and also behavioral approaches. Also, parental report on temperament of the child may be subject to bias (Sameroff et al. 1982). Regarding this, it is important to note that sustained construct validity for the ECBQ and other child behavior questionnaires as the IBQ has been probed (Casalin et al. 2012; Gartstein and Marmion 2008; Reck et al. 2013; Rothbart et al. 2001). Thus, these questionnaires converge to a moderate degree with similar behaviors recorded (Gartstein and Marmion 2008; Rothbart 1986; Zentner and Bates 2008) as well as with additional conceptually related scales from other questionnaires (Casalin et al. 2012). Finally, there were some concerns surrounding missing data, which is not uncommon in longitudinal human research. The employment of state-of-the-art estimation techniques (FIML), moderate size sample (N=159), and reasonable amount of missing outcome measures (24 %) across a relatively tight period of follow-up (2 years) adds confidence to our findings. However, additional replication studies will continue to address these limitations.

Despite such limitations, the current report contributes to the understanding of variables that influence maternal peripartum and postpartum anxiety trajectories. Indeed, the present results illustrate the role of early adverse experiences in maternal anxiety during pregnancy and through the postpartum, pointing to a greater reduction of state anxiety during early maternity. Finally, the inter-relationship between maternal anxiety and the temperament of the child stresses the importance of transactional processes, not only for the development of the child but also for the affectivity of new mothers.

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