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SHORT COMMUNICATION

Positive life events predict salivary cortisol in pregnant women

Michael Pluess [a], Harald Wurmser [b], Angelika Buske-Kirschbaum [c], Mechthild Papousek [d], Karl-Martin Pirke [e], Dirk Hellhammer [e], Margarete Bolten [f,*]

[a] Institute of Psychiatry, King's College London, London, United Kingdom
[b] Department of Pediatrics, Technical University of Munich, Munich, Germany
[c] Department of Biological Psychology, Technical University of Dresden, Dresden, Germany
[d] Child Care Centre, Ludwig-Maximilians-University Munich, Munich, Germany
[e] Department of Psychobiology, University of Trier, Trier, Germany
[f] University of Basel, Child and Adolescents Psychiatric Clinic, Department of Developmental psychopathology, Basel, Switzerland

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Abstract Maternal stress during pregnancy has been repeatedly associated with problematic child development. According to the fetal programming hypothesis adverse experiences during pregnancy increase maternal cortisol, which is then assumed to exert a negative effect on fetal development. Recent studies in non-pregnant women report significant associations between positive emotionality and low cortisol levels. We tested in a sample of 60 pregnant women whether both negative and positive life events independently predicted third-trimester baseline awakening cortisol levels. While the effect of negative life events proved unrelated positive life events significantly predicted lower cortisol levels. These findings suggest that positive experiences are of relevance regarding maternal morning cortisol levels in pregnancy reflecting a resource with potentially beneficial effects for the mother and the developing fetus. It might be promising for psychological intervention programs to focus on increasing positive experiences of the expecting mother rather than exclusively trying to reduce maternal stress during pregnancy.

1. Introduction

An extensive number of both human and animal studies suggests that experiences during the prenatal period influence fetal development (for review see, e.g. Talge et al., 2007). Most of these studies focus on the negative effects of

* Corresponding author at: University of Basel, Child and Adolescents Psychiatric Clinic, Department of Developmental psychopathology, Schanzenstrasse 13, CH-4056 Basel, Switzerland.
Tel.: +41 0 61 265 89 71; fax: +41 0 61 265 89 61.
E-mail address: margarete.bolten@upkbs.ch (M. Bolten).

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maternal stress during pregnancy on problematic outcomes in offspring. According to the prevailing hypothesis elevated levels of maternal cortisol, in response to prenatal stress, produce permanent alterations of the hypothalamic–pituitary–adrenal (HPA) axis of the developing fetus (Weinstock, 2008). Studies that also consider potentially protective effects of psychosocial resources on fetal development in the face of maternal stress during pregnancy are sparse. Further, human studies rely primarily on subjective reports of psychological stress (e.g., self-reported anxiety) that tend to be substantially confounded with inheritable maternal personality traits (for example neuroticism, see Pluess et al., 2010). Some studies, however, also include more objective measures of stress like exposure to distinct negative life events. While many of these studies chronicle associations between negative life events during pregnancy and maladaptive child outcomes, the link between adverse events and elevated maternal cortisol in pregnancy—one of the hypothesized mechanisms of fetal programming—has been more difficult to demonstrate (e.g., Wadhwa et al., 1996).

Recently, in the wake of the emerging field of positive psychology (Seligman and Csikszentmihalyi, 2000), several studies investigated associations between positive emotionality and cortisol in non-pregnant samples. For example, Steptoe et al. (2005) found a significant association between self-reported happiness and diurnal cortisol levels in a sample of 227 adult men and women with the most happy study participants exhibiting the lowest cortisol levels across the day. Similarly, Polk et al. (2005) reported significantly lower morning cortisol in healthy women characterized by high positive state affect. More recently, these findings have been extended to the study of cortisol reactivity involving a sample of 40 healthy women (Bostock et al., 2011). Women characterized with high positive emotionality had significantly lower cortisol release in response to a stressful task.

Studies investigating mechanisms of fetal programming have been focusing almost exclusively on heightened maternal cortisol levels in response to adverse experiences during pregnancy with hitherto inconsistent results in human studies. In light of recent findings reporting associations between positive emotionality and both lower diurnal cortisol levels and decreased cortisol reactivity in non-pregnant healthy women, the inclusion of positive experiences and the investigation of their effect on maternal cortisol during pregnancy may represent an important addition to research exploring mechanisms underlying fetal programming.

In the current longitudinal study we tested whether baseline awakening cortisol levels in pregnant women in the last trimester of pregnancy are predicted by both negative and positive life events which occurred within the 12 preceding months, reported retrospectively at the end of the first trimester. Given a previous analysis of the same study chronicling significant associations between psychological and biological stress measures and maternal neuroticism we controlled for maternal neuroticism (Pluess et al., 2010). Based on theory and existing research we hypothesized that negative life events would predict higher and positive life events lower maternal morning cortisol levels.

2. Method

2.1. Overview

The present work is based on data from a prospective longitudinal study on the effects of prenatal maternal stress on early postnatal infant development employing several assessment points during pregnancy and the early postpartum period (Wurmser et al., 2006). The present study includes only data collected during the prenatal period. Subject recruitment and data collection took place in Trier, Germany.

2.2. Sample and procedure

Participants were recruited in collaboration with local obstetricians/gynecologists in private practice, clinic departments of gynecology and obstetrics, information centers for pregnant women, and by advertisements in local newspapers. Women that met inclusion criteria (age of 16 years or older and fluency in German) were contacted by phone and briefly informed about the study's research protocol. Exclusion criteria were: (a) severe medical complications, (b) signs of fetal malformation, (c) multi-fetal pregnancies, and (d) self-reported psychiatric problems. After providing informed consent for participation eligible women were invited for a first assessment at 10–20 weeks gestation and a second assessment at 32–34 weeks gestation.

Originally, a total of 94 women were recruited into the project but due to attrition and missing data only 60 (63.8%) women were available for the present analysis. Comparisons between the selected sample of 60 and the 34 excluded women indicated no significant differences between the two groups on any demographic, biological, or psychological variables (see Table 1 for sample characteristics).

All women were paid 200 Euro for their time and efforts in participating in the project. The study protocol was approved by the research ethics committee of the University of Trier and is consistent with the revised Helsinki Declaration of 1975.

2.3. Measures

2.3.1. Demographic and psychological variables

Structured interviews were conducted by trained female research assistants at enrollment into the study and inquired about socio-demographic (e.g., age, education, occupation, income, and marital status) and medical information. Life events were measured using a German version of the Life Experiences Survey (LES; Sarason et al., 1978), which lists 47 events that require adjustment (e.g., marriage, change of job, relocation, and death of a family member). Subjects were asked to indicate whether the listed life events occurred during the preceding 12 months and if so, to rate the impact on a seven-point scale ranging from "1 = extremely negative" to "7 = extremely positive". Summing up the occurrences with negative impact ratings (i.e., 1–3) yielded a measure for the number of negative life events and summing up the occurrences with positive impact ratings (i.e., 5–7) a measure for the number of positive life events the participants experienced. The LES was administered in early pregnancy (10–20 weeks gestation). Neuroticism was

Table 1 Sample characteristics (N = 60).

Variables	N (%)
Age at first contact (years)	M = 30.4, SD = 4.8 (range: 16–39)
Living situation	
Living with partner	55 (91.7%)
Living without partner	5 (8.3%)
Education	
<High school	23 (38.3%)
High school graduate	20 (33.3%)
College graduate	17 (28.3%)
Monthly income per household[a]	
<750 Euro	3 (5.1%)
750–1500 Euro	9 (15.3%)
1500–3000 Euro	28 (47.5%)
>3000 Euro	19 (32.2%)
Parity	
Primiparous	25 (41.7%)
Multiparous	35 (58.3%)
Planned pregnancy	
Planned	43 (71.7%)
Unplanned	17 (28.3%)
Wanted pregnancy	
Wanted	52 (86.7%)
Unwanted	8 (13.3%)
Smoking during pregnancy	7 (11.7%)
Alcohol during pregnancy	8 (13.3%)
Neuroticism	M = 5.8, SD = 1.9
Life events	
Negative events	M = 3.9, SD = 3.4
Positive events	M = 2.7, SD = 2.8
Cortisol (nmol/L)	
Awakening	M = 27.3, SD = 8.0
30 min	M = 35.4, SD = 11.5
45 min	M = 36.4, SD = 11.4
60 min	M = 32.5, SD = 10.3

[a] 1 Euro = 1.30 US dollar (December 2011).

assessed with the global factor "anxiety" of the 16PF Questionnaire (Cattell et al., 1970) administered in late pregnancy (32–34 weeks gestation).

2.3.2. Salivary cortisol

Subjects were instructed to collect saliva at home with specially designed test tubes (Salivette®, Sarstedt, Germany) right after awakening and 30, 45, and 60 min thereafter and to store the samples in the freezer until the next study assessment. Participants collected saliva samples on two different days during the 35th and 36th week of gestation. Saliva samples were stored at −20 °C. After thawing, samples were centrifuged at 2000 × g at 10 °C for 10 min. Salivary cortisol was analyzed using a commercial competitive luminescence immunoassay (LIA; IBL, Hamburg, Germany). Intra- and inter-assay coefficients of variation were both below 10%. Every tenth sample was assayed twice. Salivary cortisol values were averaged across the two different assessments. Baseline awakening cortisol levels were calculated as the area under the curve using the trapezoid method with respect to the ground (AUCg; see Pruessner et al., 2003).

3. Results

In preliminary analyses we tested for significant associations between morning cortisol (AUCg) and all demographic variables listed in Table 1. According to bivariate correlations only planned pregnancy was significantly associated with morning cortisol ($r(60) = .28$, $p < .05$). Women indicating that their pregnancy was planned had higher morning cortisol levels (M = 2086 nmol/L, SD = 518) than women whose pregnancy was not planned (M = 1765 nmol/L, SD = 431). Consequently, planned pregnancy was included as a covariate in further analyses. Negative and positive life events scores were not correlated with each other ($r(60) = -.002$, $p > .05$).

A multiple regression model was used to test whether both negative and positive life events predict morning cortisol in pregnant women controlling for planned pregnancy and also maternal neuroticism (Pluess et al., 2010). The total model was significant ($F(4, 55) = 3.21$, $p = .02$) explaining 13% of the variance of morning cortisol. Positive life events significantly and negatively predicted morning cortisol levels with $\beta = -.26$ ($p = .04$) whereas negative life events ($\beta = -.22$, $p = .10$), planned pregnancy ($\beta = .19$, $p = .16$) and neuroticism ($\beta = -.03$, $p = .84$) failed to reach significance.

In order to compare women with high and low positive life events scores in a follow-up analyses the sample was split across the median into two groups (see Fig. 1). According to separate t-tests between the two groups on all four cortisol measurements women in the high positive life events group had significantly lower cortisol levels only at awakening ($t(58) = 2.48$, $p = .02$).

4. Discussion

The aim of the current study was to investigate effects of both negative and positive life events on maternal morning cortisol levels in the third trimester. Consistent with our hypothesis and recent studies investigating associations between positive emotionality and cortisol (Polk et al., 2005; Steptoe et al., 2005; Bostock et al., 2011) positive life events predicted significantly lower cortisol levels across the cortisol awakening response in our sample of pregnant women. Follow-up analyses suggest that this effect was most pronounced shortly after awakening. Contrary to our hypothesis, negative life events were not significantly associated with morning cortisol levels.

Inconsistent findings regarding the relationship between negative experiences during pregnancy and maternal cortisol levels are not unusual in the existing literature. For example, in a cross-sectional study by Wadhwa et al. (1996), life events stress was not associated with plasma cortisol at 28 weeks gestation while, intriguingly, social support—a psychosocial resource—significantly predicted lower cortisol levels. In a longitudinal study, Obel et al. (2005) failed to detect an effect of stressful life events on maternal cortisol levels at 14 weeks gestation but at 30 weeks gestation women reporting more stress due to life events had significantly higher cortisol levels in the evening. In a recent study by Giesbrecht et al. (2011), using elaborate measures of diurnal cortisol across three consecutive days, both stress history and daily stress failed to predict waking cortisol levels in a sample of 83 pregnant women (6–37 weeks gestation). Hence, the

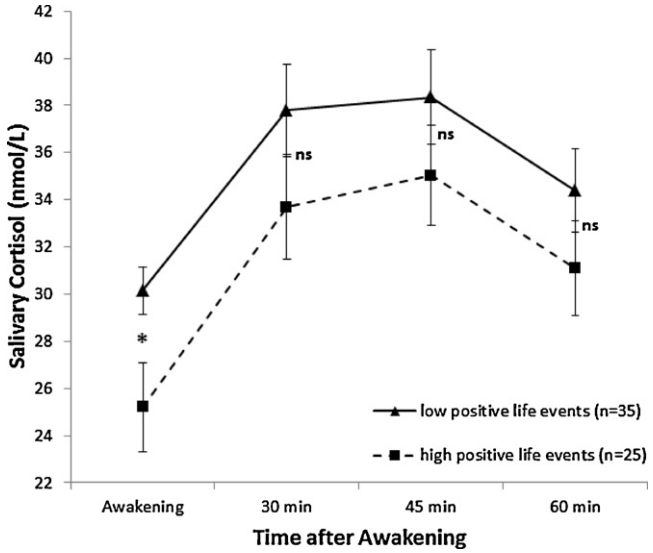

Figure 1 Baseline awakening cortisol levels at 35/36 weeks gestation. *t*-Tests between low and high positive life events groups, ns = not significant. $^{*}p < .05$.

findings of the current study that positive but not negative life events predicted lower baseline awakening cortisol levels in late pregnancy are not inconsistent with results of other existing empirical work. Important to mention is also that cortisol levels are naturally rising throughout the course of pregnancy and that it, therefore, often tends to be more difficult to detect associations between cortisol and psychosocial factors in late pregnancy (see e.g., Pluess et al., 2010).

The observation that positive experiences are significantly associated with lower cortisol levels while negative life events appear unrelated is consistent with the Transactional Model of Stress and Coping (Lazarus and Cohen, 1977) suggesting that positive experiences during pregnancy represent a psychosocial resource that may attenuate or even completely abolish the negative effects of adverse influences—at least regarding baseline awakening cortisol levels in pregnant mothers.

Fetal programming theorizing and a growing body of empirical evidence pertaining to the association between maternal prenatal stress and maladaptive outcomes in offspring lead to the logical conclusion that psychological intervention should focus on the reduction of maternal stress during pregnancy in order to ensure optimal development of the unborn child. However, the current findings suggest that positive experiences might actually be more influential—at least regarding maternal awakening cortisol levels during late pregnancy—compared to the impact of negative experiences. Hence, rather than focusing exclusively on the reduction of maternal stress during pregnancy it might be promising to also pay attention to increasing positive experiences (i.e. coping resources) in psychological intervention during pregnancy (and maybe even prior to pregnancy given that the current study assessed the influence of life events that occurred both before and during early pregnancy).

The results of the present study should be considered in the context of important methodological limitations: (1) time (compliance) of exact cortisol sampling was not assessed; (2) not all factors that are known to affect the cortisol awakening response have been controlled for (e.g., sleeping patterns, caffeine, drug abuse); (3) given that life events were assessed retrospectively (12 previous months) at 10—20 weeks gestation, the majority of events occurred before pregnancy. However, most of these life events (e.g., job change, marriage, etc.) have consequences that are likely to extend over a long period of time; and, (4) findings are based on correlational data, which do not allow for causal interpretations.

Further studies are required to replicate the reported findings and to investigate whether the detected beneficial effects of positive experiences on mothers' cortisol levels in pregnancy also positively affect fetal development including experimental designs that allow for the testing of causality.

Conflict of interest

None declared.

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