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Does infant reactivity moderate the association between antenatal maternal depression and infant sleep?

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Abstract

OBJECTIVE—A number of studies have established an association between antenatal maternal depression and infant sleep. One key question is whether all infants are equally susceptible to environmental influences, including the intra-uterine environment. Reactive temperament has been examined as a plasticity factor, with accumulating evidence suggesting that infants with reactive temperament may be more susceptible to both positive and negative environmental influences. This study examines whether infant reactivity moderates any association between antenatal depression and infant sleep in two longitudinal studies: the **ALSPAC** and **Generation R** cohorts.

METHODS—Maternal depression scores were assessed during pregnancy using the EPDS and BSI. Infant sleep duration and awakenings, in ALSPAC (N=8,318) and Generation R (N=2,241), were assessed at 18/24 months of age respectively. Infant reactivity was assessed by temperament questionnaire at 6 months of age.

RESULTS—Hierarchical linear regression models indicated a three-way interaction between reactivity and gender moderating the effect of antenatal depression on infant sleep; on sleep duration in Generation R at 24 months ($\beta = .085$, $p < .001$) in the whole sample and when limited to the Dutch/European group ($\beta = .055$, $p = .030$), and on night awakenings at 18 months in ALSPAC

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Abbreviations: EPDS, ALSPAC

($\beta = -.085$, $p = .013$). Boys with more reactive temperament exhibited shorter sleep duration and a higher number of awakenings when previously exposed to maternal symptoms of antenatal depression.

CONCLUSION—For the first time, these findings highlight, in two large cohorts, that children with temperamental reactivity may be more vulnerable to antenatal depression, raising the possibility of targeted interventions to improve infant outcomes.

Keywords

infant sleep; temperament; antenatal depression; ALSPAC; Generation R

INTRODUCTION

Depression during pregnancy (antenatal depression) has an estimated prevalence of around 11% [1]. There is substantial evidence suggesting that antenatal depression can affect child development, including higher risk of emotional and behavioral problems at 4 and 7 ½ years of age and antisocial behavior at 16 years of age [2]. More recently, antenatal depression has been associated with earlier markers of disturbed development including infant sleep, measured as shorter sleep duration, more night awakenings and sleep problems [3, 4].

This is important as sleep is a key predictor of development and in older children and adolescents disturbed sleep is a marker of neurodevelopmental disturbances [5], as well as a significant source of stress to families. More specifically, there is evidence suggesting that shorter sleep duration negatively impacts on behaviour, cognitive development and academic performance [6-8]. Sleep problems during early life have been associated with later emotional and behavioral problems, neurological functioning during adolescence, as well as anxiety/depression, attention, and aggression [9, 10]. In very early life, when few reliable measures of healthy development exist, assessment of sleep provides a useful marker of child development, as well as a potential indicator for the emergence of problems later in life. Infant sleep duration and frequency of night awakenings are important and widely researched indicators of a normal sleep rhythm. O'Connor and colleagues [4] were amongst the first to report increased rates of sleep difficulties in children of antenatally depressed mothers, whilst controlling for postnatal depression.

It is not yet fully understood what mechanisms are in play to confer the risk from maternal antenatal depression to offspring development, although fetal programming effects of exposure to depression during pregnancy may be key [11]. The fetal programming hypothesis suggests that increased plasticity during life in utero aims to assist the individual to adapt to environmental cues in anticipation of the post-birth environment. This process, from an evolutionary perspective, aims to provide the individual with a developmental advantage or to limit the developmental setbacks of a prospective harsh environment [12]. The early stages of life, including the fetal period, are characterized by rapid brain development, and sleep, as a marker of bio-behavioral organization, is an indicator of such neurodevelopment.

A key question is the extent to which all children may be equally affected by exposure to early risk, or whether certain individuals are more at risk than others. This is important when mechanisms and intervention targeting are being considered. Recent studies have suggested that children with reactive temperament may be more at risk of adverse outcomes when exposed to environmental adversities such as hostile mothering, negative life events and antenatal depression compared to those with less reactive temperament [13]. Examples of reactive temperament include higher rates of distress-to-change and prolonged crying bouts. It has been hypothesized that such highly reactive infants may have nervous systems which are disproportionately activated in response to negative stimuli. It has been proposed that these same children who are most susceptible to negative environmental pressures will also benefit the most from positive influences, such as supportive and enriched environments [14]. Within this framework of differential susceptibility, Belsky and colleagues have hypothesized that reactive temperament is a marker of developmental susceptibility [13]. A number of studies have provided evidence to support this contention but, to date, no studies have examined reactive temperament as a moderator of the association between antenatal depression and child outcomes.

A number of studies also report gender specific effects, in particular boys to be more susceptible to environmental differences. For example, Van Aken and colleagues [15] reported 16-19 months old male infants with difficult temperament to show the smallest increase in externalizing problems when reared by highly sensitive mothers compared to insensitive mothers 6 months post assessment. Morrell and Murray [16] reported that only highly distressed and irritable 4-month-old boys who experienced coercive and rejecting mothering continued to exhibit emotional and behavioural dysregulation 5 months later.

The current study analyses data from two large population cohorts; the Avon Longitudinal Study of Parents and Children and the Generation R cohort. The aim of this study was to test the hypothesis that infant reactivity and gender may moderate any association between antenatal depression and infant sleep. We hypothesized that highly reactive infants would exhibit shorter sleep duration and more awakenings, when previously exposed to antenatal depression. We also examined whether gender acted as a moderator of this association due to previous findings of gender differences, which suggest that boys may be at greater risk for poorer behavioural and cognitive outcomes following exposure to parental depression [2] and that boys with reactive temperament may be more susceptible to environmental influences.

METHODS

Design

We conducted data analysis on two longitudinal population cohorts (Table 1), the ALSPAC and Generation R studies, both beginning during pregnancy.

ALSPAC is a prospective study based in Bristol, UK investigating influences on health and development across the life course [17]. Women due to deliver between April 1991 and December 1992 were approached to participate in the study [17]. 14,541 women were recruited, resulting in 14,676 fetuses and 14,062 live births at 1 year of age. The analysis

here is restricted to participants with complete data on all variables including covariates (n=8,318 at 18 months). The study was approved by the ALSPAC Ethics and Law Committee and the Local Research Ethics Committees.

Generation R is a population- based cohort investigating development and growth, in Rotterdam, The Netherlands. All women due to deliver from April 2002 to January 2006 were approached about participating in the study, 9,778 women were originally enrolled in the study [18], of which 7,295 gave consent for postnatal follow-up. The current sample consists of n=2,241 mothers and their children, for which complete data were available at 24 months. Attrition occurred primarily in the measure of temperament where due to logistical problems 981 mothers did not receive the 6-month questionnaire. Another 1,764 did not complete the 6-months questionnaire [19]. Due the Generation R was approved by the Medical Ethical Committee of the Erasmus Medical Center, Rotterdam. Table 1 presents a brief comparison of the two cohorts.

Those families with data available at all time points were compared with those excluded due to attrition. In the ALSPAC cohort, families who remained in the study had on average slightly older mothers (mean=28.74 years SE=0.05, vs mean =26.8 years SE=0.07; $t=-20.1$, $p<.001$) and mothers who scored lower on antenatal depression (mean=6.72 SE=0.05, vs mean=7.97, SE= 0.09; $t=12.43$, $p<.001$) compared to the attrition sample. There was also a difference in the level of education of mothers, with mothers who continued the study 1.8 times more likely to have completed a higher degree ($\chi^2=86.40$, $p<.001$). There were no differences in infant gender ($\chi^2(1)=0.95$, $p=.748$). A similar analysis in Generation R revealed comparable differences between the included and excluded samples. Those families who remained in the study had mothers who were slightly older (mean=31.73 years SE=0.1 vs. mean =29.45 years SE= 0.06, $t=-16.52$, $p<.001$) and with lower scores on the depression scale during pregnancy (mean=0.12, SE=.01 vs. mean=0.30, SE =.01, $t=12.76$, $p<.001$) compared to the excluded sample. Women in the study were also 2.7 times more likely to have a university degree ($\chi^2=318.30$, $p<.001$). There was a small but significant difference in infant gender with 48.5% of the remaining sample being male, compared to 50.5% in the overall sample ($\chi^2(1)=5.96$, $p=.015$).

Measures

Maternal antenatal and postnatal depression: Depression in the ALSPAC cohort was assessed using the Edinburgh Postnatal Depression Scale (EPDS) at 32 weeks gestation and 2 months postpartum [20]. The EPDS is a well-established and widely used measure for the assessment of depression in the perinatal period. A higher score indicates greater severity of depression (range 0-30). In this sample α exceeds .80 for ante- and postnatal depression [4]. Depression in Generation R was assessed using the Brief Symptom Inventory (BSI) at 20 weeks gestation and 2 months postpartum [21]. The BSI is a validated self-report questionnaire assessing a range of psychiatric symptoms occurring in the week preceding the assessment. The depression subscale (6 items; sum score ranging from 0 to 24) is used here (antenatal $\alpha=.86$, postnatal $\alpha=.85$). The scale is then divided by 6 resulting in a possible lowest score of 0 and highest of 4. Both measures are validated for use during the perinatal

period and do not include symptoms such as fatigue or appetite change which are common in many women during pregnancy and the postnatal period.

Infant Sleep: Two variables relating to infant sleep were examined; sleep duration and night awakenings. Sleep data were collected in ALSPAC cohort at 18 months and in Generation R at 24 months of age. In both cohorts the data were collected by maternal reports. Mothers were asked to report the typical number of hours/minutes their children slept during the day and night period in the preceding week and the number of awakenings during the night. Sleep duration refers to sleep time over a 24-hour period, including daytime naps.

Infant Reactivity: In both cohorts, the reactivity factor refers to the evolutionary characteristic as identified by Belsky and colleagues in the differential susceptibility model [13] which appears to index the underlying reactivity of the neural systems. It is also related to the factor of negative affectivity described by Rothbart and colleagues [22]. In the ALSPAC cohort infant temperament was assessed at 6 months using the Infant Temperament Questionnaire [23]. Three raters (MvIJ, MB-K, PR) independently identified 40 items (which form the four following scales of the Infant Temperament Questionnaire intensity, threshold, approach, and adaptability) which related most closely to the concept of infant reactivity according to the above definition (Cronbach's $\alpha = .75$). Reactivity in Generation R was measured using a short version of the Infant Behaviour Questionnaire (IBQ-R) [22] at 6 months of age. The infant reactivity variable was computed by standardizing and averaging the following three subscales (40 items): distress to limitations, fear and recovery of distress (reflected) ($\alpha = .87$). This construct has been previously used in Generation R [24] (the items were a priori selected by MvIJ and MB-K). A higher score reflects greater reactivity.

Covariates/Confounding Variables: The following variables were used as covariates in both studies: maternal age, education, marital status, crowding (number of rooms in household divided by number of people in household), smoking and alcohol consumption and infant gender. Differences between the two cohorts are presented in Table 2. Due to the diverse ethnic composition of Generation R, analysis was also examined for the Dutch/European sample separately to match the ALSPAC composition. A comparison of the two groups (Dutch/European vs. Non-European) is presented in the supplementary table.

Statistical analysis

Outliers ($z > |3.29|$) were winsorized by replacing the outlying score with the next highest value (with $z < |3.29|$). For ALSPAC $n=39$ for sleep duration and $n=81$ for awakenings were winsorized. For Generation R $n=12$ for sleep duration were winsorised. Outlying scores were determined to belong to the distribution and the winsorizing approach allows for the subjects to be retained in the sample whilst at the same time achieving a less skewed distribution [25]. Bivariate associations between antenatal depression and infant sleep were examined in both cohorts (Pearson, two-tailed). Hierarchical regression models were constructed to examine the moderating role of reactivity. Following recommendations by Aiken and West [26], all variables were centered on zero prior to the regressions. In both cohorts, the moderator, reactivity, was found to be associated with antenatal depression and

infant sleep. As this violates the assumptions of analysis with moderators, this issue was addressed by firstly regressing reactivity on the sleep items and secondly on antenatal depression, to partial out any overlap between the moderator and the outcome or predictor variables. This step also addressed the potential association between antenatal depression and infant temperament as reported in a number of studies. The residual terms for antenatal depression and reactivity were then used for the analyses. The following variables were included in each step, Step 1: all covariates, Step 2: reactivity and depression, Step 3: 2-way interaction terms (depression X reactivity, depression X gender, reactivity X gender), Step 4: 3-way interaction term (depression X reactivity X gender). The analysis concludes with a cross-validation technique examining whether participants from the two cohorts show a similar fit of the regression models. This technique uses the regression models to construct the predicted scores. Scores calculated based on this equation are then correlated with the observed values in that cohort and the predicted scores of the second cohort. The same analysis is repeated in the second cohort. All statistical analyses were carried out using SPSS version 20.0.

RESULTS

Correlations between sleep duration and awakenings were examined within each cohort. In both cohorts, the two measures (sleep duration and night awakenings) were moderately correlated (ALSPAC $r = -.26$, $p < .001$; Generation R $r = -.23$, $p < .001$). In both cohorts antenatal depression was associated with awakenings and sleep duration (ALSPAC $r = .07$, $p < .001$, $r = -.02$, $p = .03$ and Generation R $r = .09$, $p < .001$, $r = -.08$, $p = .001$).

ALSPAC – 18 months of age

There was no evidence that reactivity X gender moderated the association between antenatal depression and infant sleep duration in the ALSPAC cohort ($\beta = -.014$, $p = .688$). The association between antenatal depression and awakenings was moderated by reactivity X gender ($\beta = -.085$, $p = .013$, Table 3). When further explored by gender a moderating effect of reactivity was found in boys ($\beta = .047$, $p = .002$), but not girls ($\beta = -.007$, $p = .676$, see Figure 1a). Reactive boys displayed more awakenings compared to boys in the low reactivity group when previously exposed to depression.

Generation R – 24 months of age

Findings from Dutch/European participants only in Generation R ($n = 1,585$) revealed a significant 3-way interaction ($\beta = .055$, $p = .030$) for sleep duration. When further explored, it was found to be significant for boys ($\beta = .117$, $p = .001$), but not for girls ($\beta = -.008$, $p = .828$); see Figure 1b. Analysis of the whole Generation R sample also revealed that the association between antenatal depression and sleep duration was moderated by reactivity X gender ($\beta = .085$, $p < .001$ – see table 3). When the interaction was further explored, reactivity moderated the association for girls ($\beta = .140$, $p < .001$) but not for boys ($\beta = -.037$, $p = .252$), a finding which was not evident in the Dutch-European group only. There was no evidence that infant reactivity X gender moderated the association between antenatal depression and awakenings (whole sample, $\beta = -.033$, $p = .172$, Dutch/European only group $\beta = -.021$, $p = .436$).

Cross Validation

In order to test the robustness of the regression models for ALSPAC and Generation R, the regression models were retested by cross-validation of the regression equation in each sample, following procedures pioneered by Bakermans-Kranenburg and colleagues [24]. The predicted equation for Generation R (European/Dutch participants), correlated with the observed values ($r = .11$, $p < .001$) and showed a cross validation for ALSPAC participants, ($r = .04$, $p < .001$). The ALSPAC predicted equation correlated with the observed values ($r = .06$, $p < .001$) and showed a cross validation for Generation R ($r = .07$, $p = .006$). The Generation R equation cross-validated without significant shrinkage ($z = -1.36$, $p = .17$). The ALSPAC equation showed small but significant shrinkage ($z = 2.06$, $p = .04$). The statistically significant difference in shrinkage may be due to the large difference in sample sizes (Generation R $n = 1,796$ ALSPAC $n = 8,233$). The estimated scores for sleep duration from both regression equations were also correlated within each sample. The correlation between the two estimates within ALSPAC was $r = .36$, $p < .001$, and the correlation within Generation R was $r = .52$, $p < .001$.

DISCUSSION

The present study used two large longitudinal cohorts to examine the role of infant reactivity as a moderator of the association between antenatal depression and infant sleep. Our findings suggest that infant reactivity and gender did act as moderators of this association. A moderating effect was found for awakenings at 18 months in the ALSPAC cohort, with reactive boys displaying more awakenings when previously exposed to antenatal depression. The association between antenatal depression and sleep duration at 24 months of age in the Generation R cohort was also moderated by reactivity. When the analysis was restricted to include Dutch/European participants only, to more closely match the composition of participants in the ALSPAC cohort, a significant 3-way interaction was found. Reactive boys exhibited shorter sleep duration in the context of high antenatal depression. Analysis with the whole Generation R sample revealed an additional finding for girls, which was not found in the Dutch/European-only group or in ALSPAC. In the context of high depression scores, girls in the low reactivity group exhibited shorter sleep duration whereas girls in the high reactivity group exhibited the opposite pattern with longer sleep duration. All of our findings held after controlling for a number of important covariates, including postnatal depression, and after partialling out the effects of infant reactivity on antenatal depression and on infant sleep.

This is the first time that reactivity has been studied as a moderator of the important association between antenatal depression in mothers and infant sleep, and the findings are in line with accumulating evidence which highlights that some individuals are more susceptible to environmental influences [11]. Indeed, there is an increasingly strong suggestion that children with reactive temperament are more susceptible than others to the effects of both positive and negative environmental influences [27]. This study adds to this literature and offers a degree of support for the role of infant reactivity as a marker of differential susceptibility. Although the effect sizes here are of small magnitude, these may be practically and theoretically important [28].

This study contributes to our understanding of the subtleties and mechanisms through which antenatal depression confers risk to offspring development and adds to only a handful of reports investigating differential susceptibility with regards to antenatal maternal mental health [24]. The findings presented here highlight an increased vulnerability for boys with reactive temperament to environmental stressors, such as antenatal depression, even during the very early stages of life. These results, interpreted in line with the programming hypothesis are suggestive of a more vigilant sleep profile. It is interesting to speculate that exposure to a stressor such as antenatal depression may encourage preparation for a more stressful environment where vigilance would enhance performance and therefore a vigilant sleep profile could confer an evolutionary advantage. An important issue when considering the implications of this research is what constitutes optimal sleep for example, longer sleep duration or no awakenings cannot invariably be interpreted as the optimal outcome. The cohorts studied here were not presenting with clinical levels of sleep disturbances and analysis was not conducted in such a way as to identify those with potential clinical levels of sleep disturbances. This study has also raised the issue of ethnic background as a potential moderator of this association which requires further exploration.

Ethnicity has not yet been adequately explored in the context of differential susceptibility or in terms of the effects of antenatal depression on child development, and the contrasting findings in the Generation R cohort when using the whole sample vs. only Dutch/European participants suggest that further exploration of ethnicity is necessary. A recent review highlights differences in sleep and suggests that, for example, children of Asian countries have shorter sleep duration (on average 1 hour) [6]

The study has a number of key strengths. It employs two large prospective birth cohorts based in two different countries, the Netherlands and the UK. Although the cohorts are independent it has been possible to use broadly comparable measures for the assessment of maternal depression, sleep and temperament as well as for the covariates included in the analysis. The longitudinal and prospective design of the studies also allows for some inference to be made about the directionality of the effects.

Large prospective studies of normal, non-clinical populations, such as the ones examined here minimize the effects of selection bias, making our findings more generalizable.

It has been noted that power to detect interactions is lower than power needed to detect main effects and that interactions in particular may be more sensitive to the scales used [26], which might result in a higher number of positive findings due to Type I error. The consistency of our results across two cohorts, using comparable but not identical scales, lowers the risk that these findings are due to Type I error.

It is important to acknowledge some limitations of the study. As this analysis was conducted on pre-established birth cohorts it was not possible to design the assessments of sleep to occur at identical time points, although they were only 6 months apart. Comparison across the same developmental age might have revealed results that were more comparable. During the early years of life sleep patterns undergo major changes as a result of brain development and maturation of the central nervous system. Even during the 6 month difference in

assessment of sleep patterns here (18 to 24 months), nighttime sleep is expected to become more consolidated and decreases in length of sleep and night awakenings are expected. Thus the descriptive characteristics of sleep across the two cohorts are not directly comparable. However, this is not likely to have a significant impact on whether infant reactivity and gender moderate the association between antenatal depression and infant sleep.

We were unable to use identical measures of infant temperament. However, the two measures do share a large number of common characteristics and attributes. The authors independently identified questionnaire items which tapped into the construct of reactive temperament, and were in agreement regarding the final composite. Both constructs show good internal consistencies.

There was large and non-random attrition in both the ALSPAC and Generation R cohorts, which may have affected the results. Mothers lost to follow-up were more likely to score higher on antenatal depression, to have lower educational qualifications and to be slightly younger in both cohorts.

All data were collected through maternal report and are therefore subject to reporter bias. This is a significant limitation but common nevertheless in large cohorts where objective measures of sleep are not possible due to financial and time constraints. Research suggests that parents tend to overestimate sleep duration [6]. The mother however presents as an ideal informer of her infant's sleep profile due to her extensive contact with him/her and her knowledge of circumstances that may be impacting on the infant's sleep such as for example illness or teething. We did not control for maternal antidepressant (SSRI) use during pregnancy. Evidence indicates that SSRIs cross the placenta in humans and that SSRI use has been associated with alterations to the circadian rhythm of the mouse [29]. It is possible therefore that SSRI use may affect sleep development in infants. However, relatively small numbers of women take SSRI medication during pregnancy, and so this is unlikely to have significantly affected our results.

Temperament in early life is an indicator of emotion regulation, it is important therefore, to consider potential maternal influences on the development of emotional regulation in infants. Certain maternal behaviours during mother-child interaction, for example touch, positive affect and calming vocalisations, have been shown to negatively correlate with infant distress and reactivity. Maternal parenting, particularly contingent responsiveness, may influence emotion regulation in infancy. Evidence suggests that in scenarios involving novel toys mothers may participate in their infants' development of emotion regulation [30]. Detailed observational data on mother infant interaction was not available in this study. Future research should investigate the potential confounding or synergistic influences of maternal behavioural reactivity on infant (sleep) behaviour.

Finally, the statistical analyses and study design implemented here, although longitudinal in design, do not allow for certainty in making any clear causal inferences. They do give useful temporal information as it is unlikely that infant reactivity can affect antenatal depression. We were also able to statistically partial out the small degree of overlap between

temperament and sleep, in accordance with recommendations for moderator analysis, so addressing this potential difficulty.

Conclusion

In conclusion, this is the first study to provide empirical evidence that the association between antenatal depression and infant sleep is moderated by reactive temperament. The association between antenatal depression and disturbed sleep was more pronounced in boys with high levels of reactivity. Infant characteristics might increase an individual's susceptibility to environmental influences, such as antenatal depression, even during fetal life, raising the possibility of considering more targeted interventions for those at risk.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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Figure 1.

Linear relations between maternal reports of depression during pregnancy and a) Number of night awakenings at 18 months of age in the ALSPAC cohort and b) Sleep duration at 24 months of age in the Generation R cohort, for Dutch/Europeans participants, presented by gender, reactivity status (high vs low, median split).

Table 1
Overview of the ALSPAC and Generation R cohorts and description of key variables

Cohort name (country)	Design	Original cohort	Number included in analysis n and % of original cohort	Antenatal depression	Infant reactivity	Infant sleep data
ALSPAC (UK)	prospective longitudinal study	n=14,062	8,318 (59.1%)	Mothers completed the EPDS at 32 weeks and 2 months postnatally	Maternal reports at 6 months using the Infant Temperament Questionnaire. The following scales comprise the infant reactivity variables: intensity, threshold, approach and adaptability.	Maternal reports at 18 months Sleep Duration Night awakenings
Generation R (NL)	prospective longitudinal study	n=9,778 n=7,295 gave postnatal consent	2,241/7,295 (30.7%)	Mothers completed the Brief Symptom Inventory at 20 weeks and 2 months postnatally	Maternal reports at 6 months using the Infant Behaviour Questionnaire (IBQ). Infant reactivity consists of the following scales fear, recovery from distress and distress to limitations.	Maternal reports at 24 months Sleep Duration Night awakenings

Table 2
Demographic Characteristics of the Samples

	ALSPAC	Generation R
	n=8,318	n=2,241
Variables	% (n)	% (n)
Maternal characteristics		
Living Situation		
Married/Living with Partner	80.7%(6713)	91.8%(2057)
Without partner	19%(1580)	8.2%(84)
Educational Qualification		
Secondary	84.9%(7062)	65.3%(1464)
Degree	15.1%(1256)	34.7%(777)
Smoking during Pregnancy		
Yes	16%(1331)	21.4%(479)
Alcohol during Pregnancy		
Yes	29.3%(2437)	62.6%(1403)
Age of mother (yrs- mean)	28.87, SD=4.56 (15-44)	31.15, SD=4.44 (16.9-46.3)
Crowding (mean)	1.59, SD=.50	2.52, SD=.87
Ethnic Group		
White	98.6%(8202)	76.7%(1700)
Depression during pregnancy (mean)	6.66, SD=4.88	.16, SD=.37
Depression 2 months postnatal (mean)	5.79, SD=4.6	.19, SD=.41
Child characteristics		
Child Gender		
Male	51.7%(4300)	48.5%(1088)
Reactivity score (mean)	(standardized) mean=-.01, SD=1.0	(standardized) mean=-.18, SD=2.17
	Intensity: mean= 25.08, SD=5.58	Fear mean=.37, SD=.30
	Threshold: mean= 27.43, SD=6.	Distress to limitations
	Approach: mean= 14.98, SD=6.3	mean=.68, SD=.32
	Adaptability: mean= 13.89, SD=5.7	Recovery of distress (reflected)
		mean=1.5,SD=.29
Sleep duration at 18 / 24 months (hh:min - mean)	11:20, SD=01:00	11:03, SD=00:48
Night time awakenings at 18 / 24 months (mean)		
0	51.4%(4268)	41.7%(824)
1-2	41.9%(3476)	52.5%(1037)
>3	6.7%(566)	5.7%(113)

Table 3

Summary of Hierarchical Regression Analysis

Variables	Generation R			ALSPAC		
	Awakenings at 24 months	Sleep duration at 24 months	Awakenings at 18 months	Sleep at 18 months		
Step 1	β	p	β	p	β	p
Postnatal Depression	.003	.919	-.018	.475	.066	.000
Gender: Boy (-1)/Girl (1)	-.027	.231	.040	.068	-.022	.046
Ed. Qualification	-.070	.007	.032	.203	-.079	.000
Alcohol	-.024	.323	.089	.000	-.006	.606
Smoking	.000	.995	.015	.514	-.030	.009
Crowding	.009	.714	.018	.421	.034	.003
Marital Status	.055	.017	-.047	.039	-.017	.131
Maternal Age	.051	.039	-.073	.003	.048	.000
Step 2						
Antenatal Depression	.068	.010	-.089	.001	-.022	.522
Reactivity	-.011	.639	-.010	.659	-.032	.360
Step 3						
Depression $\times$ Gender	-.025	.298	.049	.028	.032	.356
Depression $\times$ Reactivity	.016	.476	.052	.018	.101	.003
Reactivity $\times$ Gender	-.007	.752	-.017	.431	.021	.540
Step 4						
Depression $\times$ Reactivity $\times$ Gender	-.033	.172	.085	.000	-.085	.013
	$R^2=.018$ F(14,1959)=2.5, p=.002 n=1,974	$R^2=.041$ F(14,1994)=6.08, p<.001 N=2,009	$R^2=.014$ F(14,8295)=9.546, p<.001 n=8,310	$R^2=.022$ F(14,8304)=10.77, p<.001 n=8,318	-.014	.688

Step 4 of interaction models for total sleep time at 24 months from Generation R and awakenings at 18 months from ALSPAC.