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Prenatal Maternal Stress and Child IQ

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The evidence for negative influences of maternal stress during pregnancy on child cognition remains inconclusive. This study tested the association between maternal prenatal stress and child intelligence in 4,251 mother–child dyads from a multiethnic population-based cohort in the Netherlands. A latent factor of prenatal stress was constructed, and child IQ was tested at age 6 years. In Dutch and Caribbean participants, prenatal stress was not associated with child IQ after adjustment for maternal IQ and socioeconomic status. In other ethnicities no association was found; only in the Moroccan/Turkish group a small negative association between prenatal stress and child IQ was observed. These results suggest that prenatal stress does not predict child IQ, except in children from less acculturated minority groups.

Fetal neurodevelopment represents a vulnerable period in which maternal exposure to stress is suggested to have a long-term impact on the development in offspring (Wadhwa, Sandman, & Garite, 2001). However, its impact on child cognitive outcomes remains unclear. One of the reasons

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for inconsistent study results may be that the concept of maternal stress during pregnancy is imprecisely and differently defined; most previous research encompassed only one dimension as the measure of stress, such as psychopathology or stress reactions to *specific* events, and key confounders such as maternal IQ were often not taken into account. In this study, we assessed maternal prenatal stress as a latent construct based on several manifestations of stress in different life domains. Our population-based prospective cohort study gave us the opportunity to examine the association between stress during pregnancy and child intelligence in the offspring of mothers with various ethnic backgrounds and lifestyle characteristics.

Maternal Stress During Pregnancy and Offspring Cognition

Barker and Osmond (1986) hypothesized that maternal undernutrition during pregnancy causes fetal changes with long-term consequences in the offspring. While this theory was initially developed in relation to maternal undernutrition, it was later broadened to include other in utero exposures. This comprehensive model, termed as the "Developmental Origins of Health and Disease" (DOHaD), proposes that the environment can have a long-lasting influence during the phase of developmental plasticity, and in interaction with genetic factors determine health and risk of disease in later life (Gluckman & Hanson, 2006; Wadhwa, Buss, Entringer, & Swanson, 2009). As part of the DOHaD model the effects of prenatal psychological stress on offspring developmental outcomes have also been evaluated, with the purpose of understanding the relation between maternal stress and fetal development as well as later psychobiological outcomes (Wadhwa et al., 2009).

Studies that assessed maternal stress during pregnancy in relation to offspring outcomes have used different definitions of stress. Stress is thought to occur when individuals perceive the environmental demands as exceeding their capacity of adaptation (Cohen, Kessler, & Gordon, 1995). This broad definition of stress has led to studies of a wide variety of stressors in pregnant women, such as interpersonal problems, financial difficulties, physical complaints, depression, or worries about their pregnancy (O'Donnell, O'Connor, & Glover, 2009). Also, while many scholars consider depression and stress to be different concepts, studies on the association of prenatal stress and child outcomes often include depression in the stress definition. For example, a systematic review of the association between maternal prenatal stress and young children's cognitive development operationalized maternal psychological distress as the occurrence of depression, anxiety, perceived stress or stressful experiences during pregnancy (Kingston, McDonald, Austin, & Tough, 2015). Very similar inclusion criteria were used by Kinsella and Monk (2009) in their narrative review of maternal stress studies, which summarized the associations of maternal depression, stress, and anxiety with neurobehavioral outcomes. Pregnancy-specific anxiety has also been included as part of the maternal prenatal stress concept in studies on the association with child mental development (DiPietro, Novak, Costigan, Atella, & Reusing, 2006). The variation in the definition and measures of maternal prenatal stress reflects that stress during pregnancy can manifest differently in different domains of life. In the following section, we briefly summarize studies focusing on specific stress measures. Studies are organized according to their measure of stress to facilitate a review of the literature.

Maternal Anxiety During Pregnancy

Studies of prenatal maternal anxiety and child cognition show inconsistent results. Brouwers, Van Baar, and Pop (2001) observed an association between prenatal anxiety, as measured with the State-Trait Inventory, and less optimal offspring mental development assessed with the Bayley scales of Infant Development in a group of 105 two-year-old Dutch children. Likewise, higher maternal prenatal anxiety was associated with lower IQ scores in a sample of 57 adolescents aged 14- to 15-year old (Van den Bergh et al., 2005) and with lower academic performance in 5,801 16-year-old adolescents in the ALSPAC cohort (Pearson et al., 2016). In contrast, Grant et al. found no difference between infants of mothers with prenatal anxiety and controls in their scores for the mental development index of the Bayley scales in a sample of 77 seven-month-old children (Grant, McMahon, Reilly, & Austin, 2010). Similarly, Koutra et al. found that maternal anxiety during pregnancy did not predict less optimal cognitive development in offspring using a sample of 223 eighteen-month-old children from a population-based cohort in Greece (Koutra et al., 2013). DiPietro et al. (2010) reported that higher levels of maternal prenatal stress were related to accelerated fetal and infant neurological maturation in a sample of 112 healthy pregnancies. Also higher levels of maternal prenatal anxiety were associated with *better* offspring mental development measured with the Bayley Scales of Infant Development in 82 two-year-old children who belonged to a well-nourished, financially stable population (DiPietro et al., 2006).

Maternal Depression During Pregnancy

Studies of prenatal maternal depression and child cognitive outcomes also showed discrepant results. Self-reported depressive symptoms were assessed in a sample of 6,979 pregnant mothers from the ALSPAC cohort and children of mothers with higher levels of depressive symptoms during pregnancy had slightly worse cognitive functioning as measured by the Wechsler Intelligence Scale for Children (Evans et al., 2012). In contrast, Tse, Rich-Edwards, Rifas-Shiman, Gillman, and Oken (2010) observed that children who were exposed to maternal depression during pregnancy did not perform differently, compared to nonexposed children, on the Peabody Picture Vocabulary Test at 3 years of age in a study of 1,030 mother–child pairs.

Other Measures of Prenatal Stress

A few studies assessed maternal perceived stress during pregnancy, that is, the degree to which life events were considered stressful. Perceived maternal prenatal stress was related to lower offspring intelligence as measured with the Stanford Binet Scale in 550 three-year-old children (Slykerman et al., 2005). Other studies related pregnancy-specific anxiety to child cognitive outcomes. Huizink et al. studied pregnancy-specific anxiety in a sample of 170 mothers, and found that higher self-reported pregnancy-specific anxiety predicted lower mental developmental scores as measured with the Bayley Scales of Infant Development in 8-month-old children (Huizink, de Medina, Mulder, Visser, & Buitelaar, 2003). Similar results were observed by Davis and Sandman (2010) who studied the presence of pregnancy-specific anxiety in a sample of 125 pregnant mothers and found an association with lower mental scores on the Bayley scales in 1-year-old children. Laplante et al. studied a group of 89 mothers, who were exposed during pregnancy to an ice storm in the Canadian province of Québec. They observed that maternal prenatal stress, retrospectively reported, was associated with lower children's IQ scores at age 5 years (Laplante, Brunet, Schmitz, Ciampi, & King, 2008).

A Broad Definition of Stress

The previous studies aimed to investigate how specific aspects of maternal stress are related to child cognitive development. However, stressful events rarely happen in isolation but rather tend to co-occur, increasing the risk for a deleterious offspring effect (Appleyard, Egeland, van Dulmen, & Sroufe, 2005). Moreover, psychological or perceived stress cannot be directly observed (Milfont & Fischer, 2010) and can only be assessed by self-reported indicators that represent related aspects of stress (e.g., daily hassles, severe life events; O'Donnell et al., 2009). The substantial conceptual and phenotypic overlap of these stress measures are arguments supporting a broad concept of perceived stress. Furthermore, no specific mechanistic pathways toward offspring cognition have been established for any of the different perceived stress measures. Therefore, to examine the broad concept of perceived prenatal maternal stress, we constructed a latent variable. The latent variable model captures the structure underlying the covariance among the observed variables (the self-reported stress measures; Bartholomew, Knott, & Moustaki, 2011), while simultaneously reducing the dimensionality. This approach has an additional advantage. Members of different groups (e.g., females and males, old and young age groups, ethnic groups) are often compared with the assumption that pertinent variables represent similar constructs across groups. This assumption, known as measurement invariance, is often not tested (Milfont & Fischer, 2010). However, when there is lack of measurement invariance (when the concept is not equivalent in all groups), the interpretation and comparison of the construct (prenatal maternal stress) across groups is not meaningful. Latent variable models can be specified without this assumption if the different groups are accounted for and give insight into the extent of variability of the construct between the groups.

We modeled a broad concept of stress to account for the high co-occurrence of stress factors. This broad stress definition, that encompasses different domains, allowed us to better examine the long-term effects of prenatal stress on child cognition than an individual stressor approach. We tested the measurement invariance of the stress concept in our multiethnic population-based sample. Due to lack of invariance across ethnicities, we performed our analyses in separate ethnic groups.

Methodological Considerations

The studies on maternal stress and child cognition are not only characterized by a diversity of exposure measures but also vary in the degree to which they account for methodological challenges inherent to studies of prenatal exposure and child cognition. First, some researchers assessed maternal prenatal stress retrospectively (Laplante et al., 2008). Studies with retrospective stress assessment yielded larger effect sizes, which could reflect a problem of recall bias (Tarabulsy et al., 2014). Second, the existing literature of maternal prenatal stress and offspring cognitive outcomes includes a broad array of outcome measures in infants, children and adolescents, hampering a direct comparison of results. A meta-analysis of studies that assessed child cognitive development between 0 and 60 months of age (typically with the Bayley Scales of Infant Development) reported a small negative effect of prenatal stress (Tarabulsy et al., 2014). The literature in children between 5 and 12 years is less extensive and also shows less consistent results. Most studies examined the effect of specific stress measures and while some found a negative effect of prenatal stress (assessed as depressive symptoms, anxiety, or stress), others reported no association with child IQ. In contrast, research in adolescents shows a consistently negative effect of prenatal stress on child cognition. However, this evidence should be interpreted with caution as it is based on few, small studies and different specific cognitive measures, whereas IQ was rarely examined. Third, some studies lack adjustment for key confounders like parental intelligence. Cognitive ability is one of the most heritable traits (Polderman et al., 2015) and shared genetic effects could underlie any observed association between maternal stress and child cognition. Yet, parental intelligence is often not controlled for when examining the association between prenatal stress and child IQ. Fourth, parental education as a measure of genetic transmission and environment quality (i.e., socioeconomic status [SES] and intellectual stimulation; Rowe, Jacobson, & Van den Oord, 1999) is strongly related to maternal stress and to child cognitive development. The lack of adjustment for parental education may make it difficult to distinguish between the specific effects of prenatal stress and contextual influences on child cognitive outcomes. Most studies adjusted for parental education level; in these studies results are mixed. In contrast, studies that did not account for parental education show a consistent negative association between prenatal stress and child cognition. Fifth, stressed pregnant women tend to be stressed mothers. Postnatal stress influences caregiving and this could inappropriately augment the association between prenatal stress and child IQ. Lastly, the studies on the association of prenatal stress and child cognitive development do not usually take into account vulnerable groups, such as ethnic minorities. Modern societies are characterized by large groups of ethnic minorities, which are more likely to have financial difficulties and are vulnerable to experience stress related to acculturation due to stigma, prejudice and discrimination. This particular kind of stress has been described as "minority stress" (Marshal et al., 2008; Meyer, 2003), and it is suggested that the social stressful environment experienced by these individuals generates a higher risk of mental health problems (Meyer, 2003). Also, although ethnicity and SES are often strongly intertwined, there are unique risks related to ethnic minority status that are not accounted for by SES, such as the social community networks, the degree of acculturation, and discrimination (Dyal & Dyal, 1981; Williams, 1996).

This study fills several gaps in the literature. We present evidence on the joint effect of different stress domains on the IQ of school-aged children. In our sample, stress was examined prospectively at different time points during pregnancy, child IQ was assessed with a nonverbal test when children were 5–7 years old, and we controlled our analyses for maternal education and IQ. Furthermore, we provide evidence on the role of ethnicity in the association between prenatal stress and offspring IQ.

Aim of This Study

The aim of this study was to examine the association between global maternal prenatal stress and offspring IQ at age 6 years. We hypothesized that maternal stress during pregnancy is related to offspring intelligence, even after accounting for key confounders like maternal intelligence. We tested this hypothesis using structural equation modeling, assessing global maternal prenatal stress with a latent construct and child cognition with a nonverbal IQ test. Data were collected within the prospective multiethnic cohort of the Generation R Study.

Method

Setting and Population

This research was conducted within the framework of the Generation R Study, a population-based cohort in Rotterdam, the Netherlands (Kooijman et al., 2016). This city has a larger proportion of ethnic minorities (44% of inhabitants are of foreign background) than the Netherlands (19%). The largest ethnic minority groups in Rotterdam are the Surinamese (9%), Turkish (7%), and Moroccan (6%; Statistics Netherlands, 2004). Mothers with a delivery date from April 2002 until January 2006 were enrolled to study determinants of early development and health. Among all eligible children, the response rate was 61%. The proportion of ethnic minority groups in our cohort was higher than nationally reflecting the urban setting of the study, but differed only marginally from that in Rotterdam. The largest minority groups were the Surinamese (9%), Turkish (9%), and Moroccan (6%; Jaddoe et al., 2006). The education level and household income were higher in the study cohort than in the study area, suggesting a slight selection toward higher SES (Jaddoe et al., 2008). However, the educational distribution in Generation R was similar to that in the Netherlands; in our sample 55.4% of mothers had a high level of education, this was 53.5% in the women in the Netherlands (reference year: 2002; Statistics Netherlands, 2004).

The study was approved by the Medical Ethics Committee of the Erasmus Medical Center, Rotterdam, and written informed consent was obtained from all adult participants.

In total, there were 8,976 children whose mothers were enrolled in the Generation R Study during pregnancy. Stress information was obtained by postal questionnaires at different time points during pregnancy. Most of the information on stress was collected when the mothers were 20–25 weeks pregnant. Mothers who did not reply to this questionnaire were excluded, as were those with information available on only one of the four stress indicators (see Statistical Analysis). This left 6,812 mothers with available information on prenatal stress exposure at baseline. As our study was conducted in a multiethnic sample we examined measurement invariance of the stress construct across ethnicities. Due to lack of measurement invariance (see Statistical Analysis), mothers without information on their national origin could not be included in our study ($n = 138$), as ethnicity-specific analyses could not be performed. In total, 6,674 participants had information available at baseline for stress exposure and ethnic origin. Nonverbal intelligence was assessed when children were 6 years old. Children who did not participate in this follow-up data collection wave ($n = 2{,}168$, 32.5% lost to follow-up) were excluded. Of the 4,506 participants with available information at follow-up, children who had no complete IQ score and were, thus, set to 50, were not included as this typically represents invalid IQ scores ($n = 14$). Children who had an IQ score ≤ 70 ($n = 92$) were included only in sensitivity analyses because these scores often indicate poor compliance during the IQ test. Children whose mothers were from Non-Western American countries ($n = 50$) or Asian other than Indonesian ($n = 99$) were not included as the sample size of these groups was smaller than the number of parameters in our models. This left 4,251 mother–child pairs for analyses (see Figure 1).

Sample Characteristics

Characteristics of the study sample are presented in Table 1 for the six main ethnic groups: Dutch ($n = 2{,}567$), Non-Dutch Western ($n = 380$), Caribbean ($n = 426$), Moroccan/Turkish ($n = 532$), African ($n = 197$), and Indonesian ($n = 149$; for more details see Covariates). The majority of the mothers were of Dutch origin (60.0%) and the mean ages at enrollment ranged from 27.9 to 32.7 years. Most of the Dutch mothers had college or higher education (67.0%), whereas in the Caribbean, Moroccan and Turkish, and African mothers this percentage was below 30%. The average maternal IQ was 100.9 ($SD = 12.6$) in the Dutch group, 101.6 ($SD = 13.5$) in the Indonesian, 98.5 ($SD = 13.9$) in the Non-Dutch Western, 90.2 ($SD = 14$) in the Caribbean, 86.0 ($SD = 14.4$) in the Moroccan/Turkish, and 85.4 ($SD = 15.3$) in the African group.

In our study 51.4% of the children were girls, and the average child nonverbal IQ score was 105.3 ($SD = 13.7$) in the Dutch children, 105.2 ($SD = 12.3$) in the Indonesian, 101.6 ($SD = 13.7$) in the Non-Dutch Western, 96.7 ($SD = 12.4$) in the Caribbean, 96.2 ($SD = 11.9$) in the Moroccan/Turkish, and 97.4 ($SD = 13.1$) in the African children (Table 1).

Measures

Prenatal Maternal Stress Exposure

To examine the association between a broadly operationalized prenatal stress measure and offspring IQ at age 6 years, we used a prenatal maternal stress exposure construct developed by Cecil et al. (2014) that has previously been implemented with good model fit using Generation R data (Rijlaarsdam et al., 2016). This stress construct is based on maternal reports during

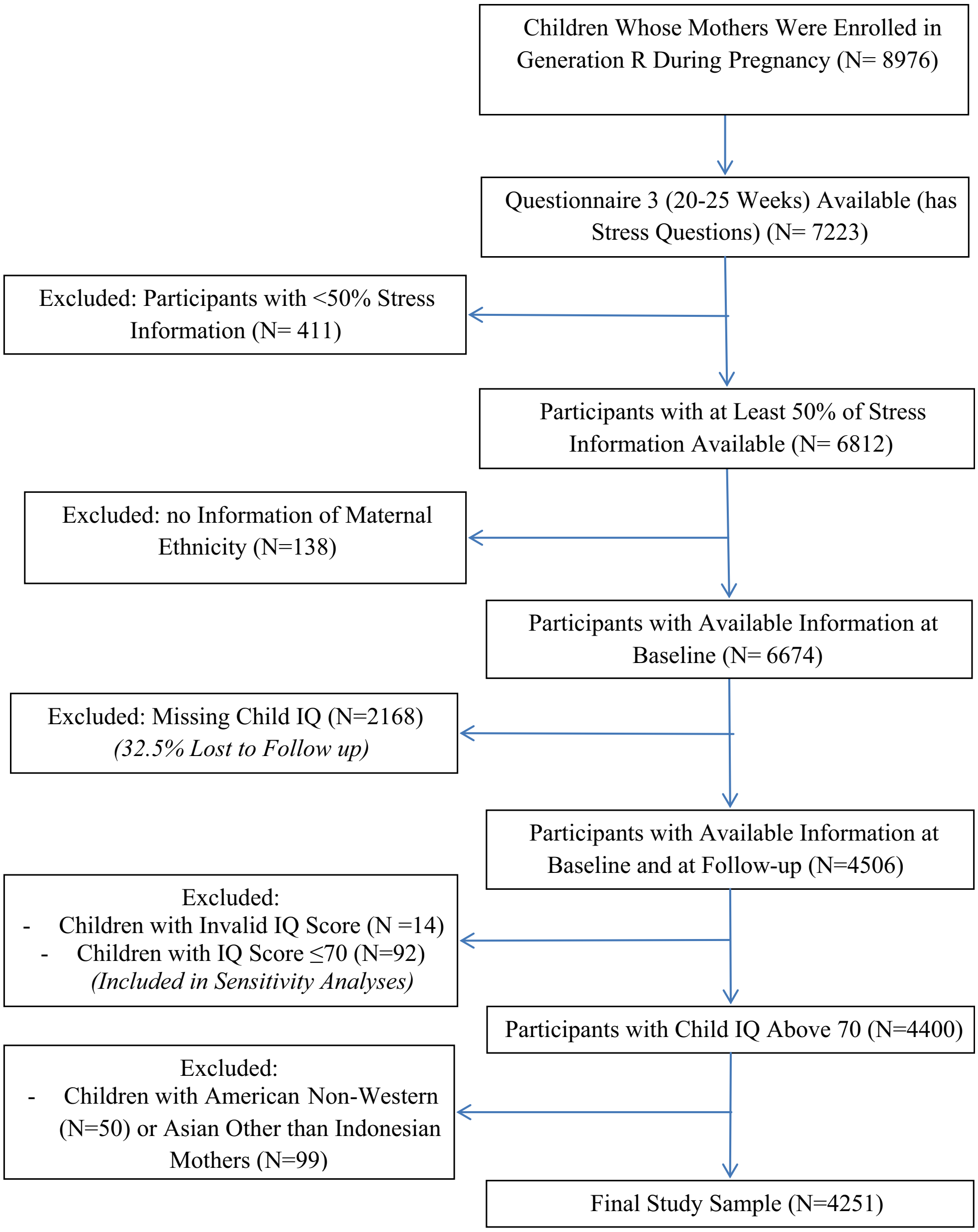

Figure 1. Flowchart of sample selection.

pregnancy in relation to four stress domains, accounting for different manifestations of stress: *life stress* (stressful life events such as illness, work-related problems, pregnancy-related anxiety), *contextual stress* (e.g., major financial difficulties, housing conditions), *personal stress* (e.g., psychiatric symptoms, criminal involvement), and *interpersonal stress* (e.g., family functioning, difficulties with others). For each stress domain, item scores were summed and divided by the number of completed items. Thus, higher scores represent greater stress exposure. For this study, we adapted the stress construct by excluding maternal education and substance use from the stress domain variables. Although related to stress experience, maternal education and substance use have been shown to affect offspring neurobehavioral development mostly by pathways independent of maternal prenatal stress (Hanscombe et al., 2012; Olds, Henderson, & Tatelbaum, 1994; Olney et al., 2002). All stress domains were positively correlated (all $p < .001$; Table 2; see Supporting Information for full item and instruments descriptions, Table S1).

Table 1
Parental and Child Characteristics

Characteristics	Dutch (n = 2,567) M (SD) or %	Non-Dutch Western (n = 380) M (SD) or %	Caribbean (n = 426) M (SD) or %	Moroccan/ Turkish (n = 532) M (SD) or %	African (n = 197) M (SD) or %	Indonesian (n = 149) M (SD) or %
Maternal						
Age, years	31.7 (4.2)	31.2 (4.5)	28.5 (5.8)	27.9 (5.1)	28.4 (5.8)	32.7 (4.9)
Education, %						
Primary	0.9	3.5	5.9	20.4	14.3	0.7
Secondary	32.1	31.9	65.1	58.4	63.8	28.2
Higher	67.0	64.6	29.0	21.2	21.9	71.1
Smoking in pregnancy, %	13.9	14.7	17.1	21.2	15.7	14.1
Alcohol frequently in pregnancy, %	12.5	11.9	2.0	0.0	4.8	13.1
Maternal IQ score	100.9 (12.6)	98.5 (13.9)	90.2 (14.0)	86.0 (14.4)	85.4 (15.3)	101.6 (13.5)
Family income, %						
< 1,200 €	4.6	8.7	38.7	43.8	56.0	9.1
1,200–2,000 €	13.8	22.2	22.3	37.8	22.2	8.8
>2,000 €	81.6	69.1	39.0	18.4	21.8	82.1
Paternal						
Education, %						
Primary	2.3	5.3	9.9	24.0	26.0	0.0
Secondary	32.1	37.6	66.1	50.2	51.7	28.0
Higher	65.6	57.1	24.0	25.8	22.3	72.0
Child						
Age, years	6.1 (0.4)	6.1 (0.4)	6.3 (0.7)	6.3 (0.6)	6.3 (0.6)	6.1 (0.5)
Child IQ score	105.3 (13.7)	101.6 (13.7)	96.7 (12.4)	96.2 (11.9)	97.4 (13.1)	105.2 (12.3)
Gender, % girls	51.4	55.5	50.0	49.2	51.8	51.7
Birthweight, grams	3,472.5 (565.7)	3,420.4 (565.8)	3,203.5 (558.5)	3,440.9 (502.0)	3,268.3 (563.0)	3,468.5 (594.1)

Note. The characteristics were measured in the imputed data set (n = 4,251).

Child Cognition

Child intelligence was measured in the research center by trained research assistants with a nonverbal IQ test when children were 5–7 years old. A nonverbal test was selected that minimized the potential bias related to the Dutch language abilities among children of Non-Dutch ethnicities. We administered two subtests of a validated Dutch nonverbal intelligence test: Snijders-Oomen Niet-verbale intelligentie test, 2.5-7- revisie (SON-R 2.5-7; Tellegen, Winkel, Wijnberg-Williams, & Laros, 2005). The subtests were "Mosaics," that evaluates spatial insight, and "Categories," that examines abstract reasoning abilities. The average alpha reliability of the total score of the SON-R 2.5-7 was of .90 (Tellegen et al., 2005) and the reliabilities for the subtest scores that we used were .73 and .71 for Mosaics and Categories, respectively. The correlation between scores derived from the two applied subsets and the scores form the complete test was .86 (P. J. Tellegen, personal communication, March 7, 2011). The raw scores were transformed into non-verbal IQ scores, using age-specific normal values based on the exact child age (Tellegen, Winkel, Wijnberg-Williams, & Laros, 1998).

The nonverbal IQ scores were normally distributed, ranging from 71 to 147 with a mean of 102.6 and a standard deviation of 13.8 in our study sample (Figure S1). During the assessment, research assistants rated the child's motivation, collaboration and understanding of instructions (Basten et al., 2014).

Covariates

The variables selected as covariates were maternal IQ score, maternal and paternal educational level, family income, maternal alcohol consumption, and smoking during pregnancy. We selected the confounders based on determinants of child cognitive development, the existing literature on the

Table 2
Correlations Between the Prenatal Stress Domains

		Correlation matrix			
	M (*SD*)	Life stress	Contextual stress	Personal stress	Interpersonal stress
Stress domains					
Life stress	1.85 (1.5)	—			
Contextual stress	1.06 (1.4)	.36	—		
Personal stress	0.13 (0.4)	.33	.37	—	
Interpersonal stress	1.90 (2.6)	.33	.42	.42	—

Note. Correlation significant at the .01 level (two-tailed). All $p < .001$. $n = 4{,}251$.

association between maternal prenatal stress and child intelligence (Eriksen et al., 2013; Henrichs et al., 2011; Tse et al., 2010), and by change-in-estimate criteria (cut-off of 5%). Maternal educational level, maternal alcohol consumption and smoking during pregnancy, family income, and paternal education level were assessed with questionnaires during pregnancy. Educational level was indicated by the highest completed education, and was classified in primary, secondary, and higher education. Smoking during pregnancy was collected at enrollment and during mid and late pregnancy and was categorized as nonsmoking during pregnancy, smoking until pregnancy was known and continued smoking throughout pregnancy. Family income, defined by the total net monthly income of the household, was classified as below social security level (< 1,200 €), low income (1,200–2,000 €), and modal to high income (more than 2,000 €). Maternal intelligence was measured at the same time when child IQ data were collected, when the mother accompanied the 6-year-old child to the research center, with the set I of the Raven's Advanced Progressive Matrices Test (Raven, 1962). This test has been shown to be a valid and reliable short form of the Raven's Progressive Matrices test to assess nonverbal cognition (Chiesi, Ciancaleoni, Galli, & Primi, 2012; Pearson, 2007) and the nonverbal aspect of the test minimizes the impact of the language abilities in the Non-Dutch mothers in our study.

Maternal Ethnicity

Information on maternal ethnicity was collected by questionnaires during pregnancy and was defined according to Statistics Netherlands (2004). The ethnic classification was based on the country of birth of the parents of the participant. If one of the parents was born abroad, the participant was considered to be of Non-Dutch ethnic origin. If both parents were born abroad, the country of birth of the participant's mother defined the participant's ethnic origin. Maternal ethnicity was initially categorized as Dutch, Non-Dutch Western, and Non-Western. The Non-Dutch Western mothers came from European, Oceanian, and Western American countries. The Non-Western group included four subgroups: Caribbean (Dutch Antillean and Surinamese), Moroccan/Turkish (Moroccan and Turkish), African (Cape Verdian and other African), and Indonesian mothers. In the ethnic minority groups, a questionnaire on self-reported Dutch language ability was administered during pregnancy. Dutch language ability was defined as a composite of three questions that referred to reading, writing, and speaking abilities. The sense of belonging to the Dutch culture was assessed during pregnancy based on the extent to which the participant agreed with the following statement: "I feel part of the Dutch culture." Following recent evidence that supports the predictive validity of single-items measures (Bowling, 2005), these items (i.e., language abilities and feeling part of the Dutch culture) were used as proxy measures for maternal acculturation. Higher scores indicated higher levels of acculturation. The distribution of these variables in the various ethnic groups is described in Table S2.

Statistical Analysis

Measurement Model

A reflective, standardized latent construct of maternal prenatal stress was estimated in R (Lavaan Package developmental version 0.6-1.1141 (Rosseel, 2012)) using the previously described four stress domains (life stress, contextual stress, personal stress, and interpersonal stress) as indicators. Internal reliability of the stress domains and of the latent construct of maternal prenatal stress was assessed with confirmatory factor analyses (see Rijlaarsdam et al., 2016). The latent construct showed good model fit as judged with the comparative fit index (CFI, acceptable fit ≥ .90, McDonald & Ho, 2002).

An important requirement for a meaningful interpretation of the analysis with a latent construct is the measurement invariance of the construct across relevant subgroups in the population (i.e., the meaning of the concept of stress is the same across members of relevant subgroups; Milfont & Fischer, 2010). We performed measurement invariance tests to examine whether the maternal stress construct was similar across child sex and maternal national origin subgroups as our cohort is a multiethnic sample. The invariance of the latent construct was evaluated with a series of hierarchically nested multigroup models in which constraints of the loadings, intercepts and variances of the latent variable were progressively implemented. To decide whether a more restricted model fitted as well as a less restricted model, we used the delta CFI cutoff of < .01 (Hirschfeld & von Brachel, 2014), which is robust for testing the between-group invariance of latent variable models (Cheung & Rensvold, 2002). Measurement invariance was tested across the groups of maternal ethnicity. We aimed to define broad ethnic groups in whom the stress construct was invariant. First, measurement invariance tests were performed across the three main maternal ethnic groups (i.e., Dutch, Non-Dutch Western, and Non-Western). Due to lack of invariance across these ethnic groups (i.e., lack of equivalent psychometric properties; see Results), we could not validly examine global prenatal stress in an unstratified sample. Therefore, the subsequent analyses were performed in more narrowly defined ethnic groups, organized by the national origins of the participants and socioeconomic characteristics shared by specific ethnic groups (Odé, 2002). The main analyses were performed in six ethnic subgroups: Dutch, Non-Dutch Western, Caribbean, Moroccan/Turkish, African, and Indonesian (see factor loadings for the measurement model of global prenatal maternal stress for the different ethnic groups in Table 3).

Structural Path Analysis

The construction of the measurement model and the analyses of the association between the latent construct of maternal prenatal stress and child cognition were simultaneously performed using structural equation modeling in R (Lavaan Package). Analyses (Path model: Figure 2) were conducted in the following ethnic subgroups: Dutch, Non-Dutch Western, Caribbean, Moroccan/Turkish, African, and Indonesian. The models were estimated with the robust maximum likelihood estimator (Huber-White standard errors) and the latent variable was scaled by standardization of the latent variable variance to 1. The path coefficients represent the change in the predicted child IQ score per standard deviation increase in maternal prenatal stress.

Confounders were initially selected based on existing literature and then by change-in-estimate criteria (cut-off of 5%; Mickey & Greenland, 1989), that is, evaluating the change in the estimate of the association between maternal stress and child intelligence when adding each confounder to the univariate regression. The confounders selected were maternal IQ, maternal education, paternal education, family income, maternal smoking during pregnancy, and alcohol consumption during pregnancy. Four

Table 3
Standardized Factor Loading Estimates (and Standard Errors) for the Global Prenatal Maternal Stress in the Measurement Model for the Different Ethnic Groups

	Factor loadings					
Indicators	Dutch *n* = 2,567 Estimate (*SE*)	Non-Dutch Western *n* = 380 Estimate (*SE*)	Caribbean *n* = 426 Estimate (*SE*)	Moroccan/ Turkish *n* = 532 Estimate (*SE*)	African *n* = 197 Estimate (*SE*)	Indonesian *n* = 149 Estimate (*SE*)
Life stress	.44 (0.03)	.54 (0.08)	.52 (0.07)	.57 (0.06)	.56 (0.08)	.67 (0.20)
Contextual stress	.55 (0.04)	.57 (0.07)	.61 (0.06)	.48 (0.05)	.79 (0.07)	.40 (0.15)
Personal stress	.48 (0.06)	.57 (0.12)	.59 (0.07)	.70 (0.05)	.60 (0.08)	.27 (0.18)
Interpersonal stress	.59 (0.04)	.62 (0.08)	.62 (0.07)	.56 (0.05)	.60 (0.08)	.49 (0.18)

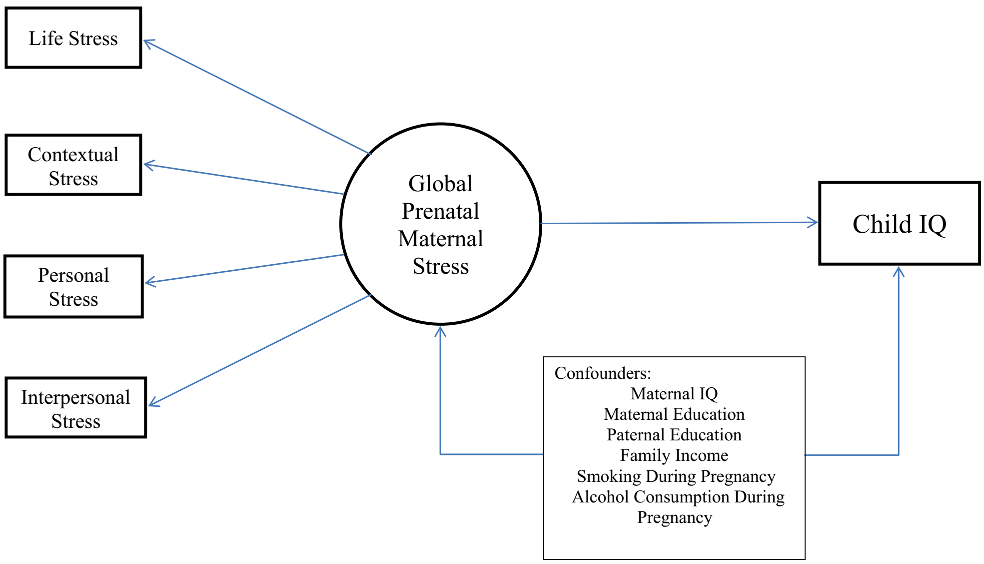

Figure 2. Path model of the structural equation model for the association between global prenatal maternal stress and child IQ scores.

models of the association between maternal stress during pregnancy and child intelligence were constructed with a progressive inclusion of covariates to show the impact of the adjustment for groups of key confounders. Adjustment for confounders was applied to the latent construct and to the prenatal stress—child IQ path. The goodness of fit of these progressively adjusted models was compared with the Bayesian information criterion (BIC) and Akaike's information criterion (AIC). A lower value for AIC and BIC indicates a better fit (Jouni, 2004).

Sensitivity Analyses

In additional analyses, we explored the association between the prenatal stress domains included in the latent construct and child IQ using multiple linear regression analyses. As in the overall model, the analyses were performed in each ethnic group and with similar adjustment for confounders. The regression estimates are presented for the standardized stress indicators.

We further examined the associations between the different prenatal stress measures and child IQ by linear regression analyses; every stress measure included in our stress latent construct was studied (for more information see Table S1). These analyses were performed in the complete unstratified sample and also separately for each ethnic group, controlling for maternal IQ, SES-related factors and substance use. We further adjusted the associations in the complete sample for ethnic groups in a second model. Analyses were not performed in a subgroup of stress variables with < 10 exposed participants.

As SES has been shown to moderate the amount of variance in IQ explained by the shared environment (Turkheimer, Haley, Waldron, D'Onofrio, & Gottesman, 2003), we explored the role of SES as a moderator in the association of prenatal stress and child IQ. To this aim, we calculated the principal component of the different SES measures (i.e., maternal and paternal education and household income). Following our main analyses, we ran an additional model adding the SES-principal component as predictor and its interaction with the stress latent construct. The stress latent construct and the interaction term were orthogonalized (i.e., their covariance was fixed to 0).

To better represent the variation of low IQ scores in the general population, we also tested if the association between prenatal stress and child IQ changed if children with IQ scores below 70 (n = 92), which are considered less valid (Mackenzie & Wonders, 2016), were included. We also used a more conservative approach in a subsequent sensitivity analysis and included only children (n = 3,702) who had good motivation, collaboration, and understanding of instructions during the IQ test.

Missing Data

The sample (n = 4,251) had complete information for child IQ scores, maternal ethnicity and for at least two of the four stress indicators. All missing value frequencies per variable were below 15% (maximum: contextual stress = 11.3%). Multiple imputation was performed for the missing values of the stress indicators and the confounders in the statistical software of R (MICE package version 2.46 (van Buuren & Groothuis-Oudshoorn, 2011)), using 40 imputations. The semTools package (semTools version 0.4-15.910 (Jorgensen et al., 2018)) was used to pool the estimates.

The acculturation variables were included in a post hoc analysis. These variables were only available for ethnic minorities. The maximum percentage of missing values was 21.2% for the variable "Feeling part of the Dutch culture" and 14.5% for Language abilities in the Moroccan/Turkish mothers.

Nonresponse Analysis

Differences in baseline characteristics between children included in our study sample and those who were not included were evaluated using chi-square tests for the categorical and independent t-tests for the continuous variables (See also the baseline characteristics of children lost to follow-up in Table S3). The nonresponse analyses showed that mothers of children who were not included were younger (mean maternal age = 28.7) and less educated (13.4% of these mothers had only primary education) than mothers of children in the study (M_{age} = 30.7, primary education = 4.6%). Also, excluded mothers were more likely to smoke throughout pregnancy (19.0%) than mothers of children in our study sample (15.3%).

Results

Measurement Model

Analyses of measurement invariance of the stress latent construct showed strict invariance when grouping participants by child sex (delta CFI < .01), but lack of invariance across the broad maternal ethnic groups (i.e., Dutch, Non-Dutch Western, and Non-Western; Table S4) and across the ethnic subgroups of the Non-Western mothers (Caribbean, Moroccan/Turkish, African, and Indonesian; n = 1,304; Table S5). However, there was strong measurement invariance within the Moroccan/Turkish, the Caribbean (Surinam and Dutch Antilles), and the African (African other than Moroccan, and Cape Verdean) subgroups (Tables S6–S8). As there was lack of invariance across the broad ethnic groupings but strong measurement invariance in more narrowly defined ethnic groups, the association of maternal prenatal stress and child IQ was evaluated in six ethnic groups separately: Dutch, Non-Dutch Western, Caribbean, Moroccan/Turkish, African, and Indonesian.

The measurement model and the structural equation model are depicted in Figure 2. The loadings of the latent stress construct on each stress indicator variable ranged from .27 (personal stress in the Indonesian mothers) to .79 (contextual stress in the African mothers) in the six ethnic groups (Table 3).

Maternal Prenatal Stress and Child IQ

Table 4 shows the association between the latent construct of maternal prenatal stress and child IQ in the six ethnic groups (Dutch, Non-Dutch Western, Caribbean, Moroccan/Turkish, African, and Indonesian). Results are shown with the stepwise confounder adjustment and presented as Model 1 (unadjusted model) to Model 4 (fully adjusted model; Table 4).

In the Dutch population, a one-standard-deviation increase in the levels of maternal stress was associated with 1.57 (SE = 0.36) points lower child IQ score in the initial analyses. After adjusting for maternal intelligence, the association was attenuated ($\beta = -1.13$ points, SE = 0.35) and finally disappeared in Model 3, after additional adjustment for the socioeconomic indicators, that is, maternal and paternal education and family income ($\beta = -.30$ points, SE = 0.38, p-value = .43). A similar stepwise reduction of the association of prenatal maternal stress and child intelligence was observed in the Caribbean group, in whom the association disappeared in the third model, after adjustment for SES ($\beta = -.61$ points, SE = 0.72, p-value = .40).

No association between maternal stress during pregnancy and child intelligence was observed in the unadjusted model in the Non-Dutch Western, the African, and the Indonesian groups. In contrast, a one-standard-deviation increase in the levels of prenatal stress in the Moroccan and Turkish mothers was related to 1.83 point lower child IQ in the initial model, and this association was only slightly attenuated after complete adjustment for potential confounders (Model 4: $\beta = -1.53$ points, SE = 0.63).

The goodness of fit of these progressively adjusted models was evaluated with the AIC and BIC for each ethnic group (Table S9). Both criteria indicated in general a better fit of the models with additional adjustment for SES-related factors and substance use (i.e., Models 3 and 4).

Table 4
Association of Global Maternal Prenatal Stress (Latent Variable) With Child IQ

		Child IQ							
		Model 1		Model 2		Model 3		Model 4	
Ethnic group	*n*	*b* (*SE*)	*p*	*b* (*SE*)	*p*	*b* (*SE*)	*p*	*b* (*SE*)	*p*
Dutch	2,567	−1.57 (0.36)	< .001	−1.13 (0.35)	.001	−.30 (0.38)	.431	−.19 (0.39)	.631
Non-Dutch Western	380	−.25 (1.01)	.805	.09 (0.97)	.929	.62 (1.01)	.539	.51 (1.01)	.613
Non-Western									
Caribbean	426	−1.58 (0.67)	.019	−1.45 (0.66)	.028	−.61 (0.72)	.398	−.43 (0.74)	.561
Moroccan/Turkish	532	−1.83 (0.65)	.005	−1.73 (0.63)	.006	−1.44 (0.64)	.024	−1.53 (0.63)	.015
African	197	.24 (1.07)	.820	.25 (1.08)	.820	.48 (1.14)	.674	.06 (1.22)	.960
Indonesian	149	−.22 (1.74)	.899	−.49 (2.01)	.809	−2.01 (1.83)	.271	−1.97 (3.54)	.577

Note. Models were constructed using structural equation modeling (Lavaan package). Values are regression coefficients, standard errors, and *p* values. The estimates are based on the standardized latent factor (global stress). A progressive adjustment was applied to the latent factor and to the structural path as listed below. All models converged in at least 38 data sets. In the Indonesian group, Model 2 and 4 had pooled negative variance for the indicator of contextual stress which probably reflects a relatively low sample size given the numbers of parameters. $n = 4{,}251$. Model 1. Without adjustment; Model 2. Model 1 + Maternal IQ; Model 3. Model 2 + Maternal education + Paternal education + Family income; Model 4. Model 3 + Maternal smoking during pregnancy + Maternal alcohol consumption during pregnancy.

We performed exploratory regression analyses between each of the maternal stress indicators and child IQ in the different ethnic groups. In the Dutch population, no association was found between any of the stress indicators (i.e., life stress, contextual stress, personal stress, and interpersonal stress) and child IQ after controlling for confounders (Table 5). Likewise, in the Moroccan/Turkish group, only suggestive associations between the maternal stress indicators and child IQ were observed after adjustment (Table 6). The stress domains were not related to child IQ in the other ethnicities, except for one of four domain measures in the Indonesians, in whom one-standard-deviation higher contextual stress in the mother was related to a 3-point lower offspring IQ ($SE = 1.36$, p-value = .02; Table S10).

In order to test if the association between maternal prenatal stress and child intelligence in the Moroccan/Turkish group was explained by minority stress, we performed a post hoc sensitivity analysis in this ethnic group. We adjusted the association of maternal prenatal stress and child IQ in Model 2 (i.e., model adjusted only for maternal IQ) for maternal acculturation variables (feeling part of the Dutch culture and language abilities). The association between maternal stress and child IQ in the Moroccan/Turkish participants remained essentially unchanged after this adjustment ($\beta = -1.73$ points, $SE = 0.63$, p-value = .01). Additionally, in separate linear regression models, we observed that acculturation was not associated with child IQ in the Moroccan/Turkish ethnic group. Better maternal language abilities were, however, related to less prenatal stress in the Moroccan/Turkish group. Also, this ethnic minority had the lowest level of self-reported acculturation in our sample (Table S2). The sensitivity analyses of the associations between the individual stress measures and child IQ are presented in Table S11. The analyses in the complete study sample demonstrate the independent contribution of ethnic origin to the association of prenatal stress and child IQ. After additional adjustment for ethnicity (Model 2), the associations between most stress variables and child IQ (already adjusted for maternal IQ, SES and substance use) were substantially reduced. Only family conflict and lack of satisfaction with obstetric care were related to lower child IQ after full adjustment for potential confounders. However, these results should be interpreted cautiously given the number of tests. We also explored the role of SES as a moderator in the association of the latent prenatal stress construct and child IQ; no significant interaction with SES on the association with IQ was observed (Table S12).

The analyses of the association between prenatal stress and IQ including children with an IQ below 70 are presented in Table S13. The associations did not change substantially, with one exception, in the Moroccan/Turkish group the association was attenuated in Model 3 and was only borderline significant. When we included only children who showed good compliance during the IQ test the associations after full adjustment for confounders were essentially unchanged if compared with the primary analysis. In this latter sensitivity analysis the

Table 5
Association Between Indicators of Maternal Prenatal Stress and Child IQ Score in the Dutch Group

	Child IQ							
	Model 1		Model 2		Model 3		Model 4	
	b (*SE*)	*p*	*b* (*SE*)	*p*	*b* (*SE*)	*p*	*b* (*SE*)	*p*
Stress variables								
Life stress	−.39 (0.32)	.22	−.19 (0.31)	.54	.09 (0.32)	0.79	.16 (0.33)	.61
Contextual stress	−1.10 (0.36)	.002	−.72 (0.34)	.03	.01 (0.39)	0.98	.10 (0.39)	.81
Personal stress	−1.19 (0.39)	.002	−.82 (0.39)	.04	−.30 (0.40)	0.46	−.19 (0.41)	.64
Interpersonal stress	−1.46 (0.36)	< .001	−1.19 (0.35)	.001	−.57 (0.37)	0.13	−.53 (0.37)	.15

Note. Models were constructed using multiple linear regression (SEM function, MLR estimator (maximum likelihood estimation with robust (Huber-White) standard errors)). Values are regression coefficients, standard errors, and *p* values. The stress variables were standardized. n = 2,567. Model 1. Without adjustment; Model 2. Model 1 + Maternal IQ; Model 3. Model 2 + Maternal education + Paternal education + Family income; Model 4. Model 3 + Maternal smoking during pregnancy + Maternal alcohol consumption during pregnancy.

Table 6
Association Between Indicators of Maternal Prenatal Stress and Child IQ Score in the Moroccan/Turkish Group

	Child IQ							
	Model 1		Model 2		Model 3		Model 4	
	b (*SE*)	*p*	*b* (*SE*)	*p*	*b* (*SE*)	*p*	*b* (*SE*)	*p*
Stress variables								
Life stress	−.86 (0.44)	.05	−.91 (0.43)	.04	−.77 (0.45)	.09	−.82 (0.44)	.06
Contextual stress	−.93 (0.46)	.04	−.97 (0.46)	.03	−.64 (0.49)	.19	−.65 (0.49)	.19
Personal stress	−.69 (0.42)	.10	−.67 (0.42)	.11	−.59 (0.44)	.18	−.62 (0.41)	.13
Interpersonal stress	−1.43 (0.51)	.01	−1.16 (0.51)	.02	−.92 (0.53)	.09	−.96 (0.51)	.06

Note. Models were constructed using multiple linear regression (SEM function, MLR estimator). Values are regression coefficients, standard errors and *p* values. The stress variables were standardized. All models converged in at least 25 imputed data sets. n = 532. Model 1. Without adjustment; Model 2. Model 1 + Maternal IQ; Model 3. Model 2 + Maternal education + Paternal education + Family income; Model 4. Model 3 + Maternal smoking during pregnancy + Maternal alcohol consumption during pregnancy.

association between stress and child IQ in the Moroccan/Turkish group remained after adjustment for confounders ($\beta = -1.64$ points, $SE = 0.79$, *p*-value = .038), indicating possible information bias in the sensitivity analysis that included children with very low IQ.

Discussion

In the ethnic Dutch group and in the Caribbean minority, no association between maternal self-reported prenatal stress and child IQ was observed after adjustment for maternal IQ and socioeconomic-related factors, contrary to our main hypothesis. No association was found, even before adjustment, between prenatal stress and child IQ in the Non-Dutch Western, the African and the Indonesian groups. Only in the Moroccan and Turkish mother–child dyads, maternal prenatal stress predicted a lower child IQ score after adjustment for confounders.

Most of the previous prenatal stress research focused on psychiatric problems such as depressive symptoms (Tse et al., 2010), anxiety (Van den Bergh et al., 2005) or in generally perceived stress (Slykerman et al., 2005), and the studies that assessed more than one manifestation of stress usually investigated the association with child cognition in separate models (e.g., DiPietro et al., 2006). In contrast, we assessed maternal prenatal stress with a latent construct based on different life domains, capturing more indices of maternal stress during pregnancy. As stressful events tend to co-occur, the simultaneous assessment of various indices of prenatal stress is more relevant to public health than the single stress measurements (Felitti et al., 1998). Additionally, the latent construct allowed us to systematically examine the shared variance of the different stress manifestations (Tinsley & Tinsley, 1987) and to test whether the stress experience was similar across different groups in society (Milfont & Fischer, 2010). Previous studies on the relation between maternal stress and offspring cognition in school-age children reported mixed findings. Some observed a negative effect of stress, whereas others did not find any association. These studies typically focused on specific stress measures, such as depressive symptoms, anxiety, or stressful events. We do not intend to reconcile this conflicting evidence with this study, but to extend the scientific knowledge with a complementary approach: testing the association between a broad, cumulative stress construct and cognitive functioning of school-age children.

The adjustment of the association between maternal prenatal stress and child IQ for family income, maternal and paternal education and maternal alcohol consumption and smoking during pregnancy could be seen by some scholars as overadjustment since these variables are life-style factors generally related to the concept of stress (Cohen, Doyle, & Baum, 2006; Hassanbeigi, Askari, Hassanbeigi, & Pourmovahed, 2013), thus the adjustment for these variables was performed in a late step and in separate models. These factors affect offspring mental development through multiple pathways other than maternal stress during pregnancy (Eriksen et al., 2013; Hanscombe et al., 2012; Olds et al., 1994; Olney et al., 2002). Parental education influences child IQ mainly by three pathways: first, education is highly correlated with IQ and thus the association of parental education and child IQ is strongly genetically determined. Second, parental education affects child cognitive development through parenting and upbringing. Third, low parental education can also be seen as a cause of stress, for example, financial stress during pregnancy. Importantly, financial stress and other education-related stress indicators were accounted for by the indicator of contextual stress. Likewise, the consumption of alcohol and tobacco during pregnancy can be seen as a marker of stress. However, pregnant women in the Netherlands are not consistently advised to be totally abstinent. Consequently, alcohol consumption in our and other study samples is associated with indicators of well-being (Kelly et al., 2012). The inclusion of these SES indicators and substance use in the stress construct would inappropriately broaden the stress definition, with implications for the etiological understanding and public health interventions.

In the offspring of the Dutch and Caribbean mothers, the association between maternal prenatal stress and child IQ was explained by maternal IQ and socioeconomic indicators (i.e., parental education and family income). Differences in the association between prenatal stress and child IQ across ethnic groups may represent a difference in the understanding of stress and the influence of the transactive nature of the genetic cognitive potential and the postnatal environment in the prediction of offspring cognition. In the Moroccan/Turkish group, mothers had, on average, a lower IQ score than the mean in our sample (average maternal IQ score = 97.1) and the percentage of mothers with only primary education was the highest among all ethnicities. In contrast, the lack of association between prenatal stress and child IQ, even in the unadjusted model, in the Non-Dutch Western, the African, and the Indonesian groups can best be explained by the lack of variance in child IQ accounted for by SES-related factors due to the homogeneity in social background.

Parental education level, as a proxy for "environmental quality" (i.e., financial resources and intellectual stimulation), is suggested to be a moderator for the heritability of IQ; typically, the IQ heritability is higher when the level of parental education is higher. Also, Rowe et al. (1999) demonstrated that the proportion of variance in IQ explained by the shared environmental effects, such as SES and family structure, is higher when the level of parental education was lower. Thus, in those ethnicities with high parental education the absence of an association between prenatal stress and IQ could be related to the low variance explained by the shared environment (such as a maternal stress). In contrast, the low education in the Moroccan and Turkish parents would imply that the IQ phenotype would be highly responsive to environmental variation. Additionally, the Moroccan and Turkish mothers may be sharing a sustained stressor, that would prolong maternal stress into the postnatal period and therefore influence cognitive development, through lower cognitive stimulation, parenting style, and the home environment (Guo & Harris, 2000; Jensen, Dumontheil, & Barker, 2014).

We examined the role of minority stress in the negative association between prenatal maternal stress and child IQ in the Moroccan and Turkish. More than 25% of the population of Rotterdam are immigrants, and most of them come from Surinam, Turkey, or Morocco (Entzinger & Engbersen, 2014). The native majority in the Netherlands corresponds to a relatively affluent and financially equal population with a good quality of life (Eurostat Statistical Book, 2015), whereas the ethnic minorities encounter high levels of stress related to the pressure of integration and acculturation (Smith, 1985; Statistics Netherlands 2005). The integration of ethnic minorities in the Netherlands remains particularly difficult for the immigrants coming from Morocco or Turkey (Statistics Netherlands 2005) as they display low levels of upward social mobility (Uitermark, 2003). We explored the influence of minority stress, as measured by the acculturation variables, on the association between maternal stress and child IQ. Among all ethnic minorities, the Moroccan and Turkish mothers had the lowest levels of self-reported acculturation. However, acculturation did not confound the association between maternal stress and child IQ in the Moroccan/Turkish sample. We cannot rule out that the low acculturation in the Moroccan and Turkish mothers, compared to other ethnicities, may indicate a vulnerability to stress, as postulated by Dyal and Dyal (1981). We were not able to test the interaction between maternal stress and acculturation as maternal prenatal stress was not invariant across ethnicities. Several other limitations must be also considered. First, the latent construct lacks direct measure and does not have inherent units (Ramlall, 2016). Therefore, the direct translation of our results to public health may be limited. However, it is difficult to imagine how a broad concept of stress could be directly measured. Second, it is possible that the latent, broad, stress construct approach obscures associations of specific stress measures, such as the association observed between the contextual stress domain and child IQ in the Indonesian ethnic group. However, an association found while examining various stress measures in different groups could be the result of multiple testing and thus reflect chance. Third, we observed a higher average IQ in the children compared to maternal IQ in all ethnicities. This may reflect the difference in the IQ measures used in children and mothers, and thus absolute IQ mother–child differences cannot be evaluated. Additionally, although a valid assessment of performance, maternal IQ is an imperfect measure of child genetic potential, as the offspring IQ is also determined by postnatal factors such as schooling (Brinch & Galloway, 2012) and by paternal IQ. In order to account for the child genetic potential we could only adjust our analyses for maternal and not for paternal IQ. Fourth, the mothers who did not respond were younger and less educated, characteristics that may suggest a higher risk of experiencing higher levels of stress. The absence of these participants in our study may affect the generalizability of our results. Fifth, we grouped participants in ethnic groups according to the presence of stress-related environmental factors, such as their socioeconomic background (Odé, 2002). Yet, genetic and cultural differences across and even within countries remain. However, the observed measurement invariance of the stress construct in our sample supported our grouping, suggesting that these ethnic groups share a similar understanding of the concept of stress (Milfont & Fischer, 2010). Sixth, the Indonesian group had a small sample size relative to the number of parameters in the model, limiting the precision of results in this group.

This study contributes to a better understanding of the association between maternal stress during pregnancy and child intelligence in the general population. We did not find support for the model predicting prenatal stress effects on later cognitive development in the majority of our study sample. We showed that any observed association was mostly explained by maternal IQ and SES indicators, except in the least acculturated ethnic minority. Most likely, postnatal factors, such as social disadvantage, sustained maternal stress, and ethnic-related stressors, may play a role in the offspring cognitive development of less acculturated minorities.

References

Appleyard, K., Egeland, B., van Dulmen, M. H. M., & Sroufe, L. A. (2005). When more is not better: The role of cumulative risk in child behavior outcomes. *Journal of Child Psychology and Psychiatry*, *46*, 235–245. https://doi.org/10.1111/j.1469-7610.2004.00351.x

Barker, D. J., & Osmond, C. (1986). Infant mortality, childhood nutrition, and ischaemic heart disease in England and Wales. *Lancet*, *1*, 1077–1081. https://doi.org/10.1016/S0140-6736(86)91340-1

Bartholomew, D. J., Knott, M., & Moustaki, I. (2011). *Latent variable models and factor analysis: A unified approach*. Chichester, UK: Wiley. https://doi.org/10.1002/9781119970583

Basten, M., van der Ende, J., Tiemeier, H., Althoff, R. R., Rijlaarsdam, J., Jaddoe, V. W. V., . . . White, T. (2014). Nonverbal intelligence in young children with dysregulation: The Generation R Study. *European Child & Adolescent Psychiatry*, *23*, 1061–1070. https://doi.org/10.1007/s00787-014-0551-x

Bowling, A. (2005). Just one question: If one question works, why ask several? *Journal of Epidemiology and Community Health*, *59*, 342–345. https://doi.org/10.1136/jech.2004.021204

Brinch, C. N., & Galloway, T. A. (2012). Schooling in adolescence raises IQ scores. *Proceedings of the National*

Academy of Sciences of the United States of America, *109*, 425–430. https://doi.org/10.1073/pnas.1106077109

Brouwers, E. P. M., Van Baar, A. L., & Pop, V. J. M. (2001). Maternal anxiety during pregnancy and subsequent infant development. *Infant Behavior & Development*, *24*, 95–106. https://doi.org/10.1016/S0163-6383(01)00062-5

Cecil, C. A. M., Lysenko, L. J., Jaffee, S. R., Pingault, J. B., Smith, R. G., Relton, C. L., . . . Barker, E. D. (2014). Environmental risk, oxytocin receptor gene (OXTR) methylation and youth callous-unemotional traits: A 13-year longitudinal study. *Molecular Psychiatry*, *19*, 1071–1077. https://doi.org/10.1038/mp.2014.95

Cheung, G. W., & Rensvold, R. B. (2002). Evaluating goodness-of-fit indexes for testing measurement invariance. *Structural Equation Modeling: A Multidisciplinary Journal*, *9*, 233–255. https://doi.org/10.1207/s15328007sem0902_5

Chiesi, F., Ciancaleoni, M., Galli, S., & Primi, C. (2012). Using the advanced progressive matrices (set I) to assess fluid ability in a short time frame: An item response theory-based analysis. *Psychological Assessment*, *24*, 892–900. https://doi.org/10.1037/a0027830

Cohen, S., Doyle, W. J., & Baum, A. (2006). Socioeconomic status is associated with stress hormones. *Psychosomatic Medicine*, *68*, 414–420. https://doi.org/10.1097/01.psy.0000221236.37158.b9

Cohen, S., Kessler, R. C., & Gordon, L. U. (1995). Strategies for measuring stress in studies of psychiatric and physical disorders. In S. Cohen, R. C. Kessler, & L. U. Gordon (Eds.), *Measuring stress: A guide for health and social scientists* (pp. 3–26). New York, NY: Oxford University Press.

Davis, E. P., & Sandman, C. A. (2010). The timing of prenatal exposure to maternal cortisol and psychosocial stress is associated with human infant cognitive development. *Child Development*, *81*, 131–148. https://doi.org/10.1111/j.1467-8624.2009.01385.x 20331658

DiPietro, J. A., Kivlighan, K. T., Costigan, K. A., Rubin, S. E., Shiffler, D. E., Henderson, J. L., & Pillion, J. P. (2010). Prenatal antecedents of newborn neurological maturation. *Child Development*, *81*, 115–130. https://doi.org/10.1111/j.1467-8624.2009.01384.x

DiPietro, J. A., Novak, M. F., Costigan, K. A., Atella, L. D., & Reusing, S. P. (2006). Maternal psychological distress during pregnancy in relation to child development at age two. *Child Development*, *77*, 573–587. https://doi.org/10.1111/j.1467-8624.2006.00891.x

Dyal, J. A., & Dyal, R. Y. (1981). Acculturation, stress and coping: Some implications for research and education. *International Journal of Intercultural Relations*, *5*, 301–328. https://doi.org/10.1016/0147-1767(81)90045-6

Entzinger, H., & Engbersen, G. (2014). *Rotterdam: A long time port of call and home to immigrants*. Washington, DC: Migration Policy Institute. Retrieved from: https://www.migrationpolicy.org/research/rotterdam-long-time-port-call-and-home-immigrants

Eriksen, H. L. F., Kesmodel, U. S., Underbjerg, M., Kilburn, T. R., Bertrand, J., & Mortensen, E. L. (2013). Predictors of Intelligence at the age of 5: Family, pregnancy and birth characteristics, postnatal influences, and postnatal growth. *PLoS ONE*, *8*, e79200. https://doi.org/10.1371/journal.pone.0079200

Eurostat Statistical Book. (2015). *Quality of life. Facts and views*. Retrieved from http://ec.europa.eu/eurostat/documents/3217494/6856423/KS-05-14-073-EN-N/

Evans, J., Melotti, R., Heron, J., Ramchandani, P., Wiles, N., Murray, L., & Stein, A. (2012). The timing of maternal depressive symptoms and child cognitive development: A longitudinal study. *Journal of Child Psychology and Psychiatry*, *53*, 632–640. https://doi.org/10.1111/j.1469-7610.2011.02513.x

Felitti, V. J., Anda, R. F., Nordenberg, D., Williamson, D. F., Spitz, A. M., Edwards, V., . . . Marks, J. S. (1998). Relationship of childhood abuse and household dysfunction to many of the leading causes of death in adults: The adverse childhood experiences (ACE) study. *American Journal of Preventive Medicine*, *14*, 245–258. https://doi.org/10.1016/S0749-3797(98)00017-8

Gluckman, P. D., & Hanson, M. A. (2006). The Developmental Origins of Health and Disease: An overview. In P. Gluckman & M. Hanson (Eds.), *Developmental Origins of Health and Disease* (pp. 1–5). Cambridge, UK: Cambridge University Press. https://doi.org/10.1017/CBO9780511544699

Grant, K. A., McMahon, C., Reilly, N., & Austin, M. P. (2010). Maternal sensitivity moderates the impact of prenatal anxiety disorder on infant mental development. *Early Human Development*, *86*, 551–556. https://doi.org/10.1016/j.earlhumdev.2010.07.004

Guo, G., & Harris, K. M. (2000). The mechanisms mediating the effects of poverty on children's intellectual development. *Demography*, *37*, 431–447. https://doi.org/10.1353/dem.2000.0005

Hanscombe, K. B., Trzaskowski, M., Haworth, C. M. A., Davis, O. S. P., Dale, P. S., & Plomin, R. (2012). Socioeconomic status (SES) and children's intelligence (IQ): In a UK-representative sample SES moderates the environmental, not genetic, effect on IQ. *PLoS ONE*, *7*, e30320. https://doi.org/10.1371/journal.pone.0030320

Hassanbeigi, A., Askari, J., Hassanbeigi, D., & Pourmovahed, Z. (2013). The relationship between stress and addiction. *Procedia-Social and Behavioral Sciences*, *84*, 1333–1340. https://doi.org/10.1016/j.sbspro.2013.06.752

Henrichs, J., Schenk, J. J., Kok, R., Ftitache, B., Schmidt, H. G., Hofman, A., . . . Tiemeier, H. (2011). Parental family stress during pregnancy and cognitive functioning in early childhood: The Generation R Study. *Early Childhood Research Quarterly*, *26*, 332–343. https://doi.org/10.1016/j.ecresq.2011.01.003

Hirschfeld, G., & von Brachel, R. (2014). Multiple-group confirmatory factor analysis in R-A tutorial in measurement invariance with continuous and ordinal

indicators. *Practical Assessment, Research & Evaluation*, *19*, 1–12.
Huizink, A. C., de Medina, P. G. R., Mulder, E. J. H., Visser, G. H. A., & Buitelaar, J. K. (2003). Stress during pregnancy is associated with developmental outcome in infancy. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *44*, 810–818. https://doi.org/10.1111/1469-7610.00166
Jaddoe, V. W. V., Mackenbach, J. P., Moll, H. A., Steegers, E. A. P., Tiemeier, H., Verhulst, F. C., . . . Hofman, A. (2006). The Generation R Study: Design and cohort profile. *European Journal of Epidemiology*, *21*, 475. https://doi.org/10.1007/s10654-006-9022-0
Jaddoe, V. W. V., van Duijn, C. M., van der Heijden, A. J., Mackenbach, J. P., Moll, H. A., Steegers, E. A. P., . . . Hofman, A. (2008). The Generation R Study: Design and cohort update until the age of 4 years. *European Journal of Epidemiology*, *23*, 801. https://doi.org/10.1007/s10654-008-9309-4
Jensen, S. K. G., Dumontheil, I., & Barker, E. D. (2014). Developmental inter-relations between early maternal depression, contextual risks and interpersonal stress, and their effect on later child cognitive functioning. *Depression and Anxiety*, *31*, 599–607. https://doi.org/10.1002/da.22147
Jorgensen, T. D., Pornprasertmanit, S., Schoemann, A. M., & Rosseel, Y. (2018). semTools: Useful tools for structural equation modeling. R package. Retrieved from https://CRAN.R-project.org/package=semTools
Jouni, K. (2004). AIC and BIC: Comparisons of assumptions and performance. *Sociological Methods & Research*, *33*, 188–229. https://doi.org/10.1177/0049124103262065
Kelly, Y. J., Sacker, A., Gray, R., Kelly, J., Wolke, D., Head, J., & Quigley, M. A. (2012). Light drinking during pregnancy: Still no increased risk for socioemotional difficulties or cognitive deficits at 5 years of age? *Journal of Epidemiology and Community Health*, *66*(1), 41–48. https://doi.org/10.1136/jech.2009.103002
Kingston, D., McDonald, S., Austin, M. P., & Tough, S. (2015). Association between prenatal and postnatal psychological distress and toddler cognitive development: A systematic review. *PLoS ONE*, *10*, e0126929. https://doi.org/10.1371/journal.pone.0126929
Kinsella, M. T., & Monk, C. (2009). Impact of maternal stress, depression and anxiety on fetal neurobehavioral development. *Clinical Obstetrics and Gynecology*, *52*, 425–440. https://doi.org/10.1097/GRF.0b013e3181b52df1
Kooijman, M. N., Kruithof, C. J., van Duijn, C. M., Duijts, L., Franco, O. H., van IJzendoorn, M. H., . . . Jaddoe, V. W. (2016). The Generation R Study: Design and cohort update 2017. *European Journal of Epidemiology*, *31*, 1243–1264. https://doi.org/10.1007/s10654-016-0224-9
Koutra, K., Chatzi, L., Bagkeris, M., Vassilaki, M., Bitsios, P., & Kogevinas, M. (2013). Antenatal and postnatal maternal mental health as determinants of infant neurodevelopment at 18 months of age in a mother–child cohort (Rhea study) in Crete, Greece. *Social Psychiatry and Psychiatric Epidemiology*, *48*, 1335–1345. https://doi.org/10.1007/s00127-012-0636-0
Laplante, D. P., Brunet, A., Schmitz, N., Ciampi, A., & King, S. (2008). Project ice storm: Prenatal maternal stress affects cognitive and linguistic functioning in 5½-year-old children. *Journal of the American Academy of Child and Adolescent Psychiatry*, *47*, 1063–1072. https://doi.org/10.1097/CHI.0b013e31817eec80
Mackenzie, G. B., & Wonders, E. (2016). Rethinking intelligence quotient exclusion criteria practices in the study of attention deficit hyperactivity disorder. *Frontiers in Psychology*, *7*, 794. https://doi.org/10.3389/fpsyg.2016.00794
Marshal, M. P., Friedman, M. S., Stall, R., King, K. M., Miles, J., Gold, M. A., . . . Morse, J. Q. (2008). Sexual orientation and adolescent substance use: A meta-analysis and methodological review. *Addiction*, *103*, 546–556. https://doi.org/10.1111/j.1360-0443.2008.02149.x
McDonald, R. P., & Ho, M.-H. R. (2002). Principles and practice in reporting structural equation analyses. *Psychological Methods*, *7*(1), 64. https://doi.org/10.1037/1082-989X.7.1.64
Meyer, I. H. (2003). Prejudice, social stress, and mental health in lesbian, gay, and bisexual populations: Conceptual issues and research evidence. *Psychological Bulletin*, *129*, 674–697. https://doi.org/10.1037/0033-2909.129.5.674
Mickey, R. M., & Greenland, S. (1989). The impact of confounder selection criteria on effect estimation. *American Journal of Epidemiology*, *129*, 125–137. https://doi.org/10.1093/oxfordjournals.aje.a115101
Milfont, T. L., & Fischer, R. (2010). Testing measurement invariance across groups: Applications in cross-cultural research. *International Journal of Psychological Research*, *3*, 111–121. https://doi.org/10.21500/20112084.857
Odé, A. W. M. (2002). *Ethnic-cultural and socio-economic integration in the Netherlands: A comparative study of Mediterranean and Caribbean minority groups*. Assen, The Netherlands: Van Gorcum.
O'Donnell, K., O'Connor, T. G., & Glover, V. (2009). Prenatal stress and neurodevelopment of the child: Focus on the HPA axis and role of the placenta. *Developmental Neuroscience*, *31*, 285–292.
Olds, D. L., Henderson, Jr., C. R., & Tatelbaum, R. (1994). Intellectual impairment in children of women who smoke cigarettes during pregnancy. *Pediatrics*, *93*, 221–227.
Olney, J. W., Wozniak, D. F., Farber, N. B., Jevtovic-Todorovic, V., Bittigau, P., & Ikonomidou, C. (2002). The enigma of fetal alcohol neurotoxicity. *Annals of Medicine*, *34*, 109–119. https://doi.org/10.1080/07853890252953509
Raven's Advanced Progressive Matrices [APM]. (2007). Pearson, Inc. Retrieved from: https://us.talentlens.com/wp-content/uploads/ravens_apm_reliability_validity.pdf

Pearson, R. M., Bornstein, M. H., Cordero, M., Scerif, G., Mahedy, L., Evans, J., . . . Stein, A. (2016). Maternal perinatal mental health and offspring academic achievement at age 16: The mediating role of childhood executive function. *Journal of Child Psychology and Psychiatry*, *57*, 491–501. https://doi.org/10.1111/jcpp.12483

Polderman, T. J. C., Benyamin, B., de Leeuw, C. A., Sullivan, P. F., van Bochoven, A., Visscher, P. M., & Posthuma, D. (2015). Meta-analysis of the heritability of human traits based on fifty years of twin studies. *Nature Genetics*, *47*, 702. https://doi.org/10.1038/ng.3285

Ramlall, I. (2016). *Applied structural equation modelling for researchers and practitioners: Using R and stata for behavioral research*. Bingley, UK: Emerald. https://doi.org/10.1108/9781786358820

Raven, J. C. (1962). *Advanced progressive matrices: Sets I and II*. London, UK: H.K. Lewis.

Rijlaarsdam, J., Pappa, I., Walton, E., Bakermans-Kranenburg, M. J., Mileva-Seitz, V. R., Rippe, R. C. A., . . . van IJzendoorn, M. H. (2016). An epigenome-wide association meta-analysis of prenatal maternal stress in neonates: A model approach for replication. *Epigenetics*, *11*, 140–149. https://doi.org/10.1080/15592294.2016.1145329

Rosseel, Y. (2012). lavaan: An R Package for Structural Equation Modeling. *Journal of Statistical Software*, *48*(2), 1–36. https://doi.org/10.18637/jss.v048.i02

Rowe, D. C., Jacobson, K. C., & Van den Oord, E. J. C. G. (1999). Genetic and environmental influences on vocabulary IQ: Parental education level as moderator. *Child Development*, *70*, 1151–1162. https://doi.org/10.1111/1467-8624.00084

Slykerman, R. F., Thompson, J. M. D., Pryor, J. E., Becroft, D. M. O., Robinson, E., Clark, P. M., . . . Mitchell, E. A. (2005). Maternal stress, social support and preschool children's intelligence. *Early Human Development*, *81*, 815–821. https://doi.org/10.1016/j.earlhumdev.2005.05.005

Smith, E. M. J. (1985). Ethnic-minorities—life stress, social support, and mental-health issues. *Counseling Psychologist*, *13*, 537–579. https://doi.org/10.1177/0011000085134002

Statistics Netherlands. (2004). *Statistical Yearbook of the Netherlands 2004*. Retrieved from https://www.cbs.nl/nr/rdonlyres/3c60b3e9-09e0-491f-87f2-99b8e54936a1/0/2004a3pub.pdf

Statistics Netherlands. (2005). *Summary of the annual report on integration 2005*. Retrieved from http://www.scp.nl/dsresource?objectid=eef5aa50-d249-4f63-9f69-0a768f345582

Tarabulsy, G. M., Pearson, J., Vaillancourt-Morel, M. P., Bussieres, E. L., Madigan, S., Lemelin, J. P., . . . Royer, F. (2014). Meta-analytic findings of the relation between maternal prenatal stress and anxiety and child cognitive outcome. *Journal of Developmental and Behavioral Pediatrics*, *35*(1), 38–43. https://doi.org/10.1097/DBP.0000000000000003

Tellegen, P. J., Winkel, M., Wijnberg-Williams, B. J., & Laros, J. A. (1998). *Snijders-Oomen nonverbal intelligence test. SON-R 2½–7 manual and research report*. Lisse, The Netherlands: Swets & Zeitlinger B.V.

Tellegen, P., Winkel, M., Wijnberg-Williams, B., & Laros, J. A. (2005). *Snijders-Oomen niet-verbale intelligentietest: SON-R 2½–7*. Amsterdam, The Netherlands: Boom Test Uitgevers.

Tinsley, H. E. A., & Tinsley, D. J. (1987). Uses of factor-analysis in counseling psychology research. *Journal of Counseling Psychology*, *34*, 414–424.

Tse, A. C., Rich-Edwards, J. W., Rifas-Shiman, S. L., Gillman, M. W., & Oken, E. (2010). Association of maternal prenatal depressive symptoms with child cognition at age 3 years. *Paediatric and Perinatal Epidemiology*, *24*, 232–240.

Turkheimer, E., Haley, A., Waldron, M., D'Onofrio, B., & Gottesman, I. I. (2003). Socioeconomic status modifies heritability of IQ in young children. *Psychological Science*, *14*, 623–628. https://doi.org/10.1046/j.0956-7976.2003.psci_1475.x

Uitermark, J. (2003). "Social mixing" and the management of disadvantaged neighbourhoods: The Dutch policy of urban restructuring revisited. *Urban Studies*, *40*, 531–549.

van Buuren, S., & Groothuis-Oudshoorn, K. (2011). mice: Multivariate Imputation by Chained Equations in R. *Journal of Statistical Software*, *45*(3), 1–67. https://doi.org/10.18637/jss.v045.i03

Van den Bergh, B. R. H., Mennes, M., Oosterlaan, J., Stevens, V., Stiers, P., Marcoen, A., & Lagae, L. (2005). High antenatal maternal anxiety is related to impulsivity during performance on cognitive tasks in 14-and 15-year-olds. *Neuroscience and Biobehavioral Reviews*, *29*, 259–269. https://doi.org/10.1016/j.neubiorev.2004.10.010

Wadhwa, P. D., Buss, C., Entringer, S., & Swanson, J. M. (2009). Developmental Origins of Health and Disease: Brief history of the approach and current focus on epigenetic mechanisms. *Seminars in Reproductive Medicine*, *27*, 358–368. https://doi.org/10.1055/s-0029-1237424

Wadhwa, P. D., Sandman, C. A., & Garite, T. J. (2001). The neurobiology of stress in human pregnancy: Implications for prematurity and development of the fetal central nervous system. *Progress in Brain Research*, *133*, 131–142.

Williams, D. R. (1996). Race/ethnicity and socioeconomic status: Measurement and methodological issues. *International Journal of Health Services*, *26*, 483–505. https://doi.org/10.2190/u9qt-7b7y-hq15-jt14

Supporting Information

Additional supporting information may be found in the online version of this article at the publisher's website:

Figure S1. Distribution of Child IQ scores (including all IQ scores)

Table S1. Stress Domains and Instruments Used

Table S2. Descriptive Information of Acculturation Among Ethnic Groups

Table S3. Nonresponse Analysis

Table S4. Measurement Invariance Across Groups of Maternal Ethnicity (Dutch, Non-Dutch Western, Non-Western)

Table S5. Measurement Invariance Across Subgroups of Maternal Non-Western Ethnicity (Caribbean, Moroccan/Turkish, African, Indonesian)

Table S6. Measurement Invariance Across Moroccan and Turkish Groups

Table S7. Measurement Invariance Across the Subgroups Within the Caribbean Ethnic Group (Dutch Antilles, Surinam)

Table S8. Measurement Invariance Across the Subgroups Within the African Ethnic Group (Cape Verde, Other African)

Table S9. Fit Indices of Models for the Association of Global Maternal Prenatal Stress (Latent Variable) and Child IQ

Table S10. Association Between the Stress Domains and Child IQ in Each Ethnic Group (Analyses in the Dutch and Moroccan/Turkish Groups are in Tables 5 and 6)

Table S11. Association of Maternal Prenatal Stress Measures and Child IQ

Table S12. Moderation Effect of Socioeconomic Status on the Association of Prenatal Stress and Child IQ

Table S13. Association of Global Maternal Prenatal Stress (Latent Variable) With Child IQ Including Child IQ Scores Below 70