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Positive maternal mental health during pregnancy associated with specific forms of adaptive development in early childhood: Evidence from a longitudinal study

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Abstract

The quality of prenatal maternal mental health, from psychological stress and depressive symptoms to anxiety and other nonpsychotic mental disorders, profoundly affects fetal neurodevelopment. Despite the evidence for the influence of positive mental well-being on health, there is, to our knowledge, no research examining the possible effects of positive antenatal mental health on the development of the offspring. Using exploratory bifactor analysis, this prospective study ($n = 1{,}066$) demonstrated the feasibility of using common psychiatric screening tools to examine the effect of positive maternal mental health. Antenatal mental health was assessed during 26th week of pregnancy. The effects on offspring were assessed when the child was 12, 18, and 24 months old. Results showed that positive antenatal mental health was uniquely associated with the offspring's cognitive, language and parentally rated competences. This study shows that the effects of positive maternal mental health are likely to be specific and distinct from the sheer absence of symptoms of depression or anxiety.

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The quality of prenatal maternal mental health, from psychological stress (e.g., Beydoun & Saftlas, 2008; Charil, Laplante, Vaillancourt, & King, 2010; Graignic-Philippe, Dayan, Chokron, Jacquet, & Tordjman, 2014) and depressive symptoms (e.g., Field, 2011; Gentile, 2017; Mulder et al., 2002; Waters, Hay, Simmonds, & van Goozen, 2014), to anxiety (e.g., Van den Bergh, Mulder, Mennes, & Glover, 2005) and other nonpsychotic mental disorders (Howard et al., 2014), profoundly affects fetal neurodevelopment. Such effects are apparent in terms of neural structure and organization (Buss et al., 2012; Qiu, Tuan, Li, et al., 2015; Qiu, Tuan, Ong, et al., 2015; Rifkin-Graboi et al., 2015), cognitive and emotional function, as well as the subsequent risk for psychopathology (Baibazarova et al., 2013; Goodman et al., 2011; Graignic-Philippe et al., 2014; O'Donnell & Meaney, 2017; Pluess et al., 2011). The effects of maternal conditions can even be transmitted to the third generation (e.g., Babenko, Kovalchuk, & Metz, 2015; Bowers & Yehuda, 2016; Gröger et al., 2016). The effects of prenatal maternal mental health persist even after controlling for postnatal maternal status (Glover, 2014; Huizink, Mulder, & Buitelaar, 2004; Pearson et al., 2013). In the case of depression, the effects of prenatal maternal states appear to be statistically more strongly associated with the later risk of depression in the offspring than are those of postnatal maternal depressive symptoms (Pearson et al., 2013). A "prenatal cross-fostering"

study in humans where pregnant mothers were related or unrelated to their child as a result of in vitro fertilization, which served to distinguish maternally inherited effects from those directly associated with the maternal phenotype, showed that maternal stress and emotional well-being were directly associated with socioemotional function in the child (Rice et al., 2010).

While about 12%–15% of pregnant women screen positively for depression (e.g., Bennett, Einarson, Taddio, Koren, & Einarson, 2004; Gavin et al., 2005; Karmaliani et al., 2009; Le Strat, Dubertret, & Le Foll, 2011), there is substantial variation in the psychological well-being among the remaining mothers (Keyes, 2002). Neuroimaging studies, including those performed with neonates, show that the influence of symptoms of anxiety and depression cuts across the entire population and are not unique the offspring of mothers with confirmed clinical disorders (Buss et al., 2012; Qiu, Tuan, Li, et al., 2015; Qiu, Tuan, Ong, et al., 2015; Rifkin-Graboi et al., 2015). The same finding emerges from studies of a wide range of neurodevelopmental outcomes. Despite the compelling evidence for the broad influence of maternal emotional well-being, the existing literature focuses almost exclusively on the effects of stress or symptoms of depression or anxiety, and does therefore not capture the full range of mental well-being. The potential effect of positive antenatal mental health on neurodevelopment in the offspring will allow us to examine the broader spectrum of mental health and consider promoting health rather than merely preventing mental disorders.

Positive Mental Health

Health is a continuum that includes a sense of well-being and is not merely defined by the absence of illness or disability (World Health Organization, 2004). Positive and negative mental health, though correlated, are distinct constructs (Huppert & Whittington, 2003). Effective interventions may reduce depressive symptoms, but do little to increase mental well-being (Newnham, Hooke, & Page, 2010), again suggesting the independence of both constructs (de Cates, Stranges, Blake, & Weich, 2015). Furthermore, positive mental health and mental illness symptoms have different antecedents including various demographics and socioemotional variables (Hu, Stewart-Brown, Twigg, & Weich, 2007).

While positive antenatal mental health has been largely neglected, existing studies show that a higher level of mental well-being serves as a protective factor against future mental disorders (Keyes, Dhingra, & Simoes, 2010; Lamers, Westerhof, Glas, & Bohlmeijer, 2015). This protective factor is apparent in children; while paternal depression strongly predicted depressive symptoms, this effect was not seen in children with positive mental health traits (Tam et al., 2017). Positive mental health in young adulthood can even predict a range of health outcomes (Aspinwall & Tedeschi, 2010; Howell, Kern, & Lyubomirsky, 2007) as well as mortality in late adulthood (Danner, Snowdon, & Friesen, 2001). Despite the evidence for the influence of positive mental well-being on health, there is, to our knowledge, no research examining the possible effects of positive antenatal mental health on the development of the offspring.

Bifactor Model of Maternal Mental Health Symptoms

While large-scale birth-cohort studies emphasize the importance of maternal mental health problems, measures of positive mental health in the study design are rarely considered. The most commonly used measures of maternal mental health focus on symptoms of depression (e.g., Edinburgh Postnatal Depression Scale [EPDS] and Center for Epidemiologic Studies Depression Scale) or anxiety (e.g., State-Trait Anxiety Inventory [STAI] and anxiety subscale of Crown Crisp Experiential Index). While such measures are used to screen for symptoms of mental disorders, it may nevertheless be possible to detect aspects of positive mental health. For example, though the General Health Questionnaire is a psychiatric disorder screening tool, Hu et al. (2007) used factor analyses to show that the positively worded items can be indicators of positive mental health and not merely absence of symptoms of mental disorders. The STAI has likewise been used to reflect positive mental health or well-being as well (Hernández-Martínez, Val, Murphy, Busquets, & Sans, 2011; Kvaal, Laake, & Engedal, 2001). Thus psychiatric disorders screening tools appear to contain items that reflect positive mental health.

Bifactor modeling is increasingly used to factor analyze the multidimensional nature of mental health. The premise of bifactor modeling is that there is an overarching general mental health or psychopathology dimension or factor that reflects responses to the mental health measures regardless of the nature of disorder (e.g., Caspi et al., 2014; Simms, Grös, Watson, & O'Hara, 2008). There is therefore considerable value to the inclusion of multiple measures of mental health within a single bifactor latent model. There is heterogeneity in antenatal mental health, even if only focused on antenatal depression (Castro et al., 2016; Santos, Tan, & Salomon, 2017). Mental health instruments are often checklists of symptoms that are commonly associated with specific disorders. However, even within measures of depression, there is substantial breadth to the features that are examined (Fried, 2017), which provide a more comprehensive analysis of maternal mental health. In this paper, we report the results of bifactor analysis using data from a longitudinal birth cohort with multiple, commonly used measures of the symptoms of anxiety or depression in women at midgestation. The results yielded coherent measures of antenatal positive mental health that predicted developmental outcomes in the children, especially those focusing on social behaviors and communication.

Method

Participants

This study was part of a prospective birth cohort study, Growing Up in Singapore Towards Healthy Outcomes (GUSTO;

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see Soh et al., 2012). The GUSTO sample (n = 1,066) included women who conceived naturally (i.e., not through in vitro fertilization), did not have any medical conditions before or during pregnancy, and gave birth to single full-term babies (i.e., non-twins) with normal birth weight (i.e., >2500 g). After delivery, the participants and their children were invited to the study clinic when the child was 12, 18, and 24 months old. At the clinic, the child was administered a battery of neurocognitive and behavioral tasks. The mothers were also given measures about their child's behavior.

Scales

Maternal mental health. Three maternal mental health measures were administered during the 26th week of pregnancy during the participants' regular clinic visit. The responses to the individual items of the measures were used in the bifactor models.

The Beck Depression Inventory—Second Edition (BDI-II; Beck, Steer, & Brown, 1996) is an inventory of 21 clusters of items describing common depressive symptoms. Each cluster contains four to seven statements describing varying severity of a common depressive symptom (e.g., feeling worthless). Participants selected the statement that best described how they felt for the past 2 weeks. The EPDS (Cox, Holden, & Sagovsky, 1987) has 10 items of depressive symptoms, and participants indicated how much each item described how they were feeling for past 7 days on a 4-point Likert scale. The STAI (Spielberger, Gorsuch, & Lushene, 1970) consisted of 40 items that are associated with anxiety (or lack of). For the first 20 items, participants responded to how much each item described how they felt right now on a 4-point Likert scale; for the next 20 items, they responded to how much the item described how they generally felt.

Child measures. When the child was 12 months old, mothers rated their child's socioemotional behavior on the Infant Toddler Socio-Emotional Assessment questionnaire (Briggs-Gowan & Carter, 1998). Twenty-one behaviors on four domains (internalizing, externalizing, dysregulation, and competence behaviors) were assessed (see Table 1 for the list of behaviors).

At 18 months of age, mothers rated their child's behavior on the 25-item Quantitative Checklist for Autism in Toddlers (QChat; Allison et al., 2008). Other than a total score, there were two subscores corresponding to the behavioral and social factors of autism traits.

At 24 months of age, the Bayley Scales of Infant and Toddler Development, Third Edition (Bayley, 2006), was used to assess the child's development in the domains of cognition, language, motor skills, socioemotional behaviors, and adaptability. The cognitive, language (i.e., receptive and expressive communication), and motor skills (i.e., fine and gross motor) components were assessed via standardized laboratory tasks. The socioemotional and adaptability (i.e., communication behavior, community use, functional pre-academic, home living, health and safety knowledge, leisure activities, self-care, self-direction skills, social skills, and motor skills) were rated by their caregiver.

Statistical analyses

Bifactor models. An exploratory bifactor model was fitted with the individual items of the mental health scales as manifest variables. Number of factors was determined with parallel analysis. In parallel analysis, eigenvalues from randomly generated correlation matrices were computed. A factor will be retained if the eigenvalue from the observed data is larger than the corresponding eigenvalue from parallel analysis (Hayton, Allen, & Scarpello, 2004). The exploratory bifactor model was estimated with Bi-Geomin rotation, which allowed the subfactors to correlate with each other. Parallel analysis was done with 1,000 randomly generated matrices. The best fitting exploratory bifactor model was then used to estimate a confirmatory bifactor model in order to compute the factor scores for subsequent analyses. Model fit indices were also used to evaluate the fit of the exploratory model.

Low factor loadings (i.e., <0.30) were set to 0 in the confirmatory model. The subfactors were allowed to correlate with each other but not with the general factor. All models were estimated using Mplus 7.4 (Muthén & Muthén, 1998–2012) with maximum likelihood robust estimation.

Correlations. The factor scores derived from the confirmatory bifactor model were used in the correlation analyses with the child's behavioral outcome measures. Heatmap was plotted to illustrate the patterns of significant correlations between the latent factor scores and outcome measures.

Results

Bifactor model

Eigenvalues derived from the parallel analysis were used to determine the number of factors. The eigenvalues and fit indices of all the exploratory bifactor models are summarized in Table 2. The eigenvalues of seven factors were higher than the randomly generated eigenvalues. Furthermore, the difference in Bayesian information criteria coefficients of the seven-factor versus eight-factor models was merely 72.75 (0.06%), suggesting little improvement in fit by increasing the number of factors to eight. The comparative fit index, root mean square error of approximate information, and standardized root mean square residual of the seven-factor model also showed an acceptable fit of data to the model. The general factor explained 62.6% of the common variance extracted and 37.4% were explained by the subfactors, which corroborated with the results that maternal mental health during pregnancy was multidimensional (Reise, 2012).

The factor loadings of items on the seven-factor model are summarized in Table 3. Factor loadings of >0.30 suggested the item loaded significantly on factor (Hair, Black, Babin,

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Table 1. *Contents of all items used in the bifactor exploratory analysis*

Questionnaire	Item	Content
EPDS	EPDS1	In the past 7 days, I have been able to laugh and see the funny side of things.
	EPDS2	In the past 7 days, I have looked forward with enjoyment to things.
	EPDS3	In the past 7 days, I have blamed myself unnecessarily when things went wrong.
	EPDS4	In the past 7 days, I have been anxious or worried for no good reason.
	EPDS5	In the past 7 days, I have felt scared or panicky for no very good reason.
	EPDS6	In the past 7 days, things have been getting on top of me.
	EPDS7	In the past 7 days, I have been so unhappy that I have had difficulty sleeping.
	EPDS8	In the past 7 days, I have felt sad or miserable.
	EPDS9	In the past 7 days, I have been so unhappy that I have been crying.
	EPDS10	In the past 7 days, the thought of harming myself has occurred to me.
BDI	BDI1	Sadness
	BDI2	Pessimism
	BDI3	Past failure
	BDI4	Loss of pleasure
	BDI5	Guilty feelings
	BDI6	Punishment feelings
	BDI7	Self-dislike
	BDI8	Self-criticalness
	BDI9	Suicidal thoughts or wishes
	BDI10	Crying
	BDI11	Agitation
	BDI12	Loss of interest
	BDI13	Indecisiveness
	BDI14	Worthlessness
	BDI15	Loss of energy
	BDI16	Changes in sleeping pattern
	BDI17	Irritability
	BDI18	Changes in appetite
	BDI19	Concentration difficulty
	BDI20	Tiredness or fatigue
	BDI21	Loss of interest in sex
STAI	STAI1	I feel calm (at this moment).
	STAI2	I feel secure (at this moment).
	STAI3	I am tense (at this moment).
	STAI4	I feel strained (at this moment).
	STAI5	I feel at ease (at this moment).
	STAI6	I feel upset (at this moment).
	STAI7	I am presently worrying over possible misfortunes (at this moment).
	STAI8	I feel satisfied (at this moment).
	STAI9	I feel frightened (at this moment).
	STAI10	I feel comfortable (at this moment).
	STAI11	I feel self-confident (at this moment).
	STAI12	I feel nervous (at this moment).
	STAI13	I am jittery (at this moment).
	STAI14	I feel indecisive (at this moment).
	STAI15	I am relaxed (at this moment).
	STAI16	I feel content (at this moment).
	STAI17	I am worried (at this moment).
	STAI18	I feel confused (at this moment).
	STAI19	I feel steady (at this moment).
	STAI20	I feel pleasant (at this moment).
	STAI21	I feel pleasant (generally).
	STAI22	I feel nervous and restless (generally).
	STAI23	I feel satisfied with myself (generally).
	STAI24	I wish I could be as happy as others seem to be (generally).
	STAI25	I feel like a failure (generally).
	STAI26	I feel rested (generally).
	STAI27	I am calm, cool, and collected (generally).
	STAI28	I feel that difficulties are piling up so that I cannot overcome them (generally).
	STAI29	I worry too much over something that really doesn't matter (generally).
	STAI30	I am happy (generally).
	STAI31	I have disturbing thoughts (generally).

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Table 1 (*cont.*)

Questionnaire	Item	Content
	STAI32	I lack self-confidence (generally).
	STAI33	I feel secure (generally).
	STAI34	I make decisions easily (generally).
	STAI35	I feel inadequate (generally).
	STAI36	I am content (generally).
	STAI37	Some unimportant thought runs through my mind and bothers me (generally)
	STAI38	I take disappointments so keenly that I can't put them out of my mind (generally).
	STAI39	I am a steady person (generally).
	STAI40	I get in a state of tension or turmoil as I think over my recent concerns and interests (generally).

Note: EPDS, Edinburgh Postnatal Depression Scale; Beck Depression Inventory—II; STAI, State-Trait Anxiety Inventory.

Anderson, & Tatham, 2009). The items that loaded on Factors 3 and 7 are of interest to the current study and will be discussed in greater details here. Items that loaded on Factor 3 pertained to the STAI items about feeling positive (e.g., feeling pleasant, self-confident, content, and satisfied). This factor was thus labeled as positive mood. Items that loaded on Factor 7 were fewer and pertained to how participants felt or perceived themselves in general (e.g., feeling happy or perceived self as a person who makes decision easily). Factor 7 was labeled as positive self. Two items crossed-loaded on these two factors. Factors 3 and 7 also had the highest correlation ($r = .24$) as compared to other pairs of factors ($rs \leq |.15|$).

The seven-factor bifactor model was estimated using confirmatory bifactor modeling to obtain the factor scores. The fit indices showed acceptable fit of the confirmatory factor analysis model to data (root mean square error of approximation = 0.042, comparative fit index = 0.824, standardized root mean square residual = 0.057). Table 4 summarized the items for each factor and the corresponding factor loadings from the confirmatory model.

Reliability indices for the general and subfactors were also computed (see Table 5) with the Excel-based Bifactor Indices Calculator (Dueber, 2016), as previously suggested (Rodriguez, Reise, & Haviland, 2016). Factor determinacy (FD) is the correlation between factor scores and the factors and estimates the reliability the estimated factor score. A high FD coefficient (i.e., ≥ 0.80) suggests high reliability of factor score (Gorsuch, 1983). Both the factor scores of positive mood (FD = 0.938) and positive self (FD = 0.89) passed the threshold and were thus used for subsequent analyses. However, according to the ω_H coefficient, which reflect the unique variance associated with subfactor score once partitioning out general factor's variance, positive mood ($\omega_H = 0.512$) was more reliable than positive self ($\omega_H = 0.427$). The seemingly low ω_H coefficients were not surprising as all the items in these two subfactors loaded on the general factor as well (Rodriguez et al., 2016), which also accounted for the higher ω_H coefficient that does not control for variance accounted for by general factor. Construct reliability (i.e., *H* index) reflects how well the items represent the latent factor that they load on. With a criterion of 0.70 (Hancock & Mueller, 2001), positive mood ($H = 0.867$) was well represented by the corresponding sets of items, with positive self ($H = 0.653$) slightly below the threshold. As such, results pertaining to the positive self factor score should be interpreted with some caution Nevertheless, these findings suggest that the positive mental health construct can be reliably extracted from screening tools for depression and anxiety.

Correlations

The factor scores estimated from the confirmatory model were used in subsequent correlation analyses with the child behavioral outcomes. As this was an exploratory study, Bonferroni correction was not implemented to avoid inflation of Type II errors. While spurious results may occur without correction, what is of interest is not any particular significant finding, but the pattern of responses, which is less likely to be due to chance (Moran, 2003).

The Pearson correlation coefficients and the corresponding *p* values are summarized in Table 6. A heatmap (Figure 1) was plotted to better illustrate the pattern of significant correlations of positive mood and positive self on child behavioral outcomes. Positive mood and/or self were positively associated with the cognitive, language (i.e., receptive and expressive languages), social–emotional, and motor components of the Bayley scales. There were negative association with the total score and social component of the QChat; there was no significant association of positive mood or self on the behavioral component. The positive factors were positively associated with most of the competence subscales of the ITSEA. There was also a positive association with peer aggression. In general, positive maternal mood during pregnancy was associated with the behaviors in children that are associated with sociability, communication, and parentally rated competence.

Discussion

We used a bifactor modeling approach to demonstrate the feasibility of using common screening instruments for mental disorders to examine positive maternal mental health. An exploratory analysis revealed associations between our measures of antenatal positive maternal mental health and specific

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Table 2. *Bifactor model fit statistics*

Model	Eigenvalue	Eigenvalue From Parallel Analysis	Model *df*	χ^2	AIC	BIC	Adjusted BIC	RMSEA	RMSEA *p*	CFI	SRMR
					Exploratory Models						
1 factor[a]	19.12	1.55	2345	14781.11	135065.95	136110.00	135443.00	0.071	<.001	0.609	0.077
2 factor	4.64	1.51	2276	10025.40	130448.24	131835.34	130949.18	0.057	<.001	0.757	0.052
3 factor	3.00	1.48	2208	8165.56	128724.40	130449.57	129347.43	0.050	.329	0.813	0.041
4 factor	2.11	1.46	2141	7279.17	127972.01	130030.28	128715.34	0.047	1.00	0.839	0.036
5 factor	1.81	1.43	2075	6434.20	127259.04	129645.44	128120.87	0.044	1.00	0.863	0.032
6 factor	1.61	1.40	2010	5703.83	126658.67	129368.22	127637.21	0.042	1.00	0.884	0.029
7 factor	1.43	1.39	1946	5134.65	126217.49	129245.23	127310.94	0.039	1.00	0.900	0.027
8 factor	1.33	1.36	1883	4622.68	125831.52	129172.48	127038.09	0.037	1.00	0.914	0.025
					Confirmatory Model						
7 factor	—	—	2359	6809.58	131018.16	132350.57	131499.354	0.042	1.00	0.824	0.057

Note: AIC, Akaike information criteria; BIC, Bayesian information criteria; RMSEA, root mean square error of approximation; CFI, comparative fit index; SRMR, standardized root mean square residual.
[a]This is a unidimensional model, not a bifactor model that requires at least two factors (1 general & 1 specific).

domains of child development. These associations were strongest in measures of social behavior and communication, which were apparent on both maternal-report measures as well as those that employ an independent observer (i.e., Bayley scales). These findings suggest that data from past or existing birth-cohort studies can be examined for potential effects of positive maternal mental health, even in the absence of scales directly intended to examine this construct.

Most of the items on the three mental health questionnaires loaded strongly on the general factor, suggesting an underlying general psychopathology factor that affected the responses of all the items regardless of questionnaires. This could also reflect the comorbidity often found between depression and anxiety measures. Existing research has interpreted this general factor as either general propensity to develop psychopathology symptoms (Caspi et al., 2014) or general level of distress (Simms et al., 2008). Items about punishment feelings, self-criticalness, and loss of interest in sex did not load highly on the general factor.

The subfactors did not contain items from multiple measures. This finding suggests that mental health measures are checklists of different psychopathology symptoms with little overlap. While this may not be surprising, as the STAI and BDI-II are measures of anxiety and depression, respectively, there was also no overlap between the two depression measures (BDI-II and the Edinburgh Postnatal Depression Scale). Inclusion of multiple mental health measures does have added value as they may provide a more comprehensive capture of individuals' mental health. This thought is also in line with the understanding that mental health, even within a single mental disorder such as depression, is highly heterogeneous across the population (e.g., Chekroud et al., 2017; Fried, Nesse, Zivin, Guille, & Sen, 2014; Santos et al., 2017).

The positively worded items in the battery loaded negatively on the general factor, suggesting that positive mental health could be a protective factor against psychopathology symptoms. Moreover, these items loaded on two subfactors that were interpreted as positive mood and positive self, the latter containing fewer items and is more similar to self-esteem. These two factors are correlated with expected cross-loading of items. The parsing of positively worded items as distinct factors suggests that it is possible to study positive mental health using commonly used psychiatric screening measures. This finding implies that existing birth cohorts or epidemiological studies with standard screens for maternal psychopathology could be exploited for more comprehensive study of mental health in the general population with the existing data used to reveal variations in positive mental health across community samples.

The presence of two separate, but correlated, factors also suggests that positive mental health can be examined from different perspectives. This finding is consistent with existing theoretical conceptualization of psychological well-being that goes beyond merely positive feelings. Psychological well-being has been operationalized into six dimensions: purpose in life, personal growth, environmental mastery, autonomy, self-

Table 3. *Factor loadings and correlations from seven-factor exploratory bifactor model*

Item	G Factor	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7
BDI1	**.548**	.177	.043	.004	−.215	.064	.005
BDI2	**.418**	.258	−.004	−.051	−.104	−.010	.003
BDI3	**.474**	**.334**	.068	−.016	.027	−.068	−.025
BDI4	**.494**	.159	−.04	.183	−.092	.059	−.039
BDI5	**.499**	.290	.062	.023	−.045	−.050	.040
BDI6	**.363**	.293	.07	−.102	−.012	−.008	.031
BDI7	**.431**	**.389**	−.027	.092	.023	−.084	.069
BDI8	**.481**	**.328**	.037	−.033	−.03	−.080	.009
BDI9	**.336**	**.425**	−.026	.046	−.023	−.024	.017
BDI10	**.52**	.115	.08	.047	−.223	−.003	−.031
BDI11	**.484**	.144	.043	.240	−.043	.036	−.042
BDI12	**.469**	.177	−.003	.275	−.015	.039	−.055
BDI13	**.502**	.230	.052	.191	.066	−.017	−.097
BDI14	**.51**	**.446**	.002	.057	.031	−.045	.039
BDI15	**.359**	−.123	.031	**.591**	−.024	.013	−.028
BDI16	.274	−.005	−.008	**.366**	−.02	−.035	.083
BDI17	**.473**	.075	.02	**.352**	.002	−.050	.011
BDI18	.139	.040	0	**.334**	−.065	−.020	−.001
BDI19	**.478**	.057	−.007	**.385**	.07	−.047	−.023
BDI20	**.329**	−.028	−.01	**.551**	.026	−.016	.083
BDI21	.154	.043	−.054	.262	−.012	0	.049
EPDS1	**−.343**	−.232	.098	−.138	.226	−.085	.028
EPDS2	**−.384**	−.169	.136	−.146	.172	−.029	.079
EPDS3	**.500**	−.085	−.008	−.197	−.024	−.171	.004
EPDS4	**.565**	−.300	.102	.023	−.057	−.164	−.019
EPDS5	**.565**	−.191	.048	−.041	−.093	−.082	.058
EPDS6	**.520**	−.176	.005	.075	−.107	−.147	.069
EPDS7	**.567**	−.035	−.042	−.025	−.298	−.015	.135
EPDS8	**.678**	−.06	.034	−.047	**−.372**	−.040	.015
EPDS9	**.587**	−.024	.042	−.098	**−.360**	−.071	.034
EPDS10	**.472**	.181	.019	−.146	−.203	−.058	.059
STAI1	**−.454**	.009	**.518**	−.011	.06	−.081	−.044
STAI2	**−.460**	−.057	**.588**	.042	−.032	−.026	−.030
STAI3	**.443**	−.054	−.114	.034	−.054	**.397**	.150
STAI4	**.384**	−.107	−.058	.047	−.158	**.432**	.100
STAI5	**−.425**	.027	**.594**	.035	−.055	.002	−.210
STAI6	**.555**	.058	−.059	−.055	−.061	**.364**	.017
STAI7	**.494**	−.023	.040	.014	.082	**.322**	−.015
STAI8	**−.430**	.002	**.560**	.023	−.048	.001	−.007
STAI9	**.477**	.048	.052	−.075	.021	**.378**	−.043
STAI10	**−.427**	.022	**.560**	−.034	.032	−.030	.059
STAI11	**−.442**	.019	**.582**	−.061	−.124	.048	.054
STAI12	**.517**	−.02	.075	.034	.046	**.423**	.018
STAI13	**.485**	−.024	.004	−.049	.205	**.360**	.035
STAI14	**.448**	−.01	.004	−.001	.251	.235	.009
STAI15	**−.498**	.006	**.615**	−.072	−.053	−.020	−.029
STAI16	**−.435**	−.019	**.600**	.036	.105	.052	−.088
STAI17	**.567**	−.036	.07	−.015	.037	**.395**	−.144
STAI18	**.554**	.067	.057	−.027	.035	**.412**	−.078
STAI19	**−.476**	−.06	**.604**	−.008	.023	.031	.016
STAI20	**−.479**	−.055	**.643**	−.023	.003	.001	.011
STAI21	**−.535**	−.021	**.410**	.018	.122	−.053	**.333**
STAI22	**.605**	−.089	.004	.056	.162	.156	.069
STAI23	**−.533**	−.025	**.390**	−.019	−.061	.018	**.354**
STAI24	.290	.082	.020	−.085	.012	.055	.181
STAI25	**.536**	.206	−.026	−.188	.25	.016	−.031
STAI26	**−.380**	.105	**.301**	−.071	−.007	.008	.142
STAI27	**−.566**	.046	**.364**	−.005	−.073	.067	.273
STAI28	**.594**	.028	−.022	−.019	.256	−.001	.099
STAI29	**.603**	−.195	.110	−.021	.063	−.008	−.067
STAI30	**−.531**	.046	.280	.002	.197	−.022	**.364**
STAI31	**.648**	−.024	.047	−.052	.194	.104	.029

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Table 3 (*cont.*)

Item	G Factor	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7
STAI32	**.536**	.082	.051	−.035	.196	.003	−.085
STAI33	**−.505**	.011	**.425**	.110	.003	−.020	.245
STAI34	**−.536**	.042	.215	−.023	−.156	.141	**.311**
STAI35	**.478**	−.018	−.012	−.111	.297	.037	.048
STAI36	**−.513**	.011	**.421**	.099	.125	.008	.123
STAI37	**.584**	−.148	.082	.079	.052	.056	.056
STAI38	**.607**	−.068	.081	.092	.04	.093	.019
STAI39	**−.549**	−.026	**.306**	.005	.028	.041	**.360**
STAI40	**.580**	−.076	−.037	−.058	.238	.073	.173
Factor correlations							
Factor 2	.00	1					
Factor 3	.00	−.02	1				
Factor 4	.00	.11*	−.03	1			
Factor 5	.00	−.09*	.04	−.07*	1		
Factor 6	.00	−.12*	.03	−.03	.15*	1	
Factor 7	.00	−.06	.22	−.07*	−.02	.10	1

Note: Bold indicates factor loading > |.30|. G Factor, general factor; BDI, Beck Depression Inventory—II; EPDS, Edinburgh Postnatal Depression Scale; STAI, State-Trait Anxiety Inventory.
*$p < .05$.

acceptance, and relations with others (Ryff, 1989). While positive mood is not one of the six traditionally defined dimensions of well-being, it may be a consequence of fulfillment in one or more of the six aspects. Factor analyses of other common psychiatric screening tools have also found a factor of positive affect that comprises the positively worded items (Hernández-Martínez et al., 2011; Hu et al., 2007; Iwata et al., 1998; Shafer, 2006). Deeper research into positive mental health will require a distinction of the different aspects of psychological well-being. However, this does not negate the value of using positive mood, particularly in epidemiological studies that have practical limitations on the measures that can be included.

Effect of positive mental health

Positive antenatal mental health revealed specific associations with child outcomes. Specifically, positive antenatal mental health was significantly associated with cognitive, language/communication, social, and competence development. The receptive and expressive language and cognitive abilities were assessed through objective laboratory tasks, which minimize the possibility that parents who were more positive might have rated their child's cognitive and language more positively. In addition, the parent-rated language component of the QChat had no associations with antenatal maternal mental health. Taken together with the associations with the competence measures, positive antenatal mental health may affect the positive spectrum of a child's development instead of socioemotional vulnerabilities more commonly associated with measures of maternal depression and anxiety. The specificity of the effect of positive mental health is underscored by the finding that most of these same measures were not associated with either the subfactors that reflected a poorer quality of maternal mental health or, in certain instances, even the general factor, despite the liberal p value threshold used in this exploratory analysis. Positive maternal mental health may thus have very specific influences on child development.

The pattern of correlations with language, sociability, and competences aligns with what is known about children's positive affect, language ability, and social traits. Infant positive affect or joyful expressions predict receptive and expressive language abilities in toddlerhood (Dixon & Smith, 2000; Laake & Bridgett, 2014; Moreno & Robinson, 2005). Moreover, a behavioral genetics analysis showed some heritability for sociability and positive affect (Eid, Riemann, Angleitner, & Borkenau, 2003), thus supporting the link between positive affect and sociability.

The effects of positive antenatal mental health on child's language and social abilities may have other long-term indirect benefits. Children who are more sociable may be more accepted by peers, which protects against psychopathological and antisocial behaviors (Parker & Asher, 1987; Szekely et al., 2016). Being more accepted by peers may also contribute to less peer victimization or bullying, which has been found to have serious psychological effects (e.g., Gini & Espelage, 2014; Kawabata, Tseng, & Crick, 2014; Schwartz, Lansford, Dodge, Pettit, & Bates, 2015). These detrimental effects can even last into adulthood as the victimized child enters adolescent and adulthood (McDougall & Vaillancourt, 2015). Taken together with our results, promoting positive antenatal mental health may serve as preventive measures against mental health issues in the next generations.

Promoting positive mental health during pregnancy can also protects against high antenatal stress (see Graignic-Phi-

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Table 4. *Specific latent factors and contents of items*

EFA Factor Loadings			
General Factor	Subfactor	Item	Contents
		Factor 2: Self-Loath	
0.51	0.47	BDI14	Worthlessness
0.34	0.43	BDI9	Suicidal thoughts or wishes
0.43	0.39	BDI7	Self-dislike
0.47	0.33	BDI3	Past failure
0.48	0.33	BDI8	Self-criticalness
		Factor 3: Positive Mood	
−0.48	0.64	STAI20	I feel pleasant (at this moment).
−0.48	0.60	STAI19	I feel steady (at this moment).
−0.44	0.60	STAI16	I feel content (at this moment).
−0.43	0.59	STAI5	I feel at ease (at this moment).
−0.46	0.59	STAI2	I feel secure (at this moment).
−0.44	0.58	STAI11	I feel self-confident (at this moment).
−0.43	0.59	STAI15	I am relaxed (at this moment).
−0.43	0.56	STAI10	I feel satisfied (at this moment).
−0.43	0.56	STAI8	I feel comfortable (at this moment).
−0.45	0.52	STAI1	I feel calm (at this moment).
−0.51	0.43	STAI33	I feel secure (generally).
−0.51	0.42	STAI36	I am content (generally).
−0.54	0.41	STAI21	I feel pleasant (generally).[a]
−0.53	0.39	STAI23	I feel satisfied with myself (generally).[a]
−0.57	0.36	STAI27	I am calm, cool, and collected (generally).
−0.55	0.21	STAI39	I am a steady person (generally).[a]
−0.38	0.30	STAI26	I feel rested (generally).
		Factor 4: Psychosomatic	
0.34	0.59	BDI15	Loss of energy
0.33	0.55	BDI20	Tiredness or fatigue
0.48	0.39	BDI19	Concentration difficulty
0.27	0.37	BDI16	Changes in sleeping pattern
0.47	0.35	BDI17	Irritability
0.14	0.33	BDI18	Changes in appetite
		Factor 5: Melancholy	
0.68	0.37	EPDS8	In the past 7 days, I have felt sad or miserable.
0.59	0.36	EPDS9	In the past 7 days, I have been so unhappy that I have been crying.
		Factor 6: Anxiety	
0.38	0.43	STAI4	I feel strained (at this moment).
0.52	0.42	STAI12	I feel nervous (at this moment).
0.55	0.41	STAI18	I feel confused (at this moment).
0.44	0.40	STAI3	I am tense (at this moment).
0.57	0.40	STAI17	I am worried (at this moment).
0.48	0.38	STAI9	I feel frightened (at this moment).
0.56	0.36	STAI6	I feel upset (at this moment).
0.49	0.36	STAI13	I am jittery (at this moment).
0.49	0.32	STAI7	I am presently worrying over possible misfortunes.
		Factor 7: Positive Self	
−0.53	0.36	STAI30	I am happy (generally).
−0.55	0.36	STAI39	I am a steady person (generally).[a]
−0.53	0.35	STAI23	I feel satisfied with myself (generally).[a]
−0.54	0.33	STAI21	I feel pleasant (generally).[a]
−0.54	0.31	STAI34	I make decisions easily (generally).

Note: BDI, Beck Depression Inventory—II; STAI, State-Trait Anxiety Inventory; EPDS, Edinburgh Postnatal Depression Scale.
[a]Item is cross-loaded on Factors 3 and 7.

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Table 5. *Reliability indices from confirmatory bifactor model*

Factors	Factor Determinacy	ω	ω_H	*H* Index
General	.970	.861	.581	.957
Self-loath	.778	.475	.344	.544
Positive mood	.938	.575	.512	.867
Psychosomatic	.820	.715	.553	.652
Melancholy	.761	.405	.301	.425
Anxiety	.824	.378	.325	.626
Positive self	.890	.504	.427	.653

Note: ω, omega coefficient; ω_H, omega hierarchical coefficient; *H*, construct reliability.

lippe et al., 2014, for review on antenatal stress and detrimental effects on fetal development). Positive mental health has been associated with better self-care (Giltay, Geleijnse, Zitman, Buijsse, & Kromhout, 2007; Steptoe, Wright, Kunz-Ebrecht, & Iliffe, 2006), higher adherence to medical advice (Cooper, Lloyd, Weinman, & Jackson, 1999), healthier regulation of immune and neuroendocrine systems during stress (Antoni, Carver, & Lechner, 2009; Antoni et al., 2006; Creswell et al., 2005; Sherman, Bunyan, Creswell, & Jaremka, 2009; Taylor, Lerner, Sherman, Sage, & McDowell, 2003), and lower likelihood of developing clinical depression after experiencing a crisis (Fredrickson, Tugade, Waugh, & Larkin, 2003). Childbirth is a life-changing experience that can be highly stressful or anxiety provoking, particularly for first-time mothers. Promoting

Table 6. *Pearson correlations and p values (in italics) of latent factor scores and child behavioral outcomes*

		Latent Factor Scores						
Measure	Subscales	General	Loath	Positive Mood	Psychosomatic	Melancholy	Anxiety	Positive Self
Bayley Scale of Infant & Toddler Development	Cognitive	−.034	−.013	**.133**	**.137**	−.049	−.048	**.107**
		.467	*.781*	*.005*	*.003*	*.299*	*.306*	*.023*
	Receptive communication	−.091	.019	**.115**	.052	−.025	−.082	.088
		.053	*.682*	*.015*	*.267*	*.603*	*.082*	*.062*
	Expressive communication	−.084	.012	**.133**	.084	−.052	−.073	.091
		.077	*.805*	*.005*	*.075*	*.270*	*.122*	*.054*
	Fine motor skills	−.070	−.063	.047	.066	−.058	−.012	.034
		.139	*.183*	*.318*	*.163*	*.219*	*.799*	*.472*
	Gross motor skills	−.004	−.061	.064	.083	.040	−.004	.049
		.928	*.199*	*.178*	*.080*	*.403*	*.930*	*.301*
	Social–emotional	−0.186	−.053	**.136**	.003	−.085	−.076	.099
		.000	*.280*	*.005*	*.951*	*.080*	*.117*	*.041*
	Communication behavior	−.038	.055	.057	−.048	−.082	.029	.057
		.437	*.260*	*.239*	*.324*	*.090*	*.547*	*.239*
	Community use	−.037	.017	.001	−.075	−.045	.000	−.023
		.450	*.727*	*.985*	*.121*	*.358*	*.996*	*.630*
	Functional preacademic	−.015	−.022	.092	−.006	−.031	−.015	.086
		.760	*.653*	*.057*	*.909*	*.524*	*.763*	*.076*
	Home living	−.070	.031	.010	.007	−.053	.011	.006
		.150	*.518*	*.840*	*.887*	*.272*	*.817*	*.905*
	Health & safety knowledge	**−.142**	.073	.090	−.031	−.080	−.069	.052
		.003	*.133*	*.066*	*.521*	*.099*	*.153*	*.284*
	Leisure activities	**−.103**	.055	.090	−.020	−.080	−.088	.058
		.033	*.259*	*.063*	*.681*	*.098*	*.069*	*.230*
	Self-care	−.062	.068	.025	−.019	−.042	−.008	.017
		.201	*.159*	*.607*	*.695*	*.392*	*.871*	*.721*
	Self-direction skills	**−.1**	.067	.010	−.045	−.058	−.017	.003
		.038	*.168*	*.842*	*.360*	*.233*	*.721*	*.959*
	Social skills	**−.122**	.006	.045	−.068	−.093	−.033	.031
		.012	*.905*	*.357*	*.163*	*.054*	*.499*	*.523*
	Motor skills	**−.135**	−.076	**.111**	−.028	−.095	.015	**.11**
		.005	*.120*	*.022*	*.559*	*.051*	*.763*	*.023*
Qchat 18 months	Total score	**.171**	−.075	**−.142**	−.022	.014	.060	**−.132**
		.001	*.163*	*.008*	*.686*	*.794*	*.265*	*.014*
	Social factor	.052	.040	**−.16**	.044	−.012	.043	**−.149**
		.332	*.459*	*.003*	*.414*	*.828*	*.427*	*.006*
	Behavioral factor	**.16**	−.072	−.040	−.045	−.003	.037	−.050
		.003	*.181*	*.457*	*.404*	*.957*	*.492*	*.353*
	Language factor	.060	−.051	−.033	−.028	.026	.056	−.038
		.268	*.342*	*.543*	*.608*	*.625*	*.298*	*.477*

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Table 6 (*cont.*)

Measure	Subscales	Latent Factor Scores						
		General	Loath	Positive Mood	Psychosomatic	Melancholy	Anxiety	Positive Self
Infant Toddler Social-Emotional Assessment	Activity/impulsivity (externalizing)	**.143**	.017	.010	.063	−.011	.025	.021
		.003	*.713*	*.838*	*.182*	*.820*	*.598*	*.654*
	Aggression/defiance (externalizing)	**.167**	.006	.001	.050	−.070	.079	.033
		.000	*.894*	*.986*	*.298*	*.145*	*.097*	*.488*
	Peer aggression (externalizing)	**.115**	.074	**.132**	.068	**−.136**	.064	**.142**
		.032	*.166*	*.013*	*.203*	*.010*	*.228*	*.008*
	Depression/withdrawal (internalizing)	**.225**	.051	−.021	−.028	−.027	.090	.023
		.000	*.288*	*.652*	*.556*	*.566*	*.058*	*.636*
	Fear	.080	−.001	.006	−.022	−.018	.025	.034
		.098	*.990*	*.900*	*.653*	*.705*	*.602*	*.482*
	General anxiety (internalizing)	**.179**	.017	−.031	−.076	.012	.090	.059
		.000	*.726*	*.516*	*.108*	*.809*	*.058*	*.215*
	Separation distress (internalizing)	.087	.024	−.043	.051	.028	−.053	−.020
		.068	*.609*	*.368*	*.283*	*.563*	*.263*	*.675*
	Inhibition to novelty (internalizing)	.048	−.003	.032	.019	−.032	−.012	.053
		.319	*.952*	*.500*	*.687*	*.507*	*.808*	*.272*
	Negative emotionality (dysregulation)	**.257**	.083	−.001	.047	.003	.009	.026
		.000	*.081*	*.975*	*.324*	*.950*	*.851*	*.584*
	Sleep dysregulation	.079	−.081	.032	.031	−.009	.069	.046
		.097	*.091*	*.502*	*.521*	*.854*	*.148*	*.339*
	Eating dysregulation	**.13**	−.002	−.059	.054	.006	**.098**	−.042
		.007	*.970*	*.218*	*.257*	*.904*	*.041*	*.376*
	Sensory sensitivity (dysregulation)	**.112**	.025	.047	.052	.003	**.105**	**.118**
		.019	*.604*	*.322*	*.276*	*.944*	*.028*	*.013*
	Compliance (competence)	**−.118**	.003	**.115**	−.068	−.059	.025	**.133**
		.013	*.949*	*.015*	*.154*	*.220*	*.606*	*.005*
	Attention (competence)	**−.11**	−.020	**.15**	−.027	−.066	.091	**.178**
		.021	*.677*	*.002*	*.569*	*.163*	*.057*	*.000*
	Mastery motivation (competence)	−.091	.064	**.119**	.038	−.021	.025	**.142**
		.056	*.178*	*.012*	*.424*	*.665*	*.592*	*.003*
	Imitation/play (competence)	−.055	.045	**.101**	−.009	−.049	−.004	**.115**
		.248	*.346*	*.034*	*.858*	*.302*	*.932*	*.016*
	Empathy (competence)	−.003	.046	**.123**	−.073	−.048	.093	**.144**
		.943	*.341*	*.010*	*.126*	*.315*	*.052*	*.002*
	Prosocial peer relations (competence)	−.046	−.009	−.021	**−.164**	−.055	.050	.017
		.383	*.862*	*.686*	*.002*	*.297*	*.342*	*.754*
	Maladaptive item cluster	.087	−.079	−.049	−.001	−.039	.093	.004
		.068	*.099*	*.311*	*.987*	*.421*	*.051*	*.933*
	Social relatedness item cluster	**−.146**	.042	**.094**	.061	−.083	−.053	**.108**
		.002	*.382*	*.047*	*.200*	*.081*	*.267*	*.023*
	Atypical item cluster	**.128**	−.063	−.090	.026	−.005	.065	−.037
		.007	*.185*	*.059*	*.592*	*.910*	*.177*	*.441*

Note: Bold indicates significant correlation at the $\alpha = 0.05$ level.

positive antenatal mental health may thus be a more proactive approach to prevent stress-related pregnancy issues before they become severe enough to warrant attention.

Limitations and future research

This exploratory study reveals specific associations between antenatal positive mental health and child development. As such, future research on positive maternal mental health should use measures or laboratory tasks that assess normal development and competences rather than deficient or atypical development. However, current findings are not conclusive and should be interpreted with caution. The mechanisms of how maternal positive mental health affect fetal and child development is unknown. While this study suggests the plausible effects of antenatal positive mental health on fetal and child development, this is an exploratory study with liberal thresholds for significant findings. As such, results require replication.

Another limitation is the lack of postnatal maternal mental health data in this study. As such, we are not able to parcel out

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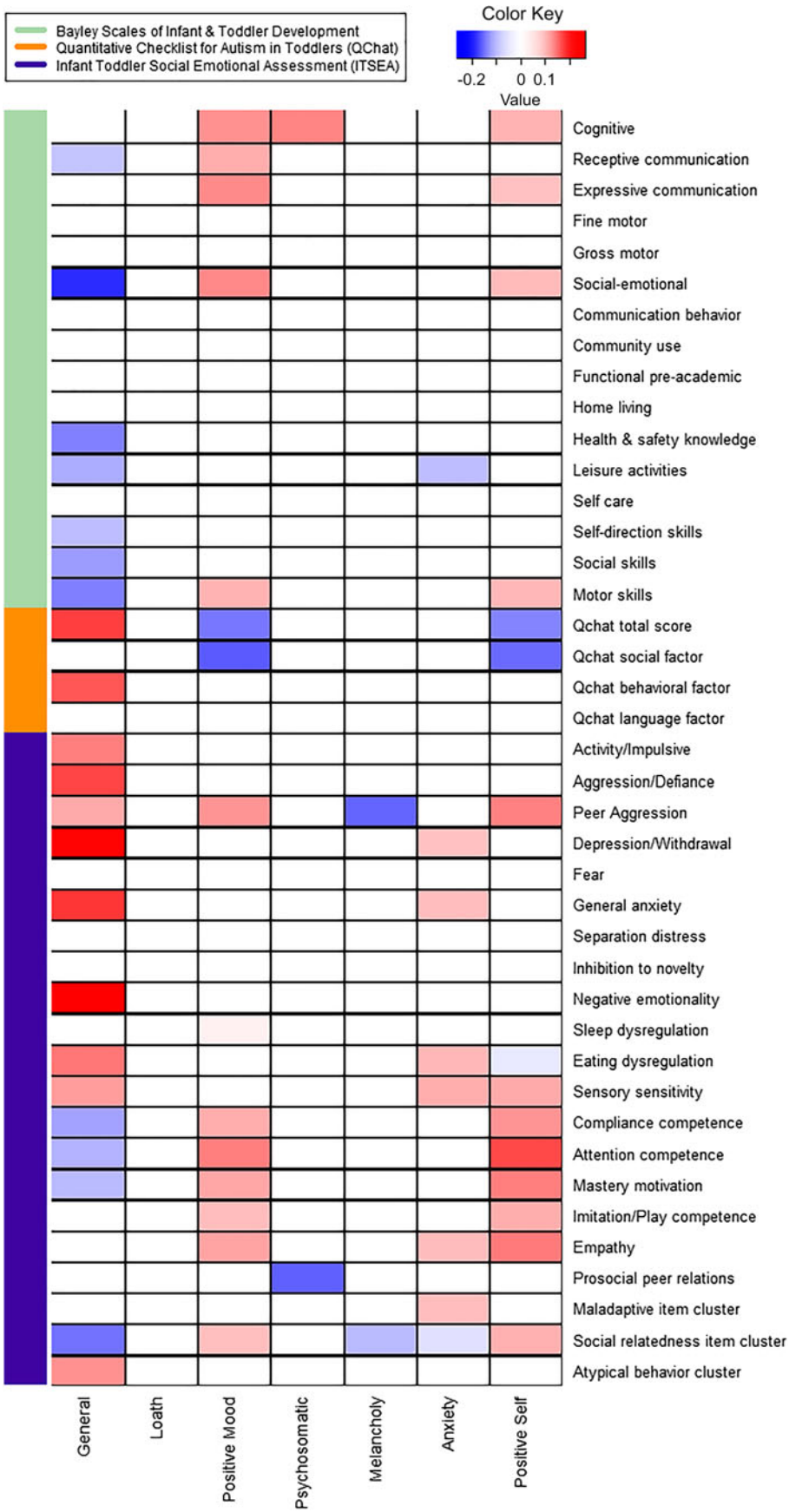

Figure 1. (Color online) Heat map illustrating significant correlations between maternal mental health factors and child behavioral outcomes.

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the effect of postnatal positive mental health on the child's outcomes. It is possible that antenatal positive mental health persisted into postnatal mental health, which in turn affected child outcomes. Nevertheless, this does not negate the importance of antenatal positive mental health. If the effect of antenatal positivity is mediated by postnatal positivity, it then may suggest the importance of intervention or mental health promotion to begin prenatally. Finally, it is important to note the correlational nature of these analyses. This approach cannot discount the possibility of a maternally inherited effect. A recent genome-wide association study (Okbay et al., 2016) described the genetics of emotional well-being, although genetic variation accounted for only a small percentage of the variation in well-being.

Conclusion

This study demonstrates the feasibility of using common psychiatric disorder screening tools to examine the effect of positive mental health. With this, it is possible for data from past or existing birth-cohort studies to be reexamined from the perspective of positive mental health. Moreover, the effects of positive mental health are likely to be specific and different from the lack of mental disorders. As such, a deeper understanding of positive mental health will allow for more comprehensive understanding of fetal and child development. This also highlights the need to promote mental health among the general population in addition to preventing mental disorders.

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