FULL TEXT ARTICLE

Maternal Response to Positive Affect Moderates the Impact of Familial Risk for Depressio Winning Reward in 6- to 8-Year-Old Children

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Abstract

Background

A growing body of research has demonstrated that adolescent offspring of depressed parents show diminished responding in the ventral striatum to reward. M emerge earlier than adolescence in offspring at familial risk for depression, although factors associated with neural alterations in childhood remain poorly und

Methods

We tested whether 6- to 8-year-old children, 49% at heightened risk for depression via maternal history, showed altered neural responding to winning reward moderated the association between familial risk and child neural response to reward. Participants were 49 children 6 to 8 years of age (24 with a maternal hist any psychiatric disorder). Children underwent functional magnetic resonance imaging while completing the Doors Guessing Task, a widely used reward guess responses to child positive affect.

Results

Findings demonstrated that children at high familial risk for depression showed lower ventral striatum responding to winning reward relative to low-risk chil dampening responses to their child's positive emotion expressions.

Conclusions

Neural reward alterations in the ventral striatum may emerge earlier than previously thought, as early as 6 to 8 years of age, specifically in the context of mate that focus on coaching mothers on how to encourage child positive emotions may be beneficial for supporting child reward-related brain development.

Children with a maternal history of depression have a threefold increased risk for developing depression in their own lifetime (1). Maternal history of chronic depression in offspring (2). Although risk for depression, as well as for other psychiatric illness, is well established for children with a maternal history of dep transmission of depression are less understood.

Disruptions in reward-related brain function appear to be one underlying mechanism associated with the development of depression (3). Neural reward proc demonstrated that reward function is altered in the context of clinical levels of depression in adolescents and adults (5 6 7). Specifically, depression is associa region involved in motivation, pleasure, and goal-directed behavior, and heightened activity in the medial prefrontal cortex and anterior cingulate, and these r positive affectivity (7).

Adolescent offspring of depressed parents show similar reward-related neural disruptions, even in the absence of their own psychiatric problems. Specifically, offspring show lower responding in the VS and dorsal striatum (8 9 10 11). These reward-related neural disruptions also seem to be predictive of the emergen

Intriguingly, newly emerging evidence suggests that these reward-related disruptions appear to emerge earlier than adolescence in offspring at risk for depres young children at risk for depression show observed behavioral differences in positive affect (PA) and reward (19 , 20), children as young as 6 to 10 years of a response to social reward and lower VS response to monetary reward (17 , 18). These findings are important, as they suggest that reward disruptions not onl sensitivity (21) and the onset of depressive symptoms (22), but also may start much earlier in development. Middle childhood is an important development healthy reward function is key to these processes (23) as well as to recovery from stress (4). Thus, early emerging reward-related neural disruptions may lin early-life stressors.

Certain parent socialization behaviors, such as maternal warmth and encouragement, are integral for supporting healthy reward function (24). In the early ye (e.g., modeling, contingent responding) that either support or discourage child emotion expressions via implicit or explicit means (25 , 26). Parent emotion s often comprise three components: acknowledgement, imitation, and elaboration of child positive emotion expression (27 28 29). These components serve to emotion expression. In contrast, parental emotion socialization behaviors that dampen child positive emotion expression often include dismissive, invalidatin child positive emotions (26 , 30).

Maternal depression may interfere with the use of positive emotion socialization behaviors (29). This can be problematic, as parental emotion socialization be term (24). For example, low levels of maternal warmth during early childhood and adolescence have been associated with reward-related neural disruptions 31). In contrast, maternal positive parenting was shown to buffer the effects of parental depression on reward processing in a sample of 9-year-old children (positive emotion plays an integral role in the development of neural reward systems, particularly for youths who are vulnerable to depression. What is still nee is related to child neural reward systems during childhood. Understanding how maternal emotional socialization behaviors and familial risk for depression wo identifying effective interventions to prevent the intergenerational transmission of depression.

The current study evaluated reward-related neural function in children at high and low risk for depression and examined how maternal positive emotion socia high-risk children. We hypothesized that high-risk children would show lower responding in multiple reward-related neural regions especially in the VS. We h levels of maternal encouragement and higher levels of maternal dampening in response to child positive emotions relative to mothers without this history. Las encouragement and high dampening) would moderate the association between maternal depression history and child reward-related neural disruptions.

Methods and Materials

Participants were 6- to 8-year-old children (N = 49, mean = 6.88 years, SD = 0.75 years) with no lifetime history of psychiatric illness. Participants were 53% (12%), and White (74%). One child identified as Hispanic/Latinx. Mothers reported a mean annual household income of $89,050 (SD = $64,889; range, $0–$ maternal depression as well as from community advertisements. Children were excluded from the study if they met criteria for any psychiatric disorder (e.g., a developmental disability, or neurological disorder. Children were categorized as high risk for depression (n = 24) if their mothers met criteria for two or more Structural Clinical Interview for DSM-IV (SCID-IV) (i.e., recurrent and/or chronic depression). Mothers were ineligible if they met lifetime criteria for a manic dependence. In the high-risk group, 7 mothers were currently depressed at the time of the study. Also, 17 mothers in the high-risk group met lifetime criteria posttraumatic stress disorder, n = 4 generalized anxiety disorder, n = 1 obsessive-compulsive disorder). Children were categorized as low risk for depression (

Participants completed two laboratory visits for the study. At the first visit, mothers and children completed clinical interviews to assess psychiatric history an affect and about child affective symptoms. At the second visit, children completed a reward guessing game during a functional magnetic resonance imaging (fM days; range, 1–105 days). The University of Pittsburgh Human Research Protections Office approved all research procedures, and written informed consent w

Measures

Clinical Interviews

Mothers were interviewed using the SCID-IV to assess maternal current and lifetime history of depression and other psychiatric history. Children and mothers Disorders and Schizophrenia–Present and Lifetime Version (K-SADS-PL) by the same interviewer to assess child current and lifetime psychiatric history. Sum and child report. Once again, none of the children in either group met lifetime criteria for any disorder on the K-SADS-PL. For both interviews (SCID-IV and K clinical psychologist. Eighteen percent of the SCID-IV clinical interviews and the K-SADS-PL clinical interviews (n = 12) were double coded by a licensed clini agreement for SCID-IV; 98.0% for K-SADS).

Maternal Response to Child Affect

Mothers completed the Parents' Reaction to Children's Positive Emotions Scale (33). This scale has demonstrated strong convergent validity with other meas positive emotions) (34 , 35) and predictive validity of child outcomes (e.g., depressive symptoms and disruptive behavior problems) (30 , 36) in prior resea series of 12 vignettes in which children typically show a range of positive emotions (e.g., happiness, excitement, curiosity) on a 7-point Likert scale (1 = very u a wedding and my child is giggling with a cousin seated next to him/her, I would. . . ." Responses are categorized into 4 subscales: encouragement, explanation included, "smile and let him/her have fun with his/her cousin" (encouragement), "tell my child that his giggling is disturbing the other people and would redir (explanation), "be embarrassed by my child's behavior" (discomfort), and "frown at my child and firmly tell him/her to be quiet" (reprimand). The encourager positive emotion expression. The explanation subscale captures explanation of the appropriateness of positive emotion expression in context. The reprimand s expression. The discomfort subscale captures disapproval or irritation with the child's positive emotion expression. Similar to prior research (36), we chose t dampening composite, as these two scales were highly correlated (r = 0.68) and reflected harsh responses that may dampen child positive emotion expression scale (α = 0.69) in separate statistical models for the current study.

Child Affective Symptoms

Mothers reported on child depressive and anxiety symptoms using the Mood and Feelings Questionnaire (MFQ) (37) and the Screen for Child Anxiety Relate mothers rated their children's depressive symptoms within the past 2 weeks on a 3-point Likert scale (0 = not true, 1 = sometimes, 2 = true). The SCARED has the past week on a 3-point Likert scale (0 = not true/hardly ever true, 1 = somewhat true or sometimes true, 2 = very true or often true). Both the MFQ and th SCARED).

Doors Guessing Task

We employed a modified version of a widely used reward guessing game, the Doors Guessing Task (13 , 14 , 39). In this 6.5-minute, event-related task, partic guess by button press which door was hiding a token. If children guessed correctly, they won that token (win trial). If they guessed incorrectly, they did not wi guess quickly or else the computer would guess for them. Behavioral performance was recorded to ensure that children responded with button press within 4 s

Prior versions of this task have utilized monetary incentives and included loss trials as well (e.g., winning 50 cents, losing 25 cents); however, we chose to simp normative developmental concerns of our sample (i.e., varying understanding of money). The task consisted of 40 trials (20 win, 20 no win/neutral), with a jit fMRI and event-related potential work has demonstrated that the Doors Guessing Task yields an internally consistent measure of neural reward response with the fMRI scan that they would be able to exchange their tokens for a prize and that the more tokens they won, the better the prize. Unbeknownst to the child, t same number of tokens. Children were debriefed following the scan using age-appropriate language. To evaluate neural response to winning reward, we used t

fMRI Acquisition and Preprocessing

Each participant was scanned using a Siemens 3T TIM Trio scanner. Structural images were acquired using magnetization prepared rapid acquisition gradient 2200/3.35 ms, field of view = 256 mm, matrix 256 × 240, flip angle = 9°). Blood oxygen level–dependent functional images for the Doors Guessing Task were and covered 39 axial slices, 3.1 mm thick, beginning at the cerebral vertex and encompassing the entire cerebrum and the majority of the cerebellum (repetitic 64, flip angle = 90°). All scanning parameters were selected to optimize the quality of the blood oxygen level–dependent signal while maintaining enough slice participant, we acquired and inspected a reference echo-planar imaging scan to confirm the absence of artifacts and good signal across the entire volume of ac

Preprocessing of fMRI data was completed using SPM8 and analyses were conducted in SPM12 (http://www.fil.ion.ucl.ac.uk/spm (http://www.fil.ion.ucl.ac.uk/spm)). St matter. For each functional scan, data were realigned to the first volume to correct for head motion and unwarped to correct for static inhomogeneity interacti participant's anatomical image. The anatomical image was then spatially normalized into standard stereotactic space (Montreal Neurological Institute templat width at half maximum Gaussian filter. Voxels were resampled during preprocessing to 2 mm^3 . Preprocessed data were analyzed using first-level random-ef random-effects models that account for participant-to-participant variability were then conducted to determine task-specific regional responses.

Data Analytic Strategy

First, within-sample *t* tests that included child age and sex were conducted in SPM12. Whole-brain analyses were used to identify significant clusters of interes our a priori region of interest (VS) using an anatomically defined mask for the win > no win condition. For both whole-brain and region-of-interest analyses, w for multiple comparisons using familywise error (FWE) of $p_{FWE} < .05$ at the peak level (42). Finally, we extracted eigenvariate values from the VS cluster in S status, maternal encouragement, and their multiplicative interaction (risk × maternal encouragement) on VS activity; and 2) evaluate the role of risk status, m dampening) on VS activity. Because maternal dampening and maternal encouragement were strongly correlated with one another, they were evaluated in sepa interactive effects, in which we estimated the association of risk status on neural response to winning reward at differing levels of maternal socialization (±1 S

Results

Descriptive Statistics

Children at high familial risk for depression did not differ on age, sex, race, family income, or child depressive or anxiety symptoms from children at low risk f dampening of child PA was significantly related to maternal history of depression (see Table 1 (tbl1)).

Table 1

Descriptive Statistics by Group

Characteristic	High Risk (*n* = 24)	Low Risk (*n* = 25)	F_{48} or χ^2_{48}, *p*
Age, Years, Mean (SD)	6.92 (0.78)	6.84 (0.75)	$F = 0.12$, $p = .73$
Sex, Female, *n* (%)	12 (50%)	14 (56%)	$\chi^2 = 0.18$, $p = .45$
Race, %	8% Black, 17% multiracial, 75% White	20% Black, 8% multiracial, 72% White	$\chi^2 = 1.93$, $p = .38$
Family Income, $, Mean (SD)	$77,363.64 ($61,506.52)	$103,333.33 ($67,778.19)	$F = 1.61$, $p = .21$
Child Anxiety Symptoms, Mean (SD)	8.21 (6.81)	7.12 (5.50)	$F = 0.38$, $p = .54$
Child Depressive Symptoms, Mean (SD)	4.25 (3.29)	2.64 (3.00)	$F = 3.21$, $p = .08$
Maternal Education Level	16% high school education or lower	16% high school education or lower	$\chi^2 = 0.00$, $p = 1.00$
Maternal Encouragement of Child PA, Mean (SD)	53.29 (9.13)	50.68 (8.61)	$F = 1.06$, $p = .31$
Maternal Dampening of Child PA, Mean (SD)	91.75 (19.84)	83.42 (24.94)	$F = 1.67$, $p = .21$
Ventral Striatal Activity, Mean (SD)	1.14 (3.30)	2.75 (3.39)	$F = 3.05$, $p = .09$

PA, positive affect.

Intercorrelations

Older children had lower VS response to winning reward. As expected, maternal encouragement and maternal dampening of child PA were negatively correlat symptoms were positively correlated. Greater maternal dampening of child PA was significantly associated with higher child anxiety symptoms on the SCARE

Table 2

Intercorrelations of Study Variables

Variable	1	2	3	4	5
1 Child Age	–	–	–	–	–
2 Child VS Response	–0.37 [a] (tbl2fna)	–	–	–	–

Variable	1	2	3	4	5
3 Child Anxiety Symptoms	–0.24	0.06	–	–	–
4 Child Depressive Symptoms	–0.21	0.13	0.36 [b] (tbl2fnb)	–	–
5 Maternal Encouragement of Child PA	–0.04	–0.06	0.18	0.12	–
6 Maternal Dampening of Child PA	–0.26	0.04	0.33 [b] (tbl2fnb)	0.26	–0.32 [b] (tbl2fnb)

PA, positive affect; VS, ventral striatal.

a $p < .01$.

b $p < .05$.

Task Effects

Whole-brain analyses used to examine task effects revealed that winning reward (relative to not winning reward) was associated with greater activation in mul junction, anterior insula, superior parietal lobe, and bilateral occipital lobe (see Table 3 (tbl3)). Further, region-of-interest analysis showed that winning reward 4.10, $p_{FWE} = .037$) (see Figure 1 (fig1)). [1] (fn1)

1 When we limited our within-sample t test to the 37 participants with <2-mm movement, our VS cluster remained statistically significant (159 voxels, [2, 22, −4], $t = 6.01$, p_F interactive effect of risk and maternal behavior on child reward response using only the 37 participants with <2-mm movement produced substantively similar results for the ir .07–.10).

Split-half analyses revealed a significant positive correlation of VS activation to winning reward for even and odd trials (Pearson's $r = 0.29$, Spearman-Brown

Table 3

Within-Sample Task Effects for Win Versus No Win

Region	Voxels	Peak Coordinates	t_{47}	p_{FWE} (Peak Level)
Temporoparietal Junction, Posterior Insula, Left	934	−46, −22, 22	6.22	.004
Occipital Lobe, Left	1173	−12, −92, −14	6.20	.004
Occipital Lobe, Right	1091	30, −84, −16	6.15	.005
Superior Parietal Lobe, Left	1000	−44, −20, 54	5.85	.011
Anterior Insula, Rolandic Operculum, Left	300	−48, 4, 2	5.46	.035
Dorsal Anterior Cingulate, BA 32, Left	472	−6, 10, 42	5.40	.041

Findings are significant using whole-brain analyses at a cluster-forming threshold of $p < .001$ and using FWE at $p < .05$ at peak level.

BA, Brodmann area; FWE, familywise error.

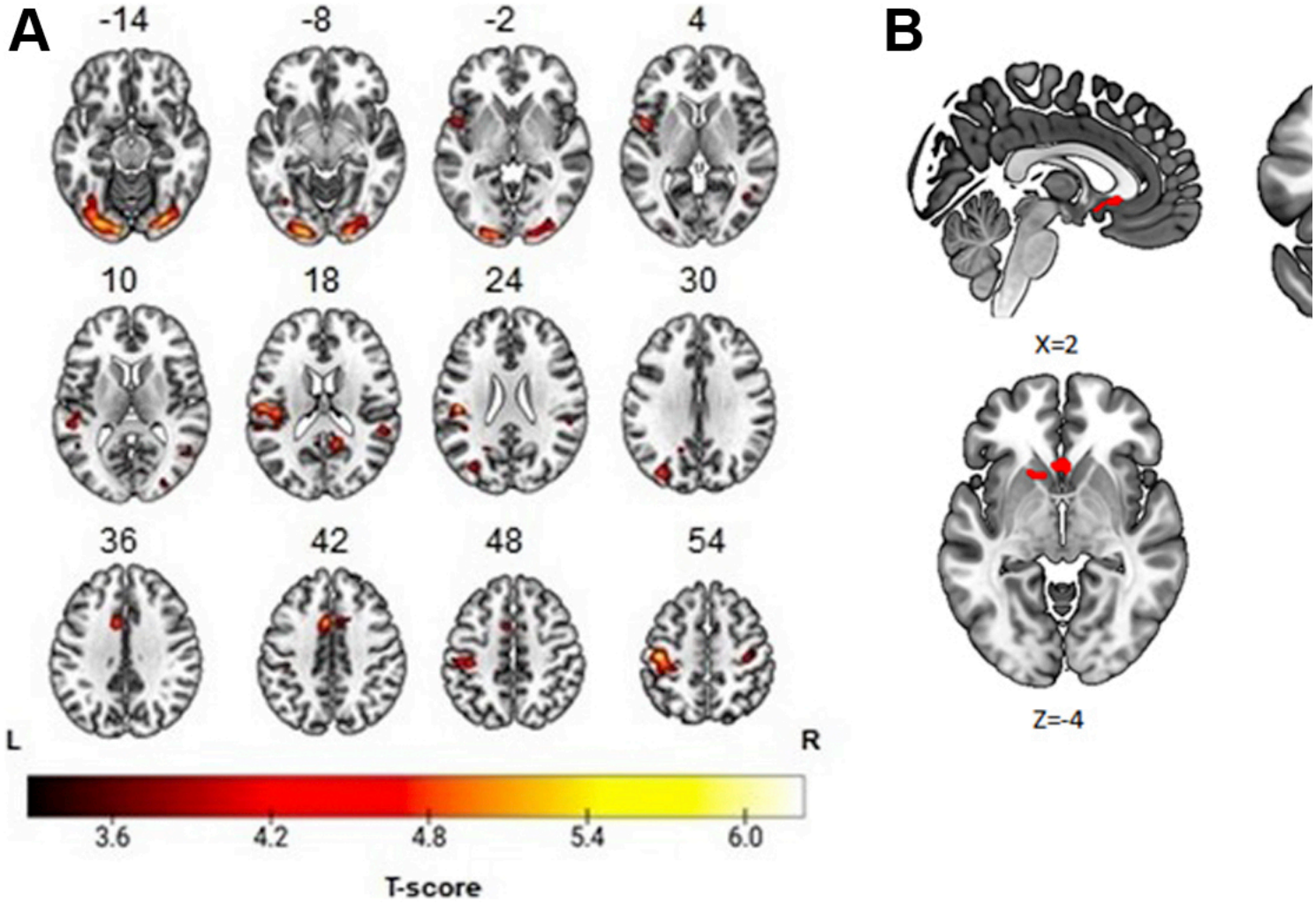


Figure 1

Neural response to winning reward in 6- to 8-year-old children. **(A)** Whole-brain findings: temporoparietal junction, 934 voxels [−46, −22, 22]; superior parietal lobe, 1000 voxels [−4
voxels [−6, 10, 42]; occipital lobe, left, 1173 voxels [−12, −92, −14]; occipital lobe, right, 1091 voxels [30, −84, −16]. **(B)** Region-of-interest findings: ventral striatum, 48 voxels [2, 18,

Maternal Encouragement of Child PA and Child VS Response

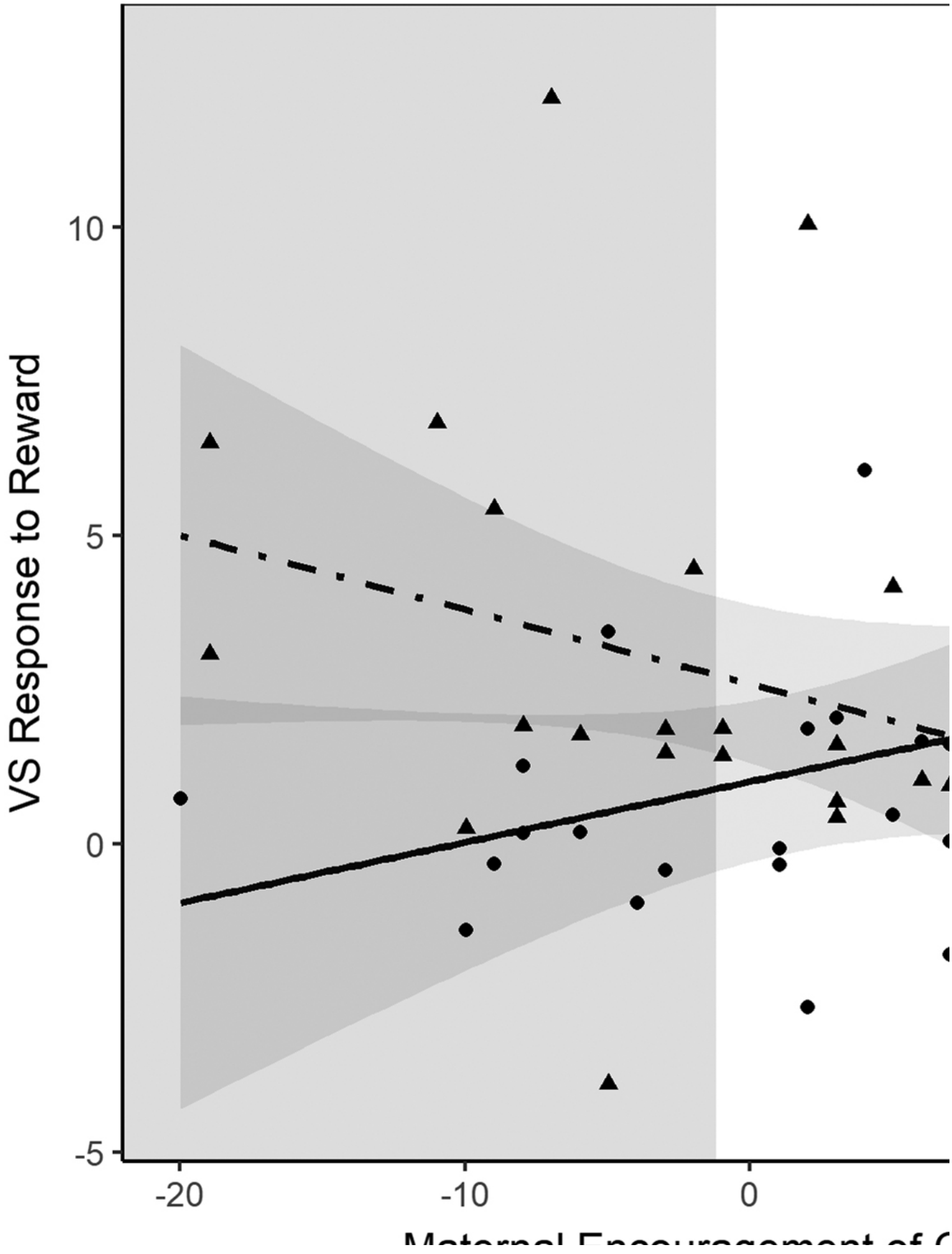
Our first regression model revealed that risk status and maternal encouragement of child PA interacted to predict VS activity (β = 0.54, t = 2.11, p = .040) (Tal
high-risk children had lower VS response to reward compared with low-risk children only when maternal encouragement of child PA was low (β = −0.54, t = -
significant differences between risk groups on VS activity (β = 0.05, t = 0.27, p = .79) (Figure 2 (fig2)). [2] (fn1)

Table 4

Role of Risk Status, Maternal Encouragement of Child PA, and Their Interactive Effect on Child Ventral Striatal Response to Winning Reward

Variable	Standardized β	t_{48}	p Value
Risk	−0.54	−2.73	.009
Maternal Encouragement of Child PA	−0.32	−1.62	.113
Risk × Maternal Encouragement of Child PA	0.54	2.11	.040

PA, positive affect.


VS Response to Reward
10
5
0
-5
-20
-10
0

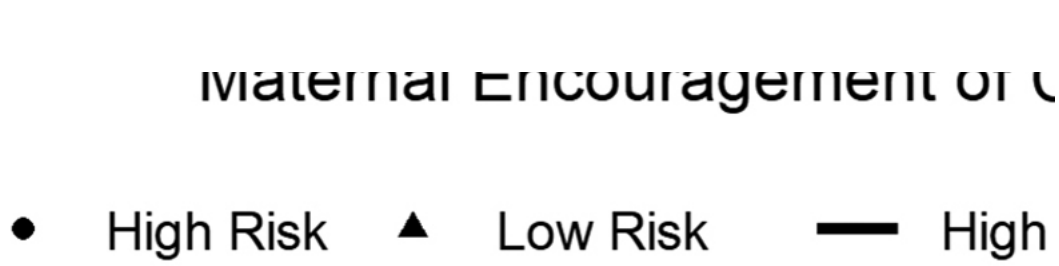


Figure 2

Interactive effect of maternal encouragement of child positive affect (PA) and familial risk for depression on ventral striatal (VS) activity in 6- to 8-year-old children.

Maternal Dampening of Child PA and Child VS Response

Our second regression model revealed that risk status and maternal dampening of child PA interacted to predict VS activity (β = −0.46, t = −2.20, p = .033) (T risk children had lower VS response to reward compared with low-risk children only when maternal dampening of child PA was high (β = −0.57, t = −2.90, p = significant differences between risk groups on VS activity (β = 0.07, t = 0.34, p = .74) (Figure 3 (fig3)). [2] (fn2)

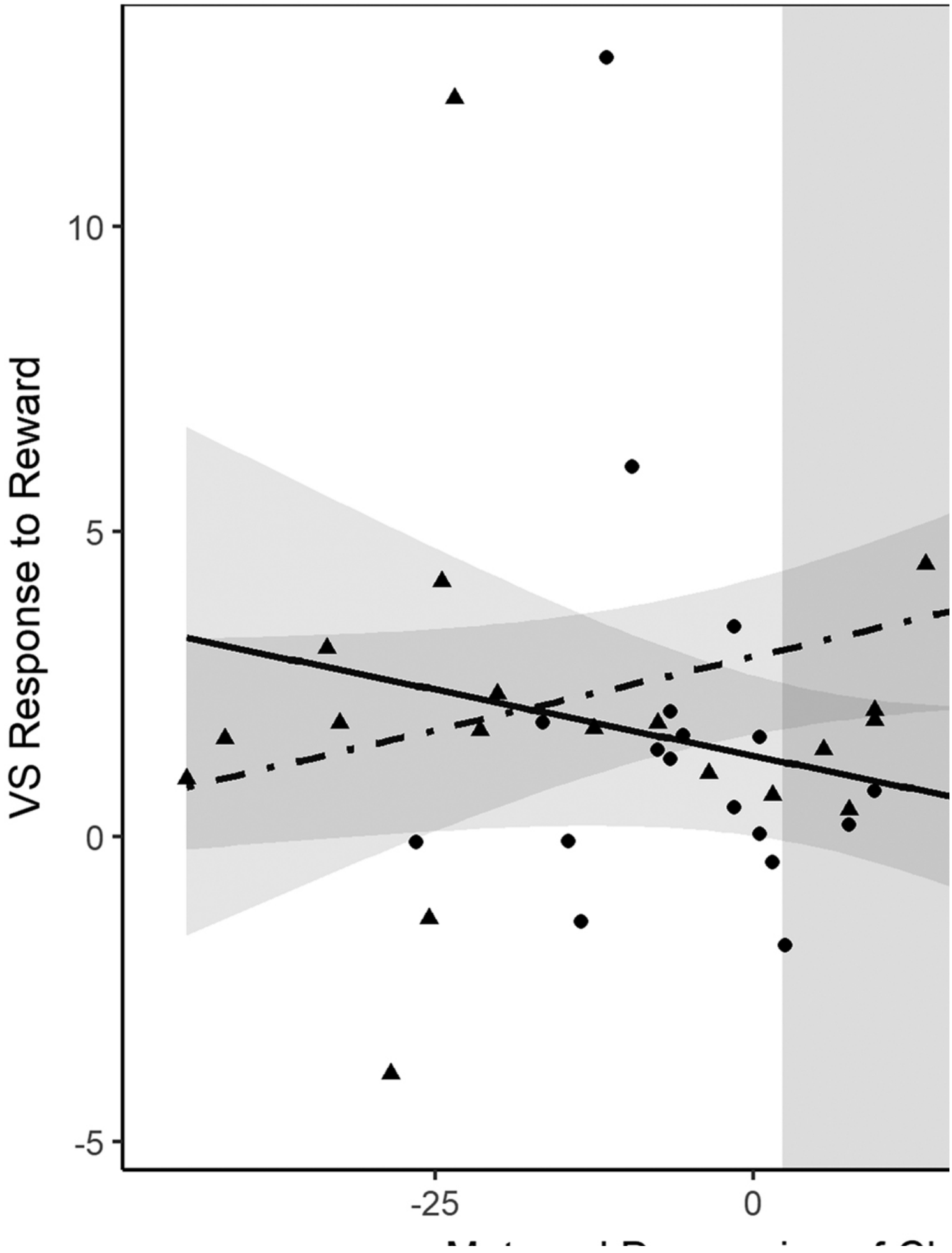
2 Models in which we included the SCARED and MFQ as covariates yielded substantively similar results.

Table 5

Role of Risk Status, Maternal Dampening of Child PA, and Their Interactive Effect on Child Ventral Striatal Response to Winning Reward

Variable	Standardized β	t_{48}	p Value
Risk	−0.57	−2.90	.006
Maternal Dampening of Child PA	0.33	1.88	.087
Risk × Maternal Dampening of Child PA	−0.46	−2.20	.033

PA, positive affect.


VS Response to Reward
10
5
0
-5
-25
0

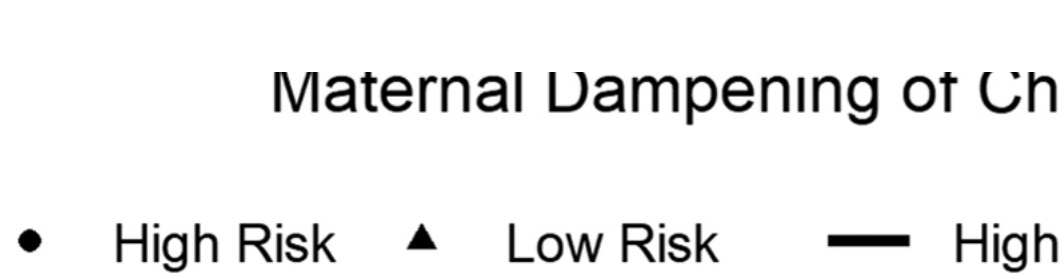


Figure 3

Interactive effect of maternal dampening of child positive affect (PA) and familial risk for depression on ventral striatal (VS) activity in 6- to 8-year-old children.

Discussion

Our study provided evidence that children as young as 6 to 8 years at high familial risk for depression show diminished VS activity to winning reward relative t encouragement or high maternal dampening of child positive emotion expression. Our findings suggest that familial behavior patterns seem to be related to di the onset of puberty, when many known developmental changes in VS activity occur (21). Importantly, our findings indicate that familial risk-based alteratio emotional socialization behaviors that serve to discourage or dampen positive emotions. In this regard, associations between maternal depression and child di mothers were less enthusiastic and responsive, and/or more dismissive or punitive during child positive emotional exchanges.

Maternal encouragement of child positive emotions, which may take the form of acknowledging, imitating, and elaborating on child positive emotion expressi integral to emotional learning and play during middle childhood (23). On the other hand, maternal dampening responses, which are characterized as dismiss over time, limit children's positive emotion expressions, thereby diminishing the opportunity for these reward regions to be reinforced via repeated use. Positi properties, including broadening cognition, fostering exploration of new settings, and promoting social approach (4). In this regard, our findings fall in line v positivity in child socioemotional and brain development (43). These findings also suggest that preventive interventions should be tailored to focus on mater development in youths, especially those with a family history of depression.

Traditional behavioral parent training paradigms (e.g., Helping the Noncompliant Child) (44) often include modules in which parents are trained on how to a as well as how to provide increased attention toward their child's positive behaviors. In addition, a new adaptation to Parent-Child Interactive Therapy that te emotional expressions (Parent-Child Interactive Therapy–Emotional Development) includes a module in which parents are trained on how to support childre and interventions (including Helping the Noncompliant Child and Parent-Child Interactive Therapy–Emotional Development) often target children with exist child negative emotion. Our findings suggest that preventive interventions that are generalizable to children who are not yet displaying clinical disorders, but v larger component focusing on socialization of positive emotion are needed.

Unexpectedly, we did not find that maternal depression was significantly associated with maternal socialization of emotion. It is important to note that althou), there is considerable heterogeneity in positive emotion expression in individuals with depression (47). Accordingly, some mothers with depression may be because they have less alteration in their own reward circuitry or greater temperamental PA themselves. Additionally, there is some evidence to suggest that m remission of maternal depression, which may have influenced the heterogeneity of maternal socialization of positive emotion in our sample. Specifically, our p nondepressed mothers with a prior history of depression, were less likely to imitate their preschool age children's positive emotion expressions (29).

The VS is a primary reward region that has been implicated in healthy positive emotion expression (5) and is critical to recovery from stress and psychiatric il vulnerable period of adolescence. Relatedly, blunted responding in the VS in adolescents has been linked to increases in depressive symptoms across adolesce developmental functions. Understanding what factors, such as maternal emotion socialization behaviors, support healthy VS activity is important for preventi

Extensive work has already established that reward-related neural disruptions are present in adolescent offspring of depressed parents (8 9 10 11). Our findin emerge even earlier than previously suspected (17 , 18 , 49). Because children in our study were required to be free of psychiatric illness, our findings also su to precede the onset of psychiatric illness and are not explained by preexisting subthreshold affective symptoms.

Future longitudinal work should evaluate how early maternal behavior and child VS response to reward predicts the onset of depression during the vulnerable note, we found that greater maternal dampening of child positive emotions was associated with greater child anxiety symptoms. This finding falls in line with predictive of anxiety disorders (50 , 51). However, our design limits our ability to pinpoint directionality in this association as well as rule out the role of shar anxiety).

Our study has several strengths, including its 1) evaluation of neural response to winning reward in a very young sample of 6- to 8-year-old children, 2) exami activity, and 3) use of a well-characterized sample with a maternal history of recurrent or chronic depression. Its primary limitations were use of an fMRI task depression versus other parental psychopathology, and its inclusion of children who were psychiatrically healthy. Future studies with larger sample sizes and t potentials) will also be needed to replicate these findings.

In summary, our findings provide evidence that children as young as 6 to 8 years who are at risk for depression may show diminished response in the VS wher child positive emotion expression. In other words, in the context of high levels of maternal encouragement or low levels of maternal dampening of child PA ex and low familial risk for depression. This finding provides hopeful news, as this suggests that mothers' own history of depression is insufficient to influence ch change, appears to play an important modulatory role. Interventions geared at coaching parents to encourage positive emotions in their young children, via ac on child reward-related brain development, which in turn may be beneficial during the vulnerable period of adolescence.

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All authors report no biomedical financial interests or potential conflicts of interest.

Supplementary Material

Supplementary Material (/ui/service/content/url?section=static%2fimage&eid=1-s2.0-S2451902222000209&path=24519022%2FS2451902221X00092%2FS2451902222000209%

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