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Væver, Mette Skovgaard; Pedersen, Ida Egmose; Smith-Nielsen, Johanne; Tharner, Anne

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ARTICLE

Maternal postpartum depression is a risk factor for infant emotional variability at 4 months

Mette Skovgaard Væver[1] | **Ida Egmose Pedersen**[1] | **Johanne Smith-Nielsen**[1] | **Anne Tharner**[2]

[1]Center for Early Intervention and Family Studies, Department of Psychology, University of Copenhagen, Copenhagen K, Denmark

[2]Clinical Child and Family Studies, Faculty of Behavioural and Movement Sciences, Vrije Universitet Amsterdam, Amsterdam, the Netherlands

Correspondence
Mette Skovgaard Væver, PhD, Centre for Early Intervention and Family Studies, Department of Psychology, University of Copenhagen, Øster Farimagsgade 2A, 1353 Copenhagen K, Denmark.
Email: Mette.vaever@psy.ku.dk

ABSTRACT

Maternal postpartum depression (PPD) is a risk for disruption of mother–infant interaction. Infants of depressed mothers have been found to display less positive, more negative, and neutral affect. Other studies have found that infants of mothers with PPD inhibit both positive and negative affect. In a sample of 28 infants of mothers with PPD and 52 infants of nonclinical mothers, we examined the role of PPD diagnosis and symptoms for infants' emotional variability, measured as facial expressions, vocal protest, and gaze using microanalysis, during a mother–infant face-to-face interaction. PPD symptoms and diagnosis were associated with (a) infants displaying fewer high negative, but more neutral/interest facial affect events, and (b) fewer gaze off events. PPD diagnosis, but not symptoms, was associated with less infant vocal protest. Total duration of seconds of infant facial affective displays and gaze off was not related to PPD diagnosis or symptoms, suggesting that when infants of depressed mothers display high negative facial affect or gaze off, these expressions are more sustained, indicating lower infant ability to calm down and re-engage, interpreted as a disturbance in self-regulation. The findings highlight the importance of not only examining durations, but also frequencies, as the latter may inform infant emotional variability.

KEYWORDS

infant emotional display, maternal postpartum depression, microanalysis, mother–infant interaction, self-regulation

RESUMEN

La depresión maternal posterior al parto (PPD) representa un riesgo para la alteración en la interacción madre-infante. Se ha encontrado que los infantes de madres depresivas muestran un afecto menos positivo, más negativo y neutral. Otros estudios han concluido con que los infantes de madres con PPD inhiben tanto el afecto positivo como el negativo. En un grupo muestra de 28 infantes de madres con PPD y 52 infantes de un grupo de madres no clínico, examinamos el papel de la diagnosis y síntomas de PPD en la variabilidad emocional de los infantes, medida como expresiones faciales, protesta verbal y mirada, usando microanálisis, durante una interacción cara a cara entre madre e infante. Se asociaron los síntomas y la diagnosis de PPD con 1) los infantes mostrando momentos afectuosos faciales menos negativos altos, pero más neutrales/de interés, y 2) menos momentos de miradas hacia otro lado. Se asoció la diagnosis de PPD, aunque no así los síntomas, con menos

protesta verbal del infante. La duración total de segundos de las muestras afectivas faciales y las miradas hacia otro lado por parte del infante no estuvo relacionada con la diagnosis o síntomas de PPD, lo cual sugiere que cuando los infantes de madres depresivas muestran afectos faciales negativos altos o miradas hacia otro lado, estas expresiones son más sostenidas, indicando así la más baja habilidad del infante de calmarse y volver a establecer contacto, interpretado esto como una disrupción en la auto-regulación. Los resultados subrayan la importancia no sólo de examinar las duraciones sino también las frecuencias, ya que estas últimas pudieran informar sobre la variabilidad emocional del infante.

PALABRAS CLAVES

depresión materna posterior al parto, muestra emocional del infante, interacción madre-infante, auto-regulación del infante

RÉSUMÉ

La dépression postpartum maternelle (abrégé ici dans le texte DPM) pose un risque de bouleversement de l'interaction mère-bébé. Les recherches ont montré que les bébés de mères déprimées font preuve d'un affect moins positif, plus négatif, et neutre. D'autres études ont prouvé que les bébés de mères avec DPM inhibent à la fois l'affect positif et négatif. Chez un échantillon de 28 bébés de mères avec DPM et 52 bébés de mères non-cliniques, nous avons examiné le rôle du diagnostic de la DPM et les symptômes de la variabilité émotionnelle des bébés, mesurés par les expressions faciales, la réaction vocale, et le regard en utilisant une microanalyse, durant une interaction de face-à-face mère-bébé. Les symptômes de la DPM et le diagnostic ont été liés 1) aux bébés faisant preuve de moins d'instances d'affect facial hautement négatifs mais de plus de neutre/intéressé, et 2) à moins d'instances de regard se perdant. Le diagnostic de DPM, mais non les symptômes, était lié à réaction vocale de protestation du bébé. La durée totale de secondes de démonstration affectives faciales du bébé et du regard se perdant n'était pas liée au diagnostic ou aux symptômes de DPM, suggérant que quand les bébés de mères déprimées font preuve d'un affect très fortement négatif ou d'un regard se perdant, ces expressions sont plus soutenues, indiquant une moindre capacité du bébé à se calmer et à se réengager, interprété comme une perturbation de l'auto-régulation. Les résultats mettent en lumière l'importance qu'il y a à non seulement examiner les durées mais aussi les fréquences, puisque ces dernières peuvent informer la variabilité émotionnelle du bébé.

MOTS CLÉS

dépression postpartum maternelle, affichage émotionnel du bébé, interaction mère-bébé, auto-régulation du bébé

ZUSAMMENFASSUNG

Eine postpartale Depression (PPD) der Mutter stellt ein Risiko für Störungen der Mutter-Kind-Interaktion dar. In einigen Studien wurde festgestellt, dass Säuglinge depressiver Mütter weniger positive, dafür mehr negative und neutrale Affekte zeigen. Andere Studien wiederum haben gezeigt, dass Säuglinge von Müttern mit PPD sowohl positive als auch negative Affekte unterdrücken. In einer Stichprobe von 28 Säuglingen von Müttern mit PPD und 52 Säuglingen von nichtklinischen Müttern untersuchten wir die Rolle, die eine PPD-Diagnose und -Symptome für die emotionale Variabilität von Säuglingen spielen. Die emotionale Variabilität wurde während einer direkten Mutter-Kind-Interaktionen anhand des Gesichtsausdrucks, des verbalen Protests und einer Mikroanalyse des Blicks gemessen. Die PPD-Diagnose und -Symptome konnten mit Säuglingen assoziiert werden, die 1) weniger stark negative, dafür mehr neutrale / interessierte Gesichtsausdrücke zeigten und 2) deren Blick weniger oft abschweifte. Die PPD-Diagnose, jedoch nicht die Symptome, war mit weniger verbalem Protest der Säuglinge assoziiert. Die Gesamtdauer der affektiven Gesichtsausdrücke und des abschweifenden Blickes in Sekunden hing nicht mit der PPD-Diagnose oder den Symptomen zusammen. Dies deutet darauf hin, dass stark negative Gesichtsaffekte

oder Wegschauen bei Säuglingen depressiver Mütter anhaltender sind, was auf eine geringere Fähigkeit des Kindes hinweist, sich zu beruhigen und sich wieder auf die Interaktion einzulassen, was als Störung der Selbstregulation interpretiert werden kann. Die Ergebnisse zeigen, wie wichtig es ist, nicht nur die Dauer, sondern auch die Häufigkeit zu untersuchen, da letzteres über die emotionale Variabilität des Kindes Aufschluss geben kann.

STICHWÖRTER
mütterliche postpartale Depression, emotionaler Ausdruck des Kindes, Mutter-Kind Interaktion, Selbstregulation des Kindes

抄録

母親の産後うつ病(PPD)は、母子相互作用の混乱を起こす危険がある。母親がうつ病である乳児は、肯定的な感情はより少なく、否定的ではっきりしない感情をより示しているのが見られている。他の研究では、産後うつ病の母親の乳児は、肯定的でも否定的でも感情表現が抑制されているという結果が出ている。

28組の産後うつ病の母親と乳幼児、52組の非臨床の母親と乳幼児に対し、PPD診断と症状が、母子の対面相互交流時にマイクロアナリシスを使って、顔の表情、声の主張、注視について測定した乳児の感情の可変性に対してどう関連しているかについて分析した。PPDの症状と診断の両方がある場合は、1) 乳児は、非常に消極的なのは少なく、より多く中立的/興味ある顔の感情表出を示すこと、2) 視線を外すことがより少ないこと、と関連していた。PPDの症状はないけれど診断がある場合は、乳児の声の主張がより少ないということと関連していた。乳児の顔の感情表出と視線を外すことの合計秒数は、PPDの診断にも症状にも関係がなく、そのことはうつ病である母親の乳児が非常に否定的な顔の感情表出や視線を外したりする時、その表現がより長く続くことを示唆し、それは、乳児の自分自身を落ち着かせ、再関与する能力がより低くなることを意味し、それはつまり、自己制御に問題があると解釈できる。結果は、長さだけでなく、頻度も調査する必要性を明らかにしている。なぜなら、後者は乳児の感情の可変性についての情報を得られる可能性があるからである。

キーワード
母親の産後うつ病、乳児の感情表出、母子相互作用、乳児の自己制御

摘要

母亲的产后抑郁症 (PPD) 是母婴互动中断的危险因素。抑郁母亲的婴儿在互动中表现出更少的积极情绪、更多的消极和中性情绪。其他研究发现, 患有PPD母亲的婴儿会抑制积极和消极的情绪表现。在28名患有PPD母亲的婴儿和52名非临床母亲的婴儿样本中, 我们研究了PPD的诊断和症状对婴儿情绪变异性的影响。在母婴面对面互动过程中, 我们通过微分析计量了婴儿的面部表情、声音抗议及其凝视。PPD的症状和诊断与如下两个表现有关:1) 婴儿表现出更少的消极面部表情, 却表现出更多的中性/感兴趣的面部表情; 2) 更少的凝视。PPD的诊断与更少的婴儿声音抗议相关, 而PPD的症状与其无关。婴儿面部表情和凝视的总持续时间与PPD的诊断或症状无关, 这表明当患抑郁症母亲的婴儿表现出消极的面部表情或凝视时, 这些表情会持续更久, 也同时表明婴儿镇静下来和重新参与的能力较低, 这可被解释为具有自我调节障碍。研究结果强调了检测持续时间和检测频率的重要性, 因为后者可能会影响婴儿的情绪变异性。

關鍵詞

ملخص

الاكتئاب الأمومي بعد الولادة (PPD) يمثل خطر لاضطراب التفاعل بين الأم والرضيع. وقد وجد أن الرضع من الأمهات المكتئبات يظهرون مشاعر أقل إيجابية، وأكثر سلبية ومحايدة. وقد وجدت دراسات أخرى أن الرضع من الأمهات اللاتي يعانين من اكتئاب بعد الولادة يظهرون امتناعا عن كل من المشاعر الايجابية والسلبية. تمت المقارنة بين عينة من 28 رضيعاً من الأمهات من تشخيص (PPD) و52 رضيعاً من الأمهات الأخريات، ودرسنا دور تشخيص PPD وأعراض التغير العاطفي للرضع، الذي يقاس من خلال تعبير الوجه، والاحتجاج الصوتي، والنظرة باستخدام التحليل الدقيق، خلال التفاعل وجهاً لوجه بين الأم والرضيع. ارتبطت أعراض PPD والتشخيص بـ 1) إظهار الرضع لمشاعر سلبية عالية وتعابير وجه أكثر حيادية ، و2) عدد أقل من النظر بعيدا عن الوجه. وكان هناك ارتباط بين تشخيص الاكتئاب وبين الاحتجاج الصوتي الأقل من الرضع ولكن لم يكن هناك ارتباط مع أعراض الاكتئاب. ولم ترتبط المدة الإجمالية لتعبيرات وجه الرضيع بالتشخيص أو الأعراض ، مما يشير إلى أنه عندما يظهر الرضع من الأمهات المكتئبات تأثيرًا سلبيًا عاليًا على الوجه أو ينظرون بعيدا عن الوجه، تكون هذه التعبيرات أكثر استدامة، مما يشير إلى انخفاض قدرة الرضع على الهدوء وإعادة المشاركة، مما يفسر على أنه اضطراب في التنظيم الذاتي. وتبرز النتائج أهمية دراسة المدد الزمنية وكذلك مدى التكرار، لأن هذه الأخيرة قد تساعد على فهم التباين العاطفي للرضع.

الكلمات الرئيسية: اكتئاب الأمهات بعد الولادة، المظاهر العاطفية للرضع، التفاعل بين الأم والرضيع، التنظيم الذاتي للرضع

The capacity of infants to experience, regulate, and express the full range of emotions is central for early childhood mental health (Zero to Three, 2012). Young infants communicate their emotions and needs to their caregivers with facial expressions, gaze, vocalizations, and gestures (Tronick & Cohn, 1986). It has been argued that infant expression of both positive and negative emotions is adaptive and related to more sensitive parenting and more favorable long-term outcomes with regard to different areas of child development, including attachment security, cognitive development, language development, and mental health (Dix, Meunier, Lusk, & Perfect, 2012). Also, children's ability to shift between emotional displays and to regulate their negative emotions is considered a key factor in their healthy and adaptive socioemotional development (Compas et al., 2017). Considering the significance of early emotional development for infants' long-term mental health, it is important to better understand risk factors for disturbances in infant emotional expression and variability, that is, shifting between affective displays. Therefore, the current study examines the role of maternal depressive symptoms and a diagnosis of depression for infant's expression of positive and negative emotions and the ability to shift between affective displays, seen as an index of infant emotional variability during a mother–infant face-to-face interaction.

From birth, infants express negative emotions, and negative affect is one of the most effective means for infants to communicate that something is wrong and elicit caregiving (Granat, Gadassi, Gilboa-Schechtman, & Feldman, 2017; Dix et al., 2012). Although negative emotions can be expressed in alone states, the infant's expression of positive affect requires a face-to-face social context, and infants' expression of pleasure and positive affect is seen with the emergence of the social smile around 6 weeks (Wörmann, Holodynski, Kärtner, & Keller, 2012). The infant possesses inborn regulatory behaviors, such as gaze aversion and self-touch, which serve as adaptive survival functions and reduce negative emotions in stressful situations (Granat et al., 2017; Field, 1981). However, as the infant's capacities for regulating negative affect are limited, regulation is primarily externally organized in the first year of life, and the infant's caregivers are crucial for infant emotion regulation. Infant emotions are efficiently regulated through sensitive parenting, which is characterized by the parent's ability to detect and respond to the infant's emotional signals both to create positive and reduce negative affect (Bell & Ainsworth, 1972; Tronick & Beeghly, 2011).

Maternal postpartum depression (PPD), also known as postnatal depression, is common, affecting approximately 13–18% of all women within the first year after childbirth (Gavin et al., 2005; O'Hara & Swain, 1996). It has repeatedly been shown that mothers suffering from PPD are more irritable and hostile, less engaged, exhibit less emotion and warmth, and are less sensitively attuned to their infants compared to nondepressed mothers (Field, 2010). Studies have demonstrated that mothers with PPD often show either a withdrawn or an intrusive interactional style (Cohn, Matias, Tronick, Connell, & Lyons-Ruth, 1986; Field, Healy, Goldstein, & Guthertz, 1990; Lovejoy, Graczyk, O'Hare, & Neuman, 2000). Both interactional styles are characterized by diminished maternal sensitivity and responsiveness to the infant's social and emotional signals (Murray, Halligan, & Cooper, 2010). Recent research suggests that maternal depression, especially in early infancy, is a major risk as this is a highly sensitive period where the infant is maximally dependent on maternal care, and where early brain and socioemotional development takes place (Feldman, 2015). PPD is shown to have long-term negative effects on child development as children of depressed mothers show elevated risk for adverse outcomes on a broad range of child measures, and increased

susceptibility to psychopathology, especially behavioral problems (for a review, see Netsi et al., 2018; O'Hara & McCabe, 2013). However, the mechanisms underlying these associations are not fully understood (Dix & Meunier, 2009).

A majority of studies on maternal PPD, and infant emotional expression of vocal distress and gaze aversion during the first year of life have examined maternal depressive symptoms. These studies have reported inconsistent findings. Some early studies on infant vocal expression of distress in depressed dyads found infants of depressed mothers to express more vocal distress, such as fussing and crying. Field and her colleagues (1988) found this when they examined maternal PPD symptoms and a global rating of infant vocalization, Murray, Cowley, and Cooper (1996) also found this when they looked at PPD diagnosis and a global rating of infant vocalization; and Weinberg and Tronick (1998) found the same when they microcoded infant vocalizations second by second and rated maternal depressive symptoms. However, more recently, a study using microcoding of infant vocalization showed that 4-month-old infants of mothers with depressive symptoms were more vocally activated in both positive and negative qualities than infants of nondepressed mothers (Friedman, Beebe, Jaffe, Ross, & Triggs, 2010). Also, this study showed that, compared to infants of nondepressed mothers, infants of depressed mothers were more vocally variable, specifically in and out of fuss/whimper, and they were more likely to change rather than maintain vocal states.

Similarly, findings regarding the effects of PPD diagnosis on infant gaze during mother–infant interactions are equivocal. From the very beginning of life, infants regulate their participation in social contact using gaze. Gaze on the parent signals attentiveness and engagement, whereas gaze off/looking away signals disengagement (Field et al., 1990). Some studies found no effect of PPD symptoms or PPD diagnosis on microcoded infant gaze (Chabrol, Bron, & Camus, 1996; Field et al., 1990; Field et al., 1985; Striano, Brennan, & Vanman, 2002). Other studies, all using microcoding of infant gaze found that infants of both mothers with PPD symptoms (Boyd, Zayas, & McKee, 2006; Field et al., 1988; Reissland, Shepherd, & Herrera, 2005) and infants of mothers with PPD diagnosis (Granat, Gadassi, Gilboa-Schechtman, & Feldman, 2017; White, Flanagan, Martin, & Silvermann, 2011) looked less at the mother or exhibited more gaze aversion toward their mother than infants of nondepressed mothers. One study using microcoding of gaze found that infants of mothers with depressive symptoms looked more at their mother than infants of nondepressed mothers (Beebe et al., 2008). In a previous brief report on the same sample as the current, we showed, also using microcoding of gaze, that there was no difference between infants of mothers with and without PPD symptoms in the amount of time infants looked at their mothers' faces. However, infants of depressed mothers showed reduced gaze variability, that is, shifting between gaze on and gaze off the mother, compared to infants of the nondepressed mothers (Væver, Krogh, Smith-Nielsen, Christensen, & Tharner, 2015).

Higher variability of emotional displays might be related to better emotion regulation capacities. For example, gaze

Key Finding 1

- Maternal depression, symptoms and diagnosis, is associated with both higher variability in some behaviors (more events, more shifting between low negative and neutral/interest facial affect) and lower variability in other behaviors (fewer events, less shifting and more sustained behaviors in high negative facial affect, gaze off, and vocal protest) in infants at 4 months.

Implication 1

- This finding suggests that when infants of depressed mothers display high negative facial affect or gaze off, these expressions are more sustained, indicating lower infant ability to calm down and re-engage, interpreted as a disturbance in self-regulation.

Key Finding 2

- Only maternal depression diagnosis, and not symptoms, was associated with a lower total duration of vocal protest in infants.

Implication 2

- This finding suggests the presence of a threshold effect, that is, the total duration of infant vocal protest may be affected only when a certain degree of severity in maternal depressive symptoms is beyond a certain threshold.

Key Finding 3

- Neither maternal depression diagnosis nor maternal depressive symptoms were associated with differences in total duration of infant facial expressions or gaze off.

Implication 3

- The finding highlights the importance of not only examining durations, but also frequencies when examining infant behavior, as the latter may inform infant emotional variability.

State of relevancy to the field

Children's ability to shift between emotional displays and to regulate their negative emotions is considered a key factor in their healthy and adaptive socioemotional development. This study confirms that maternal depression is a risk factor for infant's emotional variability and self-regulation at 4 months. The focus on the frequency of infant behaviors as an indicator of emotional variability points to the subtle dyadic disruption and repair regulatory processes, which form the daily ongoing experiences the infant has with his or her caregiver. The study findings may also point to clinical implications as mothers suffering from depression may be unaware of both their own and infant's behavior in the ongoing matches and mismatches of emotion, and how they can contribute to the repairing of the disruptions.

aversion is a crucial way for the infant to control the amount of stimulation s/he receives. When an overload of information is experienced, the infant can look away to process the information and modulate the arousal caused by the overload (Field, 1981). Thus, the ability to shift between different emotional displays might be an index of adaptive emotional development. This is in accordance with studies examining physiological systems underlying emotion regulation (e.g., heart rate variability), which indicate that higher variability in those systems indicates greater flexibility in reaction to a stressor as well as faster recovery (Diamond & Aspinwall, 2003). On the other hand, it has also been argued that both too high and too low behavioral variability probably are risk factors. Beebe et al. (2008 & 2010) have used the concept of an optimum midrange model in the understanding of infant emotion regulation. In this model, regulation is defined as contingency and interactive regulation is defined as the predictability of each partner's behavior from that of the other over time, that is, interactive contingency. Self-regulation, that is, self-contingency, is defined as predictability of a person's behavior over time (autocorrelation) in the presence of a particular partner and is an assessment of the degree of stability/lability within the individual's stream of behavior. Especially, it has been shown that lowered autocorrelation is a risk factor indicating insufficient stability (Margolis, Lee, Peterson, & Beebe, 2019).

Although studies consistently find differences in emotion expression and regulation between children of depressed and nondepressed mothers, there is an ongoing debate about the quality of those differences which is partly fueled by the fact that the mechanisms underlying these associations are not fully understood. Thus, different hypotheses prevail with regard to how postpartum depressive symptoms may affect infant emotion expression and regulation. Theories of the mechanism by which infants' and children's emotional expressions are formed may be categorized broadly into three theoretical models: (a) the model of mirroring, emotional contagion, and reinforcement by outcome; (b) the model of depression inhibition; and (c) the mutual regulation model (MRM). These models will shortly be described and used in the discussion of the results from the current study.

In the first model, it is suggested that infant's and children's emotional expressions are formed by processes of mirroring, emotional contagion, and reinforcement by outcome (Dix et al., 2012). According to these theories, infants of depressed mothers are expected to display more negative and flat affect and less positive affect than children of nondepressed mothers, either because children imitate or mimic their depressed mother's emotional displays, or because depressed mothers do not appropriately respond to the infant's cues and thus the infant's needs are not met, which induces frustration (Dix et al., 2012). Studies using the still-face paradigm (SFP, Tronick, Als, Adamson, Wise, & Brazelton, 1978) partly support this idea. In the SFP, social-emotional stress is induced in the parent–infant interaction in a sequence of three episodes where the infant's behavior is observed: First, the adult is asked to interact with the infant as s/he would normally do, then the adult is asked to adopt a still face and become unresponsive, and finally the adult is asked to resume a normal interaction with the infant (the reunion phase). Thus, the SFP can be seen as an experiment that mimics the emotional unavailability often seen in parental depression (Field, Vega-Lahr, Scafidi, & Goldstein, 1986). A meta-analysis of 80 empirical studies confirmed that children react negatively to this emotional unavailability: Infants were found to show reduced positive affect, reduced gaze at the mother, and increased negative affect both during the still-face episode and the reunion episode that follows the still-face when compared to baseline (for a review, see Mesman, van IJzendoorn, & Bakermans-Kranenburg, 2009). This so-called "still-face effect" is also found in infants of depressed mothers. However, recently, it has been found that infants of depressed mothers show more positive affect during the still face period compared to infants of nondepressed mothers (Graham, Blissett, Antoniou, Zeegers, & McCleery, 2018). This finding does not support the theories described above but could be explained by either the infant amplifying their positive attachment signals to engage their unresponsive mothers or by infants using positive emotions to regulate their negative emotions (Graham et al., 2018).

The "depression-inhibition hypothesis" suggests that infants and children of depressed mothers suppress their emotional displays altogether because they have experienced negative maternal reactions to their expression of need or

interest (Dix et al., 2012). This idea is supported by findings showing that children of depressed mothers not only display fewer positive, but also fewer negative emotions, even when depressive symptoms are modest. Thus, infants and young children are found to inhibit emotion as mothers' depressive symptoms increase and to withdraw from unresponsive mothers, which may adversely affect children's subsequent relationships and competencies (Dix et al., 2012). Studies, not using microanalysis but using global clinical assessments have consistently found that maternal depressive symptoms are associated with infant social withdrawal as measured by the Alarm Distress Baby Scale (ADBB, Braarud et al., 2013; Guedeney & Fermian, 2001) (Matthey, Guedeney, Starakis, & Barnett, 2005; Moe et al., 2016). Infant social withdrawal is characterized by less frequent eye contact, less smiling, and reduction of facial expressions, less cooing, or by some negative behaviors, such as self-stimulation (Guedeney & Fermian, 2001). Whereas a global social withdrawal measure, such as the ADBB, is an operationalization of a specific phenomenon and seeks to capture a number of specific behaviors, microanalysis captures behaviors without interpreting them in terms of a larger concept. For example, less frequent eye-contact may be a sign of social withdrawal or also a sign of regulation, depending on the overall context.

A third model argues that the depressive symptoms disturb the early emotional communication between mother and infant. Tronick and colleagues proposed the MRM, which states that mother–infant interactions are jointly regulated toward a state of reciprocity through a process of ongoing emotional feedback. This dyadic exchange of emotion in mother–infant interaction is not characterized by perfect harmony and synchrony but on the contrary, by messiness, ongoing emotional matches, mismatches, and repairs (Tronick & Beeghly, 2011). The emotional matching and mismatching are accompanied by shifts in infant emotion expressions; with positive affect indicating matches and negative affect indicating mismatches (Tronick & Beeghly, 2011). According to Tronick and Beeghly, the effectiveness of the mutual regulation system depends on four reciprocal processes: (a) infants' ability to self-organize and control their physiological states and behavior; (b) the integrity and maturation of sensorimotor, attentional, and socioemotional elements of infants' communicative system (e.g., gestures, gaze shifting, and affective displays); (c) parents' ability to apprehend and correctly interpret their infant's communications; and (d) parents' motivation and capacity to respond to their infant contingently and appropriately to facilitate their infant's regulatory efforts (Beeghly & Tronick, 2011). In well-functioning infant–parent dyads, the mutual regulation system is characterized by variability, flexibility, and efficient repair processes of disruptions in the emotional communication, which promote children's ability to regulate their emotional states and cope with interactive stress (Gianino & Tronick, 1988; Tronick & Beeghly, 2011). PPD has been shown to be an important risk factor for disturbing the early mother–infant emotional communication (Beebe et al., 2008; Beeghly & Tronick, 2011; Dix et al., 2012; Murray et al., 2010; Tronick & Gianino, 1986). Due to the infant's restricted repertoire of self-regulatory capacities, it is critical that the parent is capable of repairing the emotional disruptions. In the context of maternal depression, studies have found prolonged periods of emotional mismatch, more maternal difficulties in interactive repair, and less variability and flexibility of the regulatory system, which in turn is likely to negatively impact the development of infant self-regulatory skills and emerging mental representations of self-efficacy and basic trust (Beebe et al., 2008; Beeghly & Tronick, 2011; Weinberg, Olson, Beeghly, & Tronick, 2006). Those early disruptions in emotion communication may have long-term detrimental consequences for children's development, and disruption of early emotional communication might be a potential mediator in the association between maternal PPD and child development (Beebe et al., 2010; Dix et al., 2012; Granat et al., 2017; Netsi et al., 2018; Tronick & Gianino, 1986).

Overall, a number of studies have found both PPD symptoms and PPD diagnosis to be associated with more negative infant emotional displays, and a number of studies have confirmed a general pattern of infant emotional inhibition. Most of the studies examining the effects of maternal depression on infant emotion expression have looked at the duration of children's emotional displays. However, it may be that it is not just the duration of emotional expression that is disrupted in children of depressed mothers, but also the variability in the emotional communication displayed by the infant, which is in line with the MRM.

The current study examines the role of maternal depression, both as PPD-symptoms and diagnosis of PPD, that is, PPD-diagnosis, in infants' expression of positive and negative emotions and the ability to shift between affective displays as an index of infant emotional variability. Given that PPD, which may be measured as both depressive symptoms and clinical diagnosis, is an affective disorder, we examined children's affective interactive behavior, that is, infant facial affect and vocal protest in addition to regulatory behavior, that is, gaze, which has previously been found to be affected by both maternal PPD symptoms and PPD diagnosis (Væver et al., 2015).

We formulated the following hypotheses: (1) In accordance with the depression inhibition hypothesis, we expected that higher maternal depressive symptoms would be related to infant inhibition of emotional expressions and gazing at the mother in mother–infant interactions. More specifically, we expected that (a) PPD-diagnosis and higher maternal depressive symptoms would be associated with shorter duration

of facial affective displays of the infant—both positive and negative—and longer duration of neutral facial affect when interacting with the mother, and (b) PPD-diagnosis and higher maternal depressive symptoms would be associated with shorter duration of vocal protest and shorter duration of gazing at the mother. Further, (2) in accordance with the MRM, we expected that (c) PPD-diagnosis and higher maternal depressive symptoms would be related to lower variability in infants' emotional expressions and gaze. Lower variability was defined as fewer events, indicating less switching between displays within each modality, that is, less switching between facial affective displays, vocal protest, and no vocal protest expressions, and also gazing at the mother and gazing away.

1 | METHOD

1.1 | Participants

All participants were informed (oral and written) about the project, and all participants signed a written consent before their inclusion in the study. The Institutional Ethical Review Board at the university where the study was conducted approved the project (approval number: IP-IRB /2014/02), and the study has been performed in accordance with the 1975 Helsinki Declaration as revised in 2008, as well as national ethical guidelines.

Participants in this study were 82 Danish mothers from urban Copenhagen and their firstborn children who were enrolled in a longitudinal study of interactional processes and children's socioemotional development. Dyads were eligible for participation if the infant was the mother's first child, born at term, singleton, and somatically well. Exclusion criteria were drug or alcohol abuse, psychotic symptomatology, the child having any major physical or mental disabilities after birth, or the mother developing any severe neurological or somatic illnesses within the first year postpartum. Of these mothers, 52 (63%) were mothers without psychopathology from a community sample and enrolled during pregnancy via an advertisement on webpages. The remaining 30 mothers were referred to the study based on a score within the clinical range (in this study a score of 10 or more) on the Edinburgh Postpartum Depression Scale (EPDS; Cox, Holden, & Sagovsky, 1987) in routine screenings by public health nurses in the home. Both groups filled in the EPDS in the postpartum period (6–14 weeks postpartum). In the nonclinical group, the EPDS was sent by mail to the mothers to be filled out in the home. The referred mothers in the clinical group filled out the EPDS at a visit in the university setting in the presence of a project team member. A PPD diagnosis (nonclinical vs. PPD) was confirmed using clinical interviews (see below). When infants were 4 months old, dyads participated in 10 min face-to-face interaction in the university laboratory. Of note, the face-to-face set up included registration of the mothers' and infant' movements (see below) using a motion capture system with 10 cameras in the room which required that the infant wore a cap and clothes with reflective markers. Also, the set up included a microphone on both mother and infant.

Background data were collected from birth records and questionnaires. Recruitment, sampling strategy, and flow of participants are described in more detail elsewhere (Smith-Nielsen et al., 2015).

Mothers were included in the current study when data were available regarding PPD and 4-month face-to-face interactions. For diagnosis group comparisons (nonclinical vs. PPD), we excluded 4 mothers from the nonclinical group because their EPDS score was ≥ 10, and two mothers from the PPD group because their EPDS score was < 10, leaving 48 nonclinical mothers and 28 mothers with a clinical PPD diagnosis for group comparisons. Facial affect was available for 82 infants, vocal protest was available for 80 infants, and gaze was available for 73 infants. Missing data were due to noncodable video or sound recordings, for example, not visible whether the infant looked at the mother or not.

The sample was well-educated and well-functioning, with almost half of the mothers having a university education, and only two single mothers (Table 1). All mothers were Caucasian, most of them with Danish nationality. About half of the infants were boys. Mean gestational age at birth and birth weight were in the normal range in concurrence with the eligibility criteria. The nonclinical and PPD groups differed only regarding postnatal depression score (t[80] –12.33, $p < .001$, equal variances assumed).

1.2 | Procedure

Mother–infant dyads were video-taped during a face-to-face interaction at 4 months. This is when the infant is at the beginning of the primary intersubjectivity period (up to 9 months), which is optimal for assessing infant engagement in face-to-face interactions (Tronick & Cohn, 1989; Beebe et al., 2008). The laboratory visit was scheduled to fit into the infants' eating and sleeping patterns, and the interaction was conducted between two feedings, so all infants were in an alert state. Infants were seated in an infant chair placed on a table, and mothers were seated opposite in a standard face-to-face setting (Tronick & Cohn, 1986). Mothers were instructed to talk and play with their infants as they would normally do. Each interaction was scheduled to last 10 min, but the interaction was terminated if the infant cried or fussed for more than 30 consecutive seconds. In 19 (23%) of the nonclinical dyads, the interaction was terminated before the full 10 min, and in the PPD group, this happened in 7 (8%) dyads. Two video cameras (Panasonic NV-GS300, PAL; 25 fps) filmed the frontal view of the infant and the lateral

TABLE 1 Sample characteristics

		All ($N = 82$)	Maternal PPD diagnosis	
			Nonclinical ($N = 52$)	PPD ($N = 30$)
Maternal age at child birth (years)	Mean (*SD*)	30.46 (4.02)	30.46 (4.02)	30.47 (4.08)
Maternal education (years)	Mean (*SD*)	15.56 (1.65)	15.75 (1.52)	15.21 (1.84)
Maternal educational level	% Low	14.6	13.5	16.7
	% Medium	40.2	34.6	50.0
	% High	45.2	51.9	33.3
Maternal EPDS score	Mean (*SD*)	8.94 (6.48)	4.98 (3.73)	15.80 (4.00)**
Maternal marital status	% Single	2.4	1.9	3.3
	% Married	43.9	42.3	46.7
	% Cohabiting	50.0	50.0	50.0
	% Other	3.7	5.8	–
Country of origin	% Denmark	92.7	94.2	90.0
Child sex	% Boy	50.0	48.1	53.3
Gestational age at birth (weeks)	Mean (*SD*)	40.42 (1.41)	40.55 (1.26)	40.18 (1.65)
Weight at birth (g)	Mean (*SD*)	3521 (493)	3555 (529)	3447 (438)

Note: PPD and nonclinical groups (based on PSE diagnosis) were compared using independent samples *t*-test for continuous variables and Pearson Chi-Square tests for categorical variables.

**$p < .001$. Gestational age was available for 79 dyads (96%; $N = 52$ nonclinical, $N = 27$ PPD). Birthweight was available for 78 dyads (95%; $N = 51$ nonclinical, $N = 27$ PPD).

view of the dyad, respectively. Audio recordings were made using head-mounted directional high-quality microphones; a DPA 4080 miniature cardioid microphone lavalier mount was used. The sound recorder was a 744T, Sound Devices.

For the microcoding of infant gaze, facial affect, and vocal protest, 3 min (min no. 2, 3, and 4) of the interaction was used. Studies using microanalysis for behavioral coding of mother–infant interaction typically use an observation period of 2–3 min, which has been shown to be sufficient for predicting the impact of maternal depression on infant behavior (e.g., Beebe et al., 2008; Field et al., 1990). For infant gaze and facial affect, we conducted continuous timed-event coding using the video annotation software ELAN (Lausberg & Sloetjes, 2009). Coders assigned codes continuously and recorded the duration of particular events to capture changes in infant gaze and facial affect behavior down to single video frame level (corresponding to 0.04 s/25 frames per second) as opposed to assigning codes to predetermined time intervals (Bakeman & Quera, 2011). Frame-by-frame coding provides an even more fine-grained approach than has been used in previous studies using a microanalytic paradigm, which mainly have used second-by-second coding (see, e.g., Beebe et al., 2010; Tronick & Reck, 2009). The acoustic analysis and labeling were carried out using the PRAAT phonetic analysis software (Boersma & Weenink, 2001). Infant and mother vocalization, respectively, were recorded in separate channels. Only data on infant vocal protest are reported in this study. For all modalities, all coders were psychology students trained to achieve and maintain acceptable levels of agreement, as indexed by a Kappa (K) of ≥ 0.60 and a percentage of agreement $\geq 80\%$ and blind for depression status.

1.2.1 | Maternal postpartum depression

Maternal PPD was assessed in two ways, that is, (a) as maternal postpartum depressive symptoms, assessed with the EPDS (Cox et al., 1987) and (b) as diagnosis derived from clinical interviews (nonclinical vs. PPD). Depressive symptoms were assessed with the EPDS, a 10-item self-rated questionnaire intended to assess the presence and severity of depression symptoms in postpartum women (range: 0–30, with higher scores indicating more symptoms). Women are asked to indicate how they have felt in the past 7 days, for example, "I have been anxious and worried for no good reason," on a 4 point Likert-Scale ranging from 0 ("Not at all") to 3 ("Yes, very often"). A score of 10 or higher indicates possible PPD, and further assessment is recommended (Hiscock & Wake, 2001; Murray, 1992). Good validity and sensitivity against a clinical diagnosis of depression have been reported (Boyce, Stubbs, & Todd, 1993; Cox et al., 1987; Murray & Carothers, 1990). In the current study, EPDS is used as a continuous score as an indication of severity of depressive symptoms.

In addition, maternal PPD is approached categorically, as mothers with a PPD diagnosis versus nonclinical mothers. Mothers' PPD diagnosis or nonclinical status was validated in a clinical interview, the Present State Examination (PSE, Wing, Cooper, & Sartorius, 1974) administered by a

clinical psychologist at enrollment. PSE is a standardized structured interview for clinicians widely used for diagnosing psychopathology (but not personality disorders/Axis-II disorders) according to the DSM-IV-TR. Also, the PSE was used to rule out alternative Axis-I disorders.

1.2.2 | Infant facial affect

Criteria for coding of infant facial affect were adapted from Beebe et al. (2010) and Koulomzin et al. (2002). Five behavioral categories were coded: (a) high negative, (b) mild negative, (c) neutral/interest, (d) low positive, and (e) high positive. High negative face was defined as eyebrows drawn together in a "classical frown," eyes squinting, mouth open and squarish in a pre-cry or "classical cry-face;" mild negative face was defined as inner corners of eyebrows raised, mouth corners down in a grimace, or lips squeezed tightly together in a "line-mouth;" neutral/interest face was defined as forehead smooth, eyes open, mouth relaxed open/closed, or slightly pursed; low positive face was defined as forehead smooth, eyes open, mouth corners curved up, mouth open or closed; and high positive face was defined as forehead smooth, cheeks raised, mouth corners drawn back and curved up in full display, or mouth fully open in a "gape-smile." Moreover, we added a "noncodable" category, which was used in situations where the infant's face was hidden, for example, by the mother's head or hand or the infant's own hand. The coding manual can be obtained upon contact to the corresponding author. A facial expression was considered as present if it lasted at least seven frames. For example, if an infant changed his/her facial expression from a gape-smile into mild negative face, and the face went through several emotional "states" in a few frames/milliseconds, these expressions would not be considered as discrete expressions, but as part of the facial muscles changing from one facial expression to another. Based on the coding, we calculated the total amount of time (seconds) of the different coding categories, that is, the total sum of seconds across the session. Infant facial affect variability was operationalized as the number of events in each code in each interaction. A randomly selected subset ($n = 24$; 29%; 9 PPD dyads and 15 nonclinical dyads) of the total set of codable files ($N = 82$) was double-coded for calculation of interrater-reliability (time-based $K = 0.82$, event-based $K = 0.63$; Bakeman & Quera, 2011). Means and standard deviations of the different facial affect codes can be found in Table 2.

1.2.3 | Infant gaze

Following the coding criteria from Beebe et al. (2010), we coded gazing at the mother's face (gaze on) or gazing away (gaze off). Gaze on was coded when the infant looked at the mother's facial area, and not necessarily just the eyes, for a minimum of two frames. Gaze off was coded when criteria for gaze on were not fulfilled. Blinking was not coded as gaze off unless it had a duration of more than seven frames. Situation where it was not possible to detect the infants' gaze due to the mother covering the face of infant was coded as noncodable. One minute of each interaction was double coded for interrater reliability (time-based $K = 0.88$, event-based $K = 0.68$; Bakeman & Quera, 2011). Based on the coding, we calculated the total amount of time (seconds) of the different coding categories, that is, the total number of seconds across the session. Infant gaze variability was operationalized as the number of gaze on, gaze off, and noncodable events and the total number of events in each interaction. Means and standard deviations for gaze can be found in Table 2.

1.2.4 | Infant vocal protest

Vocal protest was defined as any sound produced by the infant that expressed an affect within the negative spectrum––ranging from fuss and whimper to angry protest and cry and coded for onset and offset times, coded as present/absent (Beebe et al., 2008). Interrater reliability was calculated for 20% of each recording (time-based $K = 0.84$, event-based $K = 0.75$; Bakeman & Quera, 2011). Table 2 shows means and standard deviations for vocal protest.

1.3 | Statistical approach

The aim of this study was to examine whether maternal PPD was associated with infant facial affect, vocal protest, and gaze in a 4 month face-to-face interactions with the mother. Maternal PPD was analyzed in two ways, that is, as maternal depressive symptoms (PPD symptoms) and as maternal PPD diagnosis mothers with a PPD diagnosis versus nonclinical mothers. With this approach, we aimed to examine more subtle associations that may also take place within the nonclinical range of maternal depression, but which may also allow a more clinical interpretation of the findings.

First, we addressed the question whether maternal PPD symptoms and maternal PPD diagnosis were associated with (a) the total duration of infants' facial affective displays and (b) with the frequency of events of different facial affective displays: To assess associations between maternal PPD symptoms and infants' facial affective displays, we first ran multivariate regression analyses with maternal PPD symptoms as predictor. Outcome variables were (a) total duration (seconds) of infant facial affective states and (b) frequency (number) of events as an index of variability. For continuous outcome variables (total duration of seconds), we used linear regression analyses. For count variables (number of events, i.e., variability), we used Poisson regressions (Cameron & Trivedi, 1990; Dix et al., 2012). In accordance with previous literature (Dix et al., 2012), analyses were adjusted for child sex, child age, maternal educational level, and the amount of noncodable facial affect. We also included duration of the

TABLE 2 Descriptive statistics infant facial affect, gaze off, and vocal protest for the total sample, and according to maternal PPD diagnosis

		All		Maternal PPD diagnosis	
				Nonclinical	PPD
		M (*SD*)	% of total *M* (*SD*)	*M* (*SD*)	*M* (*SD*)
Infant facial affect					
Total duration (seconds)	High negative	13.80 (25.03)	7.80 (13.94)	17.65 (23.81)	9.96 (28.58)
	Mild negative	52.90 (33.99)	29.77 (18.73)	52.85 (32.41)	54.04 (36.80)
	Neutral/interested	74.16 (37.04)	41.69 (20.59)	69.81 (40.41)	78.66 (31.82)
	Low positive	16.48 (15.97)	9.16 (8.86)	15.94 (17.19)	14.97 (13.31)
	High positive	4.30 (8.04)	2.40 (4.46)	4.68 (8.40)	3.83 (8.26)
	Noncodable	15.82 (24.30)	9.18 (14.19)	14.83 (20.14)	18.54 (30.83)
Frequency (number of events)	High negative	3.79 (5.14)	7.20 (9.58)	4.83 (5.58)	2.46 (4.23)*
	Mild negative	17.05 (7.99)	31.07 (10.62)	16.40 (7.34)	17.96 (6.86)
	Neutral/interested	19.15 (8.37)	34.85 (11.04)	16.56 (7.47)	22.36 (8.33)**
	Low positive	9.30 (8.26)	15.43 (11.06)	8.69 (8.86)	9.46 (7.31)
	High positive	1.98 (3.04)	3.15 (4.52)	2.13 (3.32)	1.680 (2.74)
	Noncodable	4.23 (5.30)	8.30 (10.35)	4.48 (4.96)	4.36 (6.23)
Vocal protest					
Total duration (seconds)		48.27 (60.83)	10.39 (13.87)	61.63 (69.86)	30.61 (39.03)*
Frequency (number of events)		25.26 (28.83)	–§	32.06 (32.91)	15.88 (17.98)**
Gaze					
Total duration (seconds)	Gaze off	206.96 (48.64)	68.99 (16.23)	206.33 (50.09)	211.85 (46.79)
	Noncodable	10.47 (23.29)	3.49 (7.76)	14.73 (28.21)	3.45 (6.34)*
Frequency (number of events)	Gaze off	27.40 (12.24)	48.88 (2.52)	30.13 (12.91)	23.48 (9.41)*
	Noncodable	3.71 (6.35)	5.82 (8.60)	5.06 (7.47)	1.52 (2.58)**

Note: Diagnostic group differences tested with independent samples *t*-test, two-sided.

*$p < .05$; **$p < .01$.

§Percentage of total events could not be calculated because vocal coding was not divided into events. Only events of singing and vocal protest were coded. For diagnosis group comparisons (nonclinical vs. PPD), we excluded four mothers from the nonclinical group, because their EPDS-score was ≥ 10, and two mothers from the PPD group, because their EPDS score was < 10. Usable codings of infant facial affect were available for 76 mother infant dyads ($n = 48$ nonclinical and $n = 28$ with a PPD diagnosis), vocal protest were available for 74 mother–infant dyads ($n = 48$ nonclinical and $n = 26$ with a PPD diagnosis), and gaze codings were available for 71 mother–infant dyads ($n = 46$ nonclinical and $n = 25$ with a PPD diagnosis).

coded recordings as a control variable, as this slightly varied between subjects.

To facilitate clinical interpretation, we then compared infants of mothers with a PPD diagnosis and infants of nonclinical mothers with regard to (a) total duration (seconds) of affective states and (b) frequency (number) of events using Multivariate Analyses of Covariance (MANCOVA). Maternal PPD diagnosis (PPD diagnosis vs. nonclinical) was used as the independent variable. Two separate analyses were conducted, that is (a) with total duration (seconds) of affective states as dependent variables, and (b) frequency (number) of events as the dependent variable. Noncodable seconds/events, duration of the coded recording, child sex, child age, and maternal educational level were entered as covariates/fixed factors.

Second, we addressed the question whether maternal PPD symptoms and maternal PPD diagnosis were associated with (a) the total duration of infants' vocal protest and gazing away from the mother, and (b) with the frequency of events of vocal protest and gazing away from the mother We applied the same approach as described above: We first examined both total duration (seconds) of vocal protest/gazing away from the mother and the frequency (number) of events as a function of maternal depressive symptoms using linear and Poisson regression analyses. Second, we compared infants of mothers with a PPD diagnosis and infants of nonclinical mothers with regard to (a) total duration (seconds) of vocal protest and total duration (seconds) of gazing away from the mother, and (b) as the frequency (number) of events of vocal protest and gazing away from the mother, using MANCOVA as described above.

2 | RESULTS

2.1 | Descriptive statistics

Table 2 shows means for total duration (seconds) and frequency for the different infant facial affect states for the whole

group and separately for infants of mothers with a PPD diagnosis and infants of nonclinical mothers. With regard to infant facial affect, independent-sample *t*-tests indicated that infants of mothers with a PPD diagnosis had significantly fewer high negative events ($M = 2.46$, $SD = 4.23$) than infants of nonclinical mothers ($M = 4.83$, $SD = 5.58$, t [68.87] = 2.09, $p = .040$, equal variances not assumed), but infants of mothers with a PPD diagnosis had significantly more neutral/interest events ($M = 22.36$, $SD = 8.33$) than infants of nonclinical mothers ($M = 16.56$, $SD = 7.47$, t [74] = –3.13, $p = .003$). There were no differences between infants of mothers with a PPD diagnosis and infants of nonclinical mothers with regard to total duration (seconds) of different facial affect states.

With regard to vocal protest, we found that infants of mothers with a PPD diagnosis had fewer events of vocal protest ($M = 15.88$, $SD = 17.98$) than infants of nonclinical mothers ($M = 32.06$, $SD = 32.91$, t [71.98] = 2.73, $p = .008$, equal variances not assumed), and also the total duration (seconds) of vocal protest was shorter in infants of mothers with a PPD diagnosis ($M = 30.61$ s, $SD = 39.03$) than in infants of nonclinical mothers ($M = 61.63$ s, $SD = 69.86$, t [71.89] = 2.45, $p = .017$, equal variances not assumed). Finally, with regard to gazing away from the mother, independent samples *t*-tests showed that infants of mothers with a PPD diagnosis had significantly fewer gaze-off events ($M = 23.48$, $SD = 9.41$) than infants of nonclinical mothers ($M = 30.13$, $SD = 12.91$, t [69] = 2.27, $p = .027$), but the PPD diagnosis groups did not differ in total duration (seconds) of gazing away.

2.2 | Maternal depressive symptoms and infant facial affective displays

With regard to (a) the total duration of seconds of infants' facial affective displays, regression analyses using the continuous measures of maternal PPD symptoms as predictor showed no association of maternal PPD symptoms with the total duration (seconds) of different facial affect displays. However, with regard to (b) the frequency of events of infants' facial affective displays, Poisson regressions indicated that higher PPD symptoms were associated with fewer high negative events ($B = –0.05$, $SE = 0.01$, $p < .05$, see Table 3), and more mild negative events ($B = 0.009$, $SE = 0.004$, $p = .030$) and more neutral/interest events ($B = 0.023$, $SE = 0.004$, $p < .001$). This indicates that with increasing depressive symptoms of the mother, infants shifted more often within a more narrow range of facial affect displays (less often toward high negative). Maternal PPD symptoms were not associated with the frequency of low and high positive facial affect events.

We then compared infants of mothers with a PPD diagnosis and infants of nonclinical mothers with regard to total duration of seconds of infants' facial affective displays, and frequency of events of facial affective displays using multivariate generalized linear models (GLMs) adjusted for noncodeable events, duration of coded interaction, child sex, age of the child at assessment, and maternal educational level. Findings supported unadjusted comparisons of infants of mothers with a PPD diagnosis and infants of nonclinical mothers (see descriptive statistics, Table 2). With regard to (a) total duration of seconds of infants' facial affective displays, adjusted comparisons showed no significant differences between infants of mothers with a PPD diagnosis and infants of nonclinical mothers. However, with regard to (b) the frequency of events of infants' facial affective displays, analyses showed that infants of mothers with a PPD diagnosis had fewer high negative events (F[1,68] = 3.90, $p = .05$, partial $Eta^2 = .054$), but more mild negative and more neutral/interest events than infants of nonclinical mothers (F[1,68] = 8.69, $p = .004$, partial $Eta^2 = .113$) in adjusted models.

2.3 | Maternal depressive symptoms, infant vocal protest, and infant gaze

We then examined whether maternal depressive symptoms were also related to infant vocal protest and gaze. With regard to (a) total duration of seconds of infants' vocal protest and gaze, adjusted regression analyses showed that there was no association of maternal PPD symptoms with total duration (seconds) of vocal protest and total duration (seconds) of gazing away from the mother. However, with regard to (b) the frequency of events of infant vocal protest and gazing away from the mother, higher maternal depressive symptoms were associated with fewer vocal protest events ($B = –0.038$, $SE = 0.004$, $p < .001$) and with fewer gaze off events ($B = –0.012$, $SE = 0.004$, $p < .01$, see Table 4). Together, the unchanged duration of seconds and fewer events indicate that events were more sustained and thus that there was less variability in these behaviors.

We then compared infants of mothers with a PPD diagnosis and infants of nonclinical mothers with regard to (a) total duration of seconds and (b) frequency of events of infants' vocal protest and gazing away from the mother using multivariate GLMs. For vocal protest, multivariate GLMs adjusted for duration of coded interaction, child sex, age of the child at assessment, and maternal educational level supported unadjusted diagnostic group comparisons (see descriptive statistics, Table 2). There was no significant difference with regard to (a) total duration (seconds) of vocal protest. Similarly, for gaze off, GLMs adjusted for noncodeable seconds/events, child sex, age of the child at assessment, and maternal educational level showed no significant difference between infants of mothers with a PPD diagnosis and infants of nonclinical mothers with regard to the total duration (seconds) of gaze away from the mother

However, with regard to (b) frequency of events of vocal protest, infants of mothers with a PPD diagnosis had fewer

TABLE 3 Maternal depressive symptoms (EPDS score) in the postpartum period and infants' facial affect in 4 months interactions

	Maternal postpartum depressive symptoms ($N = 82$)			
Infant facial affect	***B* (*SE*)**	***ß***	**R^2**	***p***
Total duration (seconds)				
High negative	–0.44 (0.44)	–0.114	0.008	.321
Mild negative	0.01 (0.56)	0.002	0.000	.987
Neutral/interest	0.44 (0.61)	0.077	0.003	.477
Low positive	–0.03 (0.26)	–0.013	0.000	.900
High positive	0.02 (0.14)	0.019	0.002	.866
Frequency (events)	***B* (*SE*)**	**Exp (*B*)**	**95% CI Exp (B)**	***p***
High negative	–0.050 (0.010)	0.951	0.933; 0.970	.000
Mild negative	0.009 (0.004)	1.009	1.001; 1.017	.030
Neutral/interest	0.023 (0.004)	1.023	1.015; 1.031	.000
Low positive	0.010 (0.005)	1.010	0.999; 1.021	.076
High positive	0.003 (0.012)	1.003	0.980; 1.026	.826

Note: Results of linear regression (seconds) and Poisson regression (number of events) analyses with continuous maternal depressive symptoms (EPDS-score) as predictor; adjusted for child sex, infant age, maternal educational level, amount of noncodeable facial images, and total duration of the coded recording. R^2 = variance explained by continuous maternal EPDS score (entered at block 1) regardless of other variables.

TABLE 4 Maternal depressive symptoms (EPDS score) in the postpartum period and infant's vocal protest and gaze off mother in 4 months interactions

		Maternal postpartum depressive symptoms			
	N	***B* (*SE*)**	***ß***	**R^2**	***p***
Total duration (seconds)					
Vocal protest	79	–1.078 (1.086)	–0.114	0.020	.324
Gaze off	73	0.383 (0.845)	0.051	0.003	.651
		***B* (*SE*)**	**Exp (*B*)**	**95% CI Exp (*B*)**	***p***
Frequency (events)					
Vocal protest	79	–0.038 (0.004)	0.963	0.956; 0.970	.000
Gaze off	73	–0.012 (0.004)	0.988	0.980; 0.995	.001

Note: Results of linear regression (seconds) and Poisson regression (number of events) analyses with continuous maternal depressive symptoms (EPDS-score) as predictor; adjusted for child sex, maternal educational level, total duration of the coded recording, and the amount of noncodeable images (for gaze, seconds/events). R^2 = variance explained by continuous maternal EPDS score (entered at block 1) regardless of other variables.

vocal protest events than infants of nonclinical mothers ($F[1,66] = 4.69$, $p = .034$, partial $Eta^2 = .066$). Also, infants of mothers with a PPD diagnosis showed significantly fewer gaze off events than infants of nonclinical mothers ($F[1,64] = 4.18$, $p = .045$, partial $Eta^2 = .061$).

3 | DISCUSSION

In this study, in a sample of mothers with and without PPD, we examined whether PPD symptoms and PPD diagnosis were related to infants' expression of positive and negative facial affect and the ability to shift between affective displays as an index of infant emotional variability. We also examined infants' vocal protest and regulatory behavior, that is, gaze, in relation to maternal depressive symptoms and diagnosis during 4-month face-to-face interactions with the mother.

Neither maternal depression diagnosis nor maternal depressive symptoms were associated with differences in total duration of infant facial expressions or gaze off. Further, results showed that with increasing PPD symptoms infants had fewer events of high negative facial affect, gaze off, and vocal protest. This was supported in our analyses of maternal PPD diagnosis, where infants of mothers with a PPD diagnosis had fewer events of high negative facial affect, gaze off, and vocal protest than infants of nonclinical mothers. Finally, with increasing PPD symptoms, infants had more events of low negative and neutral/interest facial affect. This was partly supported by our analyses on maternal PPD diagnosis, where infants of depressed mothers with a clinical depression had more events of a neutral/interest facial affect than infants of nonclinical mothers. Only maternal depression diagnosis—but not maternal depressive symptoms—was associated with a lower total duration of vocal protest in infants.

These results indicate that maternal depression (symptoms and diagnosis) is associated with both higher variability in some behaviors (more events, more shifting between low negative and neutral/interest facial affect) and lower variability in other behaviors (fewer events, less shifting and more sustained behaviors in high negative facial affect, gaze off, and vocal protest) in infants at 4 months. Overall, these findings support and may be interpreted within the concept of the optimum midrange model, in which both too low and too high variability indicate difficulty in the infant's self-regulation (Beebe et al., 2010). Some of the findings also partly support the depressions inhibition hypothesis as well as the MRM.

First, we examined the duration of infant affective displays in terms of sum duration of seconds. In accordance with the depression inhibition hypothesis, we expected that infants' of mothers with PPD (symptoms and diagnosis) would show fewer seconds of positive and negative emotional expressions, fewer seconds of protest vocalizations, fewer seconds of gazing at the mother, but more seconds of neutral emotional expressions, compared to infants of nonclinical mothers. Our results showed that neither maternal PPD diagnosis nor PPD symptoms were related to the total duration of different infant facial affective displays and total duration of gaze off. However, PPD diagnosis was associated with fewer seconds of vocal protest, but PPD symptoms were not. Infants of mothers who fulfilled criteria for a PPD diagnosis spent half as much time in vocal protest compared to infants of nonclinical mothers. The fact that we find this in relation to PPD diagnosis and not in relation to PPD symptoms suggests the presence of a threshold effect, that is, the total duration of infant vocal protest may be affected only when a certain degree of severity in maternal depressive symptoms is beyond a certain threshold. This finding partly supports the depression-inhibition hypothesis as the lowered total duration of vocal protest in the infants of clinically depressed mothers may indicate that they have "given up" and have withdrawn from an unresponsive mother, that is, they inhibit the expression of their negative emotions.

Second, we examined the number of events and shifting between affective displays as an indicator of emotional variability. As suggested by MRM (Tronick & Beeghly, 2011), well-functioning parent–infant interactions are characterized by an ongoing process of emotional matches, mismatches, and repairs, accompanied by shifting infant emotions. The "messy" process promotes infant emotion regulation by giving the infant experiences with handling a variety of emotions and trust in his/her ability to handle stressful emotions (Gianino & Tronick, 1988; Tronick & Beeghly, 2011). Thus, in accordance with the MRM, we expected that infants of mothers with PPD (symptoms and diagnosis) would show lower variability of emotional expressions defined as fewer events. In line with this, we found that higher PPD symptoms were associated with fewer events of high negative facial affect, fewer gaze off events, and fewer vocal protest events. This was confirmed in the analysis of maternal PPD diagnosis, where infants of depressed mothers had fewer high negative facial affect events, fewer vocal protest events, and fewer gaze off events than infants of nonclinical mothers.

In contrast, we found that higher maternal depressive symptoms were associated with more mild negative and neutral/interest facial expressions and that infants of PPD mothers (both symptoms and diagnosis) showed more neutral/interest facial expressions than infants of nonclinical mothers. Thus, as the duration was not different, a lower frequency indicates more sustained and less variable behavior. Our results documented the presence of less variability within high negative facial affect, vocal protest, and gaze off. But, more variability within mild negative and interest facial affective expressions.

Because maternal depression (both symptoms and diagnosis) was associated with greater frequency of high negative facial expressions and gaze off, but not with the total seconds of duration of these events, if follows that high negative facial affect displays and gaze off events more sustained in infants of depressed mothers. More sustained high negative facial affect may indicate that infants of depressed mothers have more difficulties downregulating their negative emotions. Gaze off is the infant's way of regulating his or her social engagement and arousal level in early interactions (Field et al., 1990). Hence, more sustained gaze off may indicate that infants of depressed mothers are less able to shift between social engagement and disengagement. More sustained gaze off can be interpreted as an effort to regulate high arousal. In line with the MRM, these more sustained expressions of high negative facial affect and gaze off may be understood as a disturbance in infant self-regulation (Gianno & Tronick, 1988) in infants of depressed mothers.

Our findings of both lowered and heightened variability in the emotional expressions of infants of depressed mothers may be integrated within a midrange model, arguing that both (too) high and (too) low variability in behavior may be a risk factor for infant development (Beebe et al., 2010). In a recent study, Beebe et al. (2016) demonstrated the presence of a negative feedback loop between self- and interactive contingencies, suggesting that high levels of self-contingency (i.e., autocorrelation, a measure of how predictable a behavior unfolds within the individual) come at the expense of interactive involvement (i.e., cross-correlation, a measure of how predictable an individual's behavior is in relation to the interaction partner's previous behavior), and vice versa. Our findings suggest that infants of depressed mothers (symptoms and diagnosis) show more stability in high negative facial expressions and gaze off, less ability to shift, and lower stability in facial expressions of low negative and neutral/interest, an overly shifting process indicating reduced self-stability and predictability, interpreted as agitated. These findings support

the concept of an optimum midrange mode, where both the high and low poles of variability are not optimal.

In contrast to theories and previous findings that maternal depression is related to a general inhibition of emotional displays, both negative and positive (e.g., Dix et al., 2012), neither level of PPD symptoms nor PPD diagnoses were associated with infant expressions of positive facial affect in our study. However, it should be noted that, overall, in our study, infants of both nondepressed and depressed mothers expressed relatively little positive facial affect during the filmed interactions. Face-to-face interactions normally elicit positive facial affect in infants, and previous studies have found that infants smile approx. 20% of the time during social interactions (Messinger & Fogel, 2007). In our study, infants displayed positive facial affect approx. 13% of the time. Although it is unclear whether this difference is statistically significant, it raises questions about whether the specific set-up of the mother–infant interaction in our study (see the Methods section) may have restricted the interaction and inhibited eliciting joy, limiting our study in the examination of variables impacting positive infant affect.

Several study limitations have to be taken into account when interpreting our findings. First, the small sample size should be noted as a limitation, as it reduces the statistical power and generalizability of the results. Second, some studies indicate that depressed symptoms may differ across the postpartum period (e.g., Martin & Redshaw, 2018). In our study, the EPDS scores used in the analyses were filled in by the mothers with a quite wide time interval (6–14 weeks), and for the nonclinical group in the homes, which may have affected our results. Third, almost all of the infants except two (one in each group) were raised within a two-parent family. Because the impact of maternal depression is stronger in single-parent families (Goodman et al., 2011), it is likely that the effects found here would be different in a more heterogeneous sample. Additionally, we did not include fathers to assess the potential moderating effect of fathers on infants' emotional display. Future research should take this into account by also including fathers/partners. Fourth, the model presented in the introduction (stating that children's emotional expressions are formed by processes of mirroring, emotional contagion, and reinforcement by outcome and that children imitate or mimic the their depressed mothers) cannot be evaluated, as we did not include measures of maternal emotion communication (e.g., the mother's facial displays, touch, and vocalizing).Thus, we could not examine whether her emotional displays mediated the relations between maternal depressive symptoms and infants' facial displays. However, a previous study found the effects of maternal depression on children's affective displays independent of maternal emotional displays in the interaction (Dix et al., 2012). Also, we did not include a measure of infant temperament. Infants may react differently to environmental stress and infant temperament may impact and interact with maternal depression (Rode & Kiel, 2016). Fifth, examining only group differences in infant behavior and examining variability as the number of shifts between affective display events within the same modality does not tell us the full story of how and for whom maternal PPD impacts negatively on infant emotional variability. Future studies could include the examination of infant individual behavior state profiles (predominant behavior). Additionally, studies could use sequential analyses, such as auto-correlation, that could capture variability from one moment to the next and across modalities. Finally, infants in our study expressed little positive facial affect. Hence, findings with regard to positive facial emotions need to be interpreted with caution. The low amount of positive affect was presumably due to the specific interaction set-up in our study that may have restricted the interaction. If the mother and the infant interacted in a more natural setting, we would expect more joyful interactions with positive infant affect. Even though we did not find an association between maternal depression and infant positive facial affect, we cannot exclude the possibility that infants of depressed mothers may show inhibition of positive affect in interactions that are designed to elicit positive emotions, as predicted by the depression inhibition hypothesis (Dix et al., 2012).

Taken together, our findings support and extend previous findings that maternal depression is a risk factor for infant's emotional variability at 4 months. First, our study confirms previous findings that the effect of PPD on child emotional development may start already in the first year of life, and thus it is important to assess and monitor these effects on the infant. Already in the first year of life, infants make great strides in expressing emotions and acquiring a regulatory repertoire, and it has been suggested that exposure to maternal depression can be most detrimental for emotional development during the first months of life, when dependence on the mother is maximal and the infant's brain and social behaviors are shaped by patterns of maternal care (Granat et al., 2017). Future studies should address more explicitly the issue of the age of the infant to gain more knowledge to understand the inconsistencies in the literature regarding whether infants of depressed mothers are more or less vocally active and how this may be related to age: Do infants try harder initially and then give up? If so, at what age does this happen, and is this related to infant characteristics, such as temperament or other factors?

Second, we extended our investigation to include other modalities than facial affect display, that is, protesting vocally and disengaging by gazing away when interacting with the mother. Third, our focus on the frequency infant behaviors as an indicator of variability gives us more insight into the effects of maternal PPD on infant interactive behavior. For instance, our finding that the variability of gaze off, and not

the duration, was related to maternal depressive symptoms, points to the importance of emotional variability and the subtle dyadic disruption and repair regulatory processes, which form the ongoing daily experiences the infant has with his or her caregiver. Our findings may also have clinical implications, as depressed mothers of infants often are unaware of both their own and infant's behaviors in the ongoing matches and mismatches of emotion, and how they can contribute to the repairing of the disruptions. Thus, supporting the mother in seeing and understanding her child's emotional expression of needs and to explore ways in which she can meet these needs are essential in early interventions aiming at preventing adverse outcomes in infants of depressed mothers.

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ORCID

Mette Skovgaard Væver
https://orcid.org/0000-0002-9675-3423
Ida Egmose Pedersen
https://orcid.org/0000-0002-1157-6828
Johanne Smith-Nielsen
https://orcid.org/0000-0003-3571-6335

REFERENCES

Bakeman, R., & Quera, V. (2011). *Sequential analysis and observational methods for the behavioral sciences*. New York: Cambridge University Press.

Beebe, B., Jaffe, J., Buck, K., Chen, H., Cohen, P., Feldstein, S., & Andrews, H. (2008). Six-week postpartum maternal depression symptoms and 4-month mother–infant self- and interactive contingency. *Infant Mental Health Journal*, *29*(5), 442–471. https://doi.org/10.1002/imhj.20191

Beebe, B., Jaffe, J., Markese, S., Buck, K., Chen, H., Cohen, P., … & Feldstein, S. (2010). The origins of 12-month attachment: A microanalysis of 4-month mother–infant interaction. *Attachment & Human Development*, *12*(1–2), 3–141. https://doi.org/10.1080/14616730903338985

Beebe, B., Messinger, D. S., Bahrick, L. E., Margolis, A., Buck, K. A., & Chen, H. (2016). A systems view of mother–infant face-to-face communication. *Developmental Psychology*, *52*(4), 556–571. https://doi.org/10.1037/a0040085

Beeghly, M., & Tronick, E. (2011). Early resilience in the context of parent–infant relationships: A social developmental perspective. *Current Problems in Pediatric and Adolescent Health Care*, *41*(7), 197–201. https://doi.org/10.1016/j.cppeds.2011.02.005.

Bell, S. M., & Ainsworth, M. D. S. (1972). Infant crying and maternal responsiveness. *Child Development*, *43*(4), 1171–1190.

Boersma, P., & Weenink, D. (2001). *Praat speech processing software*. Institute of Phonetics Sciences of the University of Amsterdam. Retrieved from http://www.praat.org

Boyce, P., Stubbs, J., & Todd, A. (1993). The Edinburgh postnatal depression scale: Validation for an Australian sample. *Australian and New Zealand Journal of Psychiatry*, *27*, 472–476.

Boyd, R. C., Zayas, L. H., & McKee, M. D. (2006). Mother–infant interaction, life events and prenatal and postpartum depressive symptoms among urban minority women in primary care. *Maternal and Child Health Journal*, *10*(2), 139–148. https://doi.org/10.1007/s10995-005-0042-2

Braarud, H. C., Slinning, K., Moe, V., Smith, L., Vannebo, U. T., Guedeney, A., & Heimann, M. (2013). Relation between social withdrawal symptoms in full-term and premature infants and depressive symptoms in mothers: A longitudinal study. *Infant Mental Health Journal*, *34*(6), 532–541. https://doi.org/10.1002/imhj.21414

Cameron, A. C., & Trivedi, P. K. (1990). Regression-based tests for overdispersion in the Poisson model. *Journal of Econometrics*, *46*, 347–364. https://doi.org/10.1016/0304-4076(90)90014-K

Chabrol, H., Bron, N., & Camus, J. L. (1996). Mother–infant and father–infant interactions in postpartum depression. *Infant Behavior and Development*, *19*, 149–152.

Cohn, J. F., Matias, R., Tronick, E. Z., Connell, D., & Lyons-Ruth, K. (1986). Face-to-face interactions of depressed mothers and their infants. *New Directions for Child and Adolescent Development*, *1986*(34), 31–45. https://doi.org/10.1002/cd.23219863405

Compas, B. E., Jaser, S. S., Bettis, A. H., Watson, K. H., Gruhn, M. A., Dunbar, J. P., … Thigpen, J. C. (2017). Coping, emotion regulation, and psychopathology in childhood and adolescence: A meta-analysis and narrative review. *Psychological Bulletin*, *143*(9), 939–991.

Cox, J. L., Holden, J. M., & Sagovsky, R. (1987). Detection of postnatal depression—Development of the 10-Item Edinburgh Postnatal Depression Scale. *British Journal of Psychiatry*, *150*, 782–786.

Diamond, L. M., & Aspinwall, L. G. (2003). Emotion regulation across the life span: An integrative perspective emphasizing self-regulation, positive affect and dyadic processes. *Motivation and Emotion*, *27*(2), 125–156. https://doi.org/10.1023/A:1024521920068

Dix, T., & Meunier, L. N. (2009). Depressive symptoms and parenting competence: An analysis of regulatory processes. *Developmental Review*, *29*, 45–68

Dix, T., Meunier, L. N., Lusk, K., & Perfect, M. M. (2012). Mothers' depressive symptoms and children's facial emotions: Examining the depression-inhibition hypothesis. *Development and Psychopathology*, *24*, 195–210. https://doi.org/10.1017/S0954579411000770

Feldman, R. (2015). Sensitive periods in human social development: New insights from research on oxytocin, synchrony, and high-risk parenting. *Development and Psychopathology*, *27*, 369–395. https://doi.org/10.1017/S0954579415000048

Field, T. M. (1981). Infant gaze aversion and heart rate during face-to-face interactions. *Infant Behavior and Development*, *4*, 307–315

Field, T. (2010). Postpartum depression effects on early interactions, parenting, and safety practices: A review. *Infant Behavior and Development*, *33*(1), 1. https://doi.org/10.1016/j.infbeh.2009.10.005.

Field, T., Healy, B., Goldstein, S., & Guthertz, M. (1990). Behavior-state matching and synchrony in mother–infant interactions of nondepressed versus depressed dyads. *Developmental Psychology*, *26*(1), 7–14.

Field, T., Healy, B., Goldstein, S., Perry, S., Bendell, D., Schanberg, S., … Kuhn, C. (1988). Infants of depressed mothers show "depressed"

behavior even with nondepressed adults. *Child Development*, *59*, 1569–1579.

Field, T., Sandberg, D., Garcia, R., Vega-Lahr, N., Goldstein, S., & Guy, L. (1985). Pregnancy problems, postpartum depression, and early mother–infant interactions. *Developmental Psychology*, *21*(6), 1152–1156.

Field, T., Vega-Lahr, N., Scafidi, F., & Goldstein, S. (1986). Effects of maternal unavailability on mother–infant interactions. *Infant Behavior and Development*, *9*, 473–478

Friedman, D. D., Beebe, B., Jaffe, J., Ross, D., & Triggs, S. (2010). Microanalysis of 4-month infant vocal affect qualities and maternal postpartum depression. *Clinical Social Work Journal*, *38*(1), 8–16. https://doi.org/10.1007/s10615-010-0261-x

Gavin, N. I., Gaynes, B. N., Lohr, K. N., Meltzer-Brody, S., Gartlehner, G., & Swinson, T. (2005). Perinatal depression–A systematic review of prevalence and incidence. *Obstetrics and Gynecology*, *106*, 1071–1083.

Gianino, A., & Tronick, E. Z. (1988). The mutual regulation model: The infant's self and interactive regulation and coping and defensive capacities. In T. M. Field, P. M. McCabe, & N. Schneiderman (Eds.), *Stress and coping across development* (pp. 47–68). Mahwah, NJ: Erlbaum.

Goodman, S. H., Rouse, M. H., Connell, A. M., Broth, M. R., Hall, C. M., & Heyward, D. (2011). Maternal depression and child psychopathology: A meta-analytic review. *Clinical Child and Family Psychology Review*, *14*, 1–27. https://doi.org/10.1007/s10567-010-0080-1

Graham, K. A., Blissett, J., Antoniou, E. E., Zeegers, M. P., & McCleery, J. P. (2018). Effects of maternal depression in the still-face paradigm: A meta-analysis. *Infant Behavior and Development*, *50*, 154–164. https://doi.org/10.1016/j.infbeh.2017.12.001

Granat, A., Gadassi, R., Gilboa-Schechtman, E., & Feldman, R. (2017). Maternal depression and anxiety, social synchrony, and infant regulation of negative and positive emotions. *Emotion*, *17*(1), 11–27. https://doi.org/10.1037/emo0000204

Guedeney, A., & Fermanian, J. (2001). A validity and reliability study of assessment and screening for sustained withdrawal reaction in infancy: The Alarm Distress Baby Scale. *Infant Mental Health Journal*, *22*(5), 559–575. https://doi.org/10.1002/imhj.1018

Hiscock, H., & Wake, M. (2001). Infant sleep problems and postnatal depression: A community-based study. *Pediatrics*, *107*, 1317–1322.

Koulomzin, M., Beebe, B., Anderson, S., Jaffe, J., Feldstein, S., & Crown, C. (2002). Infant gaze, head, face and self-touch at 4 months differentiate secure vs. avoidant attachment at 1 year: A microanalytic approach. *Attachment & Human Development*, *4*, 3–24.

Laurent, H. K., & Ablow, J. C. (2013). A face a mother could love: Depression-related maternal neural responses to infant emotion faces. *Social Neuroscience*, *8*(3), 228–239. https://doi.org/10.1080/17470919.2012.762039

Lausberg, H., & Sloetjes, H. (2009). Coding gestural behavior with the NEUROGES-ELAN system. *Behavior Research Methods*, *41*(3), 841–849. https://doi.org/10.3758/BRM.41.3.841

Lovejoy, M. C., Graczyk, P. A., O'Hare, E., & Neuman, G. (2000). Maternal depression and parenting behavior: A meta-analytic review. *Clinical Psychology Review*, *20*, 561–592. https://doi.org/10.1016/S0272-7358(98)00100-7

Margolis, A. E., Lee, S. H., Peterson, B. S., & Beebe, B. (2019). Profiles of infant communicative behavior. *Developmental Psychology* https://doi.org/10.1037/dev0000745

Martin, C. R., & Redshaw, M. (2018). Establishing a coherent and replicable measurement model of the Edinburgh postnatal depression scale. *Psychiatry Research*, *264*, 182–191.

Matthey, S., Guedeney, A., Starakis, N., & Barnett, B. (2005). Assessing the social behavior of infants: Use of the ADBB scale and relationship to mother's mood. *Infant Mental Health Journal*, *26*(5), 442–458. https://doi.org/10.1002/imhj.20061

Mesman, J., van IJzendoorn, M. H., & Bakermans-Kranenburg, M. J. (2009). The many faces of the still-face paradigm: A review and meta-analysis. *Developmental Review*, *29*(2), 120–162. https://doi.org/10.1016/j.dr.2009.02.001

Messinger, D., & Fogel, A. (2007). The interactive development of smiling. *Advances in Child Development and Behavior*, *35*, 328–366.

Moe, V., Braarud, H. C., Wentzel-Larsen, T., Slinning, K., Vannebo, U. T., Guedeney, A., … Smith, L. (2016). Precursors of social emotional functioning among full-term and preterm infants at 12 months: Early infant withdrawal behavior and symptoms of maternal depression. *Infant Behavior and Development*, *44*, 159–168. https://doi.org/10.1016/j.infbeh.2016.06.012

Murray, L. (1992). The impact of postnatal depression on infant development. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *33*, 543–561. https://doi.org/10.1111/j.1469-7610.1992.tb00890.x

Murray, L., & Carothers, A. D. (1990). The validation of the Edinburgh Postnatal Depression Scale on a community sample. *British Journal of Psychiatry*, *157*, 288–290.

Murray, L., Fiori-Cowley, A., Hooper , R., & Cooper, P. (1996). The impact of postnatal depression and associated adversity on early mother–infant interactions and later infant outcome. *Child Development*, *67*, 2512–2526.

Murray, L., Halligan, S., & Cooper, P. (2010). *Effects of postnatal depression on mother–infant interactions and child development* (2nd ed., Vol. 2, pp. 192–220). Wiley-Blackwell Handbook of Infant Development.

Netsi, E., Pearson, R. M., Murray, L., Cooper, P., Craske, M. G., & Stein, A. (2018). Association of persistent and severe postnatal depression with child outcomes. *JAMA Psychiatry*, *75*(3), 247–253. https://doi.org/10.1001/jamapsychiatry.2017.4363

O'Hara, M. W., & McCabe, J. E. (2013). Postpartum depression: Current status and future directions. *Annual Review of Clinical Psychology*, *9*, 379–407. https://doi.org/10.1146/annurev-clinpsy-050212-185612

O'hara, M. W., & Swain, A. M. (1996). Rates and risk of postpartum depression—A meta-analysis. *International Review of Psychiatry*, *8*(1), 37–54.

Reissland, N., Shepherd, J., & Herrera, E. (2005). Teasing play in infancy: Comparing mothers with and without self-reported depressed mood during play with their babies. *European Journal of Developmental Psychology*, *2*(3), 271–283.

Rode, J. L., & Kiel, E. J. (2016). The mediated effects of maternal depression and infant temperament on maternal role. *Arch Womens Mental Health*, *19*(1), 133–140. https://doi.org/10.1007/s00737-015-0540-1

Smith-Nielsen, J., Steele, H., Mehlhase, H., Cordes, C., Steele, M., Harder, S., & Væver, M. S. (2015). Links among high EPDS scores, adult attachment interview responses and symptoms of personality disorders. *Journal of Personality Disorders* https://doi.org/10.1521/pedi_2014_28_173

Striano, T., Brennan, P. A., & Vanman, E. J. (2002). Maternal depressive symptoms and 6-month-old infants' sensitivity to facial expressions. *Infancy*, *3*(1), 115–126.

Trevarthen, C., & Aitken, K. J. (2001). Infant intersubjectivity: Research, theory, and clinical applications. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *42*(1), 3–48.

Tronick, E. Z., & Cohn, J. F. (1989). Infant–mother face-to-face interaction: Age and gender differences in coordination and the occurrence of miscoordination. *Child Development*, *60*(1), 85–92.

Tronick, E. Z., & Gianino, A. (1986). The transmission of maternal disturbance to the infant. In E. Z. Tronick & T. Field (Eds.), *Maternal depression and infant disturbance* (pp. 61–82). San Francisco, CA: Jossey–Bass.

Tronick, E., Als, H., Adamson, L., Wise, S., & Brazelton, T. B. (1978). Infants response to entrapment between contradictory messages in face-to-face interaction. *Journal of the American Academy of Child and Adolescent Psychiatry*, *17*, 1–13. https://doi.org/10.1016/S0002-7138(09)62273-1.

Tronick, E., & Beeghly, M. (2011). Infants' meaning-making and the development of mental health problems. *American Psychologist*, *66*(2), 107. https://doi.org/10.1037/a0021631

Tronick, E., & Reck, C. (2009). Infants of depressed mothers. *Harvard Review of Psychiatry*, *17*, 147–156. https://doi.org/10.1080/10673220902899714

Væver, M. S., Krogh, M. T., Smith-Nielsen, J., Christensen, T. T., & Tharner, A. (2015). Infants of depressed mothers show reduced gaze activity during mother–infant interaction at 4 months. *Infancy*, *20*(4), 445–454. https://doi.org/10.1111/infa.12082

Weinberg, M. K., Olson, K. L., Beeghly, M., & Tronick, E. Z. (2006). Making up is hard to do, especially for mothers with high levels of depressive symptoms and their infant sons. *Journal of Child Psychology and Psychiatry*, *47*, 670–683.

Weinberg, M. K., & Tronick, E. Z. (1998). Emotional characteristics of infants associated with maternal depression and anxiety. *Pediatrics*, *102*(Supplement E1), 1298–1304.

White, H., Flanagan, T. J., Martin, A., & Silvermann, D. (2011). Mother–infant interactions in women with borderline personality disorder, major depressive disorder, their co-occurrence, and healthy controls. *Journal of Reproductive and Infant Psychology*, *29*(3), 223–235. https://doi.org/10.1080/02646838.2011.576425

Wing, J. K., Cooper, J. E., & Sartorius, N. (1974). *Measurement and classification of psychiatric symptoms: An instruction manual for the PSE and Catego program*. Cambridge: Cambridge University Press.

Wörmann, V., Holodynski, M., Kärtner, J., & Keller, H. (2012). A cross-cultural comparison of the development of the social smile: A longitudinal study of maternal and infant imitation in 6- and 12-week-old infants. *Infant Behavior and Development*, *35*(3), 335–347. https://doi.org/10.1016/j.infbeh.2012.03.002.

Zero to Three: Making it Happen. (2012). Retrieved from www.zerotothree.org/public-policy/federal-policy/early-child-mental-health-final-singles.pdf

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