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Maternal Depressive Symptoms Predict Girls' but Not Boys' Emotion Regulation: A Prospective Moment-to-Moment Observation Study

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Abstract

We aimed to further the understanding of maternal depressive symptoms on temporal dynamics of child emotion regulation by applying the process model of emotion regulation to preschoolers and incorporating insights from children's moment-to-moment emotional expressions. Following 108 mother–child dyads (57 girls; 72 mothers identified as White, 23 mothers as Black or African American, 10 mothers as multi-racial, 3 mothers did not report their race) from child age three (T1; $M_{child\ \mathrm{age}} = 3.23$; $SD = 0.19$) to four years old (T2; $M_{\mathrm{age}} = 4.21$; $SD = 0.15$), we asked whether T1 maternal depressive symptoms predicted T2 boys' and girls' faster transitions into and slower transitions out of negative emotion displays when children were frustrated. The results from multilevel Cox Regression models for latencies and durations of emotion displays showed that child gender moderated the associations between maternal depressive symptoms and latencies of child emotion displays for sadness but not anger. Higher levels of maternal depressive symptoms predicted faster transitions into sadness only for girls but not for boys. The findings suggested that girls of mother with elevated depressive symptoms showed impairment in antecedent-focused emotion regulation of sadness.

Keywords Emotion regulation · Maternal depressive symptoms

The development of emotion regulation capacity, especially when encountering the ordinary challenges of everyday life, is one of the essential tasks in early childhood (Cole et al., 2018). Young children rapidly gain the capacity to self-regulate their own emotions, which contributes to long-term and short-term benefits in multiple domains, including school adaptation (Eisenberg et al., 2010). Greater emotion regulation capacity in early childhood has far-reaching implications for later adjustment, including better social skills, more successful relationships, and greater psychological well-being (Graziano et al., 2007; Hill et al., 2006; Penela et al., 2015).

Emotion regulation is inherently a dynamic process (Cole et al., 2018; Morris et al., 2018). Emerging evidence suggests the importance of dynamic features, such as the sequencing and recurrence of emotional display, in understanding emotion regulation (e.g., Dagne & Snyder, 2011), yet in developmental literature there is a lack of comprehensive theoretical framework to guide research of the temporal dynamics of child emotion regulation (for notable exceptions see Cole et al., 2011; Lougheed et al., 2019). The lack of theoretical foundation impedes the understanding of the child emotion regulation development in family contexts. For example, the temporal dynamics of child regulatory deficits related to maternal depressive symptoms are poorly understood. Although it has been well-established that maternal depressive symptoms pose considerable

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risks to children's emotion regulation (Goodman et al., 2011), this understanding is limited to the summary-level information of children's emotion and emotion regulation. Up until now, most of the knowledge on the effect of maternal depression is about how it affects children's general reactions to emotional stimuli. However, the process matters—it is important to understand how children's emotional experiences evolve when stimulated (Cole et al., 2018), because emotion regulation strategies not only influence discrete emotional experiences (i.e., feeling of sadness or anger), but also influence the intensity, the onset, and recovery speed of emotional responses (Silk, 2019; Thompson, 1994). It has been unclear how the processes of child emotion regulation are vulnerable to the influence of maternal depression. Maternal depression is an affective disorder that tends to manifest as dysregulated sadness and/or lack of pleasure (Sohr-Preston, & Scaramella, 2006). The difficulties in mothers' regulation of sadness associated with maternal depression may influence the evolution of children's responses to emotional stimuli over time. The current study investigates the dynamics of child emotion regulation as indicated by the nuanced temporal features of emotion expressions and focuses on their associations with maternal depressive symptoms.

Emotion Regulation as a Dynamic Process

Emotion regulation is a series of internal and external goal-directed processes related to the monitoring, evaluation, and modification of one's emotional reactions, with specific attention to the intensity and time course of emotions (Thompson, 1994). In the adult literature, the process model of emotion regulation broadly categorized emotion regulation strategies as *antecedent-focused* and *response-focused* (Gross & John, 2003), which could facilitate the understanding of emotion regulation as a dynamic process. Antecedent-focused emotion regulation refers to regulatory efforts before the emotional responses are fully activated (e.g., situation selection, situation modification, attention deployment, and cognitive reappraisal; Gross & John, 2003). Response-focused emotion regulation refers to efforts to modulate the experiential, behavioral, and physiological responses involved in the emotional expressions (e.g., suppression; Gross & John, 2003).

The process model focuses on the dynamic process of emotion regulation, but has only been applied to research among adults. Although the notion has not been widely adopted in the developmental literature, accumulating evidence has suggested children have the capability to generate, understand, and use these antecedent-focused and response-focused strategies such as distraction and suppression (Cole et al., 2009; Feng et al., 2008). Applying this model to preschoolers may facilitate the connection between developmental and adult literature and our understanding of the dynamic emotion regulation processes in early childhood.

Some often-studied aspects of children's observed emotion regulation, including the presence of emotion displays (binary), number of occurrences (count), and proportions of well-regulated time (percentage), have provided valuable insights on how well children regulate their emotions (e.g., Feldman, 2015). Beyond these aggregate-level factors, the dynamics of emotion processes can be captured by more nuanced indicators extracted from the intensive time-series data on children's emotional experiences. In this study, we operationalize antecedent-focused emotion regulation capacity to be the observed latencies of negative emotion expressions in emotion eliciting situations. Longer latencies indicate a more effective regulatory effort to prevent negative emotion outbursts, and therefore a stronger ability for *antecedent-focused* emotion regulation. We operationalize *response-focused* emotion regulation capacity to be the duration of emotion expressions – how long it takes children to effectively down-regulate negative emotion expressions after the negative emotion has emerged (Dagne & Snyder, 2011). These time-related indicators represent the outcome and effectiveness of the regulatory process, hence may provide nuanced insights into how well children can regulate their emotions through the deployment of antecedent-focused and response-focused strategies. The intensive time-series data allows for the examination of these indicators on emotion regulation. Notably, these indicators can be used to compare emotion regulation across different developmental stages. Using latencies and durations of anger expressions as indices for regulation, Cole et al. (2011) reported developmental changes in anger expressions from infancy through early childhood. From 18 to 48 months, children display longer latencies to anger and briefer durations of anger as they age (Cole et al., 2011). Longer latency to anger was associated with the preschoolers' better deployment with distraction, an appropriate regulatory strategy (Cole et al., 2011). Moreover, shorter latencies to cry among 18-month-old toddlers were included as part of the composite for greater levels of distress to frustrating tasks, which were associated with higher levels of aggressive behaviors and fewer use of adaptive strategies (Calkins & Johnson, 1998).

Maternal Depressive Symptoms and Child Emotion Regulation

Maternal depressive symptoms pose risks for child emotion regulation development. Mother–child interactions constitute a large proportion of young children's everyday emotional experiences. Parents shape children's emotion regulation through at least three pathways (Morris et al., 2007): a) children observe and model parents' behaviors, and learn how to handle emotion through imitation (Bandura, 1978); b) parental emotion socialization practices and behaviors play a direct role in children's emotion regulation and emotional reactivity (Eisenberg et al., 2001); and c) parents set an emotional climate, which is an important part of children's day-to-day experience and contributes to children's emotional development through facilitation or disruption of the formation of secure attachment (Yan et al., 2017). Depressive symptoms may compromise parents' capacity to help young children develop effective emotion regulation skills. Depressed individuals tend to have difficulties of regulating their own emotions (Goodman & Gotlib, 1999), and thus may not model effective emotion regulation for their children. As maternal depressive symptoms increase, disengaging, unpredictable, coercive, and insensitive mother–child interactions become more common (Feng et al., 2007; Lovejoy et al., 2000). Mothers' depressed mood may also affect the family emotional climate (Yeh et al., 2016). In turn, the development of emotion regulation is affected.

Indeed, maternal depression is a well-established risk factor for impairments in child emotion regulation (Blandon et al., 2008; Feng et al., 2008; Goodman et al., 2011). A study on mothers with childhood-onset depression revealed that maternal depression was associated with impaired offspring emotion regulation abilities, especially for daughters (Silk et al., 2006), and for children more behaviorally inhibited in temperament (Feng et al., 2008). Maternal depressive symptomatology also predicted compromised development of emotion regulation among young children in community samples across the ages of 4 to 7 (e.g., Blandon et al., 2008). Yet it has been unclear how maternal depression would be associated with children's antecedent-focused and response-focused emotion regulation. Studying these associations may help gain a general understanding of how maternal depression affects the specific emotion regulation strategies within the two broad categories, given the distinctive features of antecedent-focused and response-focused emotion regulation (Goldin et al., 2008; Gross & John, 2003). Depressed individuals tend to have problems with antecedent-focused emotion regulation (LeMoult & Gotlib, 2019)—they are less likely to employ cognitive reappraisal as a strategy to prevent emotional outbursts (LeMoult & Gotlib, 2019) but more likely to ruminate and experience difficulty in disengaging from distressing stimuli (LeMoult & Gotlib, 2019). The patterns in response-focused emotion regulation associated with depression are more diverse, with some individuals showing prolonged sadness and others displaying flat affect (Sohr-Preston & Scaramella, 2006). Given that children may model how their parents regulate their emotions, maternal depressive symptoms may be a particularly strong predictor for children's deficits in antecedent-focused emotion regulation.

Sex Differences

The association between maternal depression and offspring's emotion regulation deficits was stronger for daughters than sons (e.g., Silk et al., 2006), which suggested the vulnerability to maternal depressive symptoms was not unisex. From a social constructionist perspective, Brody (1999) proposed that both biologically based predispositions (e.g., genetic differences) and gender socialization contribute to sex differences in emotion expression. Because of the gendered display rules that Western society imposes on individuals, boys are allowed to express their anger and other externalizing-oriented emotions (Chaplin & Aldao, 2013). Sex differences are also apparent in the effect of maternal depressive symptoms on child development (Zahn-Waxler et al., 2008). Meta-analytic results have shown that maternal depressive symptoms were more predictive of girls' psychopathology than boys' psychopathology (Goodman et al., 2011). This may be due to mothers' differential socialization of boys' and girls' emotion expressions (Chaplin & Aldao, 2013; Lytton & Romney, 1991; Sheeber et al., 2002; Silk et al., 2006), reinforcing girls' sadness more often than boys' sadness. Mothers' influence as role models may also be stronger for girls than boys (i.e., same-sex offspring; Sheeber et al., 2002). Boys tend to cope with stress by problem-solving, whereas girls tend to cope with stress by seeking social support (Sala et al., 2014), as they have been socialized and encouraged to do (Sheeber et al., 2002). Such a tendency could amplify girls' vulnerability to maternal depressive symptoms. Therefore, maternal depressive symptoms may be more strongly predictive of girls' than boys' emotion regulation dynamics.

The Current Study

We attempt to further the understanding of maternal depressive symptoms and child emotion regulation by incorporating insights from children's moment-to-moment emotional expressions. The individual variation in the temporal features of emotion experience may meaningfully predict long-term functioning (Nelson et al., 2020). The intensive time-series data of emotion expressions provide information that closely reflects the effectiveness of antecedent-focused and response-focused emotion regulation strategies (Gross & John, 2003). Besides, through preschooler years, children gradually engage more in active emotion regulation and rely less on other people to regulate their emotion experiences (Grolnick et al., 2006). We focused on the preschoolers' emotion expressions in a frustrating context, because depression involves the dysregulation of both anger and sadness, and the ability to manage sadness and anger in frustrating situations is an important asset for preschoolers (Blair, 2002; Ros & Graziano, 2019). Taken together, we tested these hypotheses. Maternal depressive symptoms at T1 would predict: *faster transitions into* (i.e., shorter latencies) and *slower transitions out of* (i.e., longer durations) negative emotional states at T2 (indicative of poorer emotion regulation abilities), when young children are faced with a frustrating task. The associations may be stronger for girls.

Method

Participants

Data were drawn from a larger longitudinal study of 126 children (65 girls) and their mothers conducted in a Midwestern U.S. city focusing on maternal depression and preschoolers' socioemotional adjustment (Hooper et al., 2015). To over-sample mothers with elevated depressive symptoms, mothers who were interested in participating were screened with the Center for Epidemiological Studies Depression Scale (CES-D; Radloff, 1977). At the time of enrollment, mothers' CES-D scores ranged from 0 to 51 ($M = 15.05$; $SD = 12.60$). Fifty-five mothers (43.7%) scored above the clinical cut off (16) on the CES-D, indicating an elevated level of depressive symptoms. Eligibility criteria for participation included 1) for mothers, no previous diagnosis of psychiatric disorder other than depression or comorbid depression and anxiety, and 2) for children, no previous diagnosis of developmental delay or disorders, and between the age of 3 and 3.5.

Among the 126 participating families, 109 mother–child dyads re-visited the lab one year later and completed a follow-up assessment. At the follow-up assessment, the mean score of CES-D was 14.07 ($SD = 11.18$). Thirty-three mothers scored above the clinical cutoff (16). One of the 109 children did not complete the task that we used in this study due to child refusal. The remaining 108 families (57 girls) were included in the current study. Most mothers were married (57.41%), with the remaining 14.81% living with a partner, 12.96% separated/divorced/widowed, and 14.81% never married/single. About half of the mothers (54.62%) had completed a Bachelor's degree and the remaining half (43.53%) had a high school diploma or GED. Three mothers in the sample did not identify their race, whereas 10 mothers identified with more than one race. Of the remaining 95 mothers, 72 mothers identified as White, and 23 mothers identified as Black or African American. The income-to-needs ratio (family income divided by the federal poverty line for the family size for the year of the data collection) ranged from 0.14 to 8.26 (median = 2.02). About a third of families (36.11%) had an income-to-needs ratio greater than 3, indicating middle-class status; 25% and 24.07% had an income-to-needs ratio between 1 and 2, indicating low-income status, and lower than 1, indicating poverty status, respectively. Mothers' occupational prestige was coded with Hollingshead's (1975) Four Factor Social Index (ranged from 0 to 9; $M = 4.56$; $SD = 2.89$). Fathers occupational prestige also ranged from 0 to 9 ($M = 5.26$; $SD = 2.60$). A higher score represents higher prestige (i.e., a score of 9 represents higher executives, proprietors of large businesses, and major professionals, whereas a score of 1 represents farm laborers/menial service workers.

Procedures

Participants were recruited via posting online ads and distributing flyers at daycare centers and throughout the community. Data were collected when children were at age 3 years (T1; $M = 3.23$; $SD = 0.19$) and 4 years (T2; $M = 4.21$; $SD = 0.15$). The mean age of boys (4.21) and girls (4.22) did not differ (t (105.56) = 0.17, $p = 0.87$, $d = 0.03$). At T1, mothers completed surveys on demographic information and depressive symptoms. At T2, children participated in a modified version of the Attractive Toy in the Transparent Box task (Lab-TAB; Goldsmith et al., 1995) designed to elicit frustration. Each child was asked to select one of two attractive toys to play with. A researcher locked the chosen toy in a transparent box with two numbered locks and gave two sets of keys (also numbered) to the child. The child was then told that they needed to unlock the two locks in the given order to be able to play with the chosen toy. The box was designed so that only the first lock could be opened. The researcher left the child alone in the room to try to open the box for 4.5 min while being recorded. After 4.5 min the researcher came back to the room, tried to open the box, failed, and told the child the second lock was broken. The child was then allowed to play with the other attractive toy for a while. All mothers provided informed consent and permission for their children to participate. Child assent was also obtained at the beginning of the laboratory visit. All procedures were approved by The Ohio State University's institutional review board.

Measures

Maternal Depressive Symptoms (T1). Mothers completed the 21-item Beck Depression Inventory (BDI-II; Beck et al., 1996) to measure the existence and severity of depressive symptomatology over the past two weeks. Each item of the BDI-II comes with a set of 4 statements as responses

Fig. 1 The visualization of micro-coded emotion expressions for all children participating in the task of attractive toy in the transparent box. See the online article for the color version of this figure

describing the severity (0 = *absent or mild*, 3 = *severe*) of a symptom (e.g., sad, pessimistic, fatigue, guilty feelings, loss of interest). A sum score was computed to indicate overall severity of depressive symptomatology. In the present study, the internal consistency of the inventory was high (α = 0.93).

Child Temperament (T1). Children's temperamental negative affectivity was measured with the sum score of four subscales from *Child Behavior Questionnaire – Short Form* (CBQ-SF; Rothbart et al., 2001): anger/frustration (6 items), discomfort (6 items), fear (6 items), sadness (7 items), and soothability (reverse scored; 6 items). A higher score reflects greater level of negative affectivity. The internal consistency of this scale was high (α = 0.85).

Child Emotion Expressions (T2). Children's emotional displays during the Attractive Toy in the Transparent Box task were video recorded and coded second-by-second with an event-based system (i.e., a code was given when affect changed). As a result, the child's emotion expression for each second of the task was categorized as one of the following emotional states: anger/frustration, sadness, fear, positive, neutral, or non-codable (i.e., child's face moved out of sight of the camera). These categories were mutually exclusive and collectively exhaustive over the course of the task (see Fig. 1 for the visualization of coded emotion categories during the task for all participating children, with each child represented by one horizontal line). When the child's face was obscured or out of view of the camera (usually when the children were facing downward towards the transparent box and focusing on opening it), their facial expressions was labeled as non-codable in these periods [mean percentage of non-codable period = 19%; 25th, 50th, and 75th percentile = 2%, 12%, and 29%].

We focused on the two types of negative emotions given their frequent occurrence: anger/frustration and sadness. For the coding of both anger and sadness, facial expressions, tone of voice, gestures, and verbal statements were considered. At any point during the task, the child was coded as displaying anger/frustration if at that moment the child displayed a tight angry face, drawn eyebrows, physical aggression (e.g., throwing or hitting the toy, stamping feet), or vocally expressed anger through yelling, screaming, sarcastic or hostile voice tone, or made affectively charged negative statements that indicated anger or frustration (~ blinded ~). Examples of expressions coded as sadness included frowning, pouting, droopy eyes, crying, whining, heavy sighing, and hanging the head (~ blinded ~). With approximately a fourth of the observations being double-coded, the reliability (kappa) was 0.81 for anger and 0.84 for sadness.

Antecedent-Focused Emotion Regulation. The latencies to emotion expressions reflect children's regulatory capacity before the emotions are fully activated and expressed (i.e., antecedent-focused emotion regulation). The latencies to anger and sadness expressions represent antecedent-focused regulation of anger and sadness, respectively. The following formula was used to compute the latencies, which captures the number of seconds from the beginning of the task or the end of a previous expression to the start of a new expression. Specifically, the latencies to recurring sadness and anger events were also included in the study because they represent additional occurrence of ineffective antecedent-focused emotion regulation (attempted or not).

$$Time_k = \begin{cases} start\ time\ of\ k^{th}\ anger\ /sadness\ expression,\ for\ k\ =\ 1; \\ start\ time\ of\ k^{th}\ anger\ /\ sadness - expression\ stop\ time\ of\ (k-1)^{th}\ anger\ /\ sadness \\ expression,\ for\ k\ =\ 2,\ 3, \ldots .number\ of\ anger/sadness\ occurrences \end{cases}$$

Response-Focused Emotion Regulation. The durations of emotion expressions reflect children's ability to down-regulate anger and sadness once the emotions are experienced, and were represented by the number of seconds between the start and the end of anger/sadness expressions (Time_k = stop time of k^{th} anger/sadness expression – start time of k^{th} anger/sadness expression, for $k = 1, 2, \ldots,$ Number of anger/sadness occurrences).

Demographic Variables (T1). Mothers reported their age, education level, race, family income, marital status, their partner's education level and income (if applicable). Household socioeconomic status was computed by combining the occupational prestige (coded with Hollingshead's (1975) Four Factor Social Index; ranging from 0 to 9) and education level (ranging from 1 to 8).

Analytical Approach to Emotion-Related Event Time: Multilevel Survival Analysis

Multilevel-survival analysis was used to model the emotion-related event time as the outcome of interest. Examples of emotion-related event time include time until the first occurrence of negative emotion expression, time from the recovery until the relapse into the next negative emotion display, and durations of negative emotional displays. To accommodate two main features of emotion-related event time—asymmetric truncated distributions and censoring – we used survival model to examine the individual differences in antecedent-focused and response-focused emotion regulation, as indicated by the event time. A participant is censored if the event is not observed for them over the course of the study observation. The event time is unknown/missing. Yet, the event may happen after the end of the study. In that case, the event time is an unknown value greater than the length of study. In the context of the current study, the emotion expressions of interest may or may not occur during the few minutes that children were observed. If we do not observe an anger expression, it does not necessarily mean that the child never expresses anger when frustrated. Rather, it may have taken longer than the timeframe of observations for them to display anger.

Survival analysis, also called time-to-event data analysis, is well suited to handle this type of data (Aalen et al., 2008). The use of Cox proportional hazard models (or Cox regression analysis; Cox, 2018) in analyzing behavioral durations in continuously-recorded social behaviors was first proposed by Griffin and Gardner (1990). Stoolmiller and Snyder (2006) further developed the idea of using survival analysis in social behavior modeling, by introducing the multilevel framework to accommodate the complexity in social behavior dynamics, such as the *recurrence* of events. Namely, the expression of emotions may occur more than once, and the latencies to the emotion displays of the same child are not independent, instead, they are nested within individuals. Therefore, a multi-level Cox proportional hazard model (i.e., shared frailty model) is used to model the hazard rates of event occurrences nested within individuals.

Analysis Plan

Data Preparation. The micro-coded observation data were restructured into a form suitable for survival analysis. In particular, each event of interest constituted a row in the dataset. Each row consisted of the following information regarding the event: participant ID, event time (i.e., latency or duration of emotion expressions; see the Survival Analysis section in Analysis Plan), censoring indicator, event type, maternal depressive symptoms, maternal anxiety symptoms, and demographic variables.

The censoring indicator was created with the following considerations: if the child did not display any of the emotions of interest within the 4.5 min, the event time until the emotional display was right-censored at 270 s. For any emotional states followed with "non-codable", the event was right-censored at the start of "non-codable" time, because we only knew that the emotional state persisted until that time, rather than when exactly the emotional state ended. Right-censoring is not a problem for survival analysis as long as the censored events are correctly identified.

Survival Analysis. Kaplan–Meier Estimators were used to estimate the survival function of time until the first anger/frustration display and sadness display (i.e., latencies to emotion expressions; hypothesis 1), as well as the time each child took to down-regulate their first anger/frustration display and sadness display and transition back to neutral (i.e., durations; hypothesis 2). Notably, only those children who expressed anger or sadness at any given time were included in the analysis testing hypothesis 2.

Cox's proportional hazard model is the most frequently used class of models in survival analysis. It models the *hazard rate* (i.e., probability of an event occurring at any given time t, denoted as $\lambda(t)$) as a function of the design matrix of p covariates (i.e., $X=[1, X_1, X_2, \dots X_p]$):

$$\lambda(t|X) = \lambda_0(t)exp(X\beta)$$

For example, for hypothesis 1, the event of interest is the latency of anger expressions, the hazard rate [$\lambda(t)$] describes the probability of an anger outburst beginning at time t. The baseline hazard rate $\lambda_0(t)$ represents the hazard rate when all covariates (i.e., $X_1, X_2, \dots X_p$) are equal to zero. Each element in the coefficient vector β (i.e., $\beta_1, \beta_2, \dots, \beta_p$) represents the increase in the natural log of predicted hazard rate $\left[\ln\left(\hat{\lambda}(t)\right)\right]$ for each unit increase in the corresponding covariate (i.e., $X_1, X_2, \dots X_p$), holding all other covariates constant.

To account for the nesting structure of recurring events within individuals, we used the shared frailty model:

$$\lambda(t|X, Z) = \lambda_0(t)exp(X\beta + Zb)$$

$$b \sim N(0, \Sigma(\theta))$$

Here, Z represents the design matrix for the random effect (where $Zij=1$ if event i is nested in individual j). The vector b represents the coefficients for the random effect (the shared variance in event hazard rate due to clustering within the same individual), which follows a normal distribution with mean 0 and variance $\Sigma(\theta)$.

To examine the association between maternal psychopathology (i.e., maternal depressive and anxiety symptoms) and emotion regulation of boys and girls, we conducted stepwise multi-level survival analysis using the *coxme* function in the R package *coxme* (Therneau, 2018):

Step 1:

$$\lambda_i(t|X, Z) = \lambda_{oi}(t)\,exp\,(\beta_1 MotherDepression_i + \beta_2 ChildSex_i + Zb)$$

$$b \sim N(0, \Sigma(\theta))$$

Step 2:

$$\lambda_i(t|X, Z) = \lambda_{oi}(t)exp(\beta_1 MotherDepression_i + \beta_2 ChildSex_i + \beta_3 MotherDepression_i * ChildSex_i + Zb)$$

$$b \sim N(0, \Sigma(\theta))$$

Significant interactions Significant interactions were probed by computing the conditional effects.

Model Visualizations. For visualization purposes, we conducted the same test with the first (as opposed to all) event(s) for each child (i.e., latency and duration for the first anger or sadness display), due to the difficulty to visualize results of multi-level survival models. We ran the following Cox regression model with *coxph* function in the R package *survival* (Therneau, 2015): $\lambda_i(t)=\lambda_{0i}(t)\,exp\,(\beta_1 MotherDepression_i + \beta_2 ChildSex_i + \beta_3 MotherDepression_i * ChildSex_i)$.

The visualization of this simpler model helped us interpret the interaction effects in the more complex multilevel model, because the two models were theoretically similar, and produced coefficients with the same directions and similar volumes. Predicted survival functions were plotted at different levels of significant predictors. Observed survival functions were plotted by four groups: boys with high maternal depression, girls with high maternal depression, boys with low maternal depression, and girls with low maternal depression. The groups for high versus low maternal depression were created using the median-split method.

Results

Preliminary Analyses

Table 1 shows the frequency of number of anger and sadness displays for boys and girls during the 4.5-min observations. A majority of children displayed anger or sadness less than 5 times (91.8% for both anger and sadness). Boys were more likely to display anger than girls, $\chi^2(1)=5.97, p=0.015$. There were no significant sex differences in sadness expressions.

Multilevel Survival Analyses

Sex Differences. We first tested whether there were sex differences in the latencies and durations of child anger and sadness in the multilevel Cox regression models. The results showed that boys displayed anger faster than girls ($b=1.15$, $SE=0.45$, $z=2.56$, $p=.011$). Figure 2 shows the Kaplan–Meier curves (i.e., estimates of the survival function) for the first anger and sadness displays during the task for all children and by child sex. Beyond latencies of anger,

Table 1 Frequency Table of Occurrences for Anger and Sadness Displays by Child Sex in the Task of Attractive Toy in the Transparent Box

Number of Occurrences for Emotion Displays	Total (*N* = 108)		Boys (*n* = 51)		Girls (*n* = 57)	
	Anger	Sadness	Anger	Sadness	Anger	Sadness
0	63	56	23	22	40	34
1	12	20	6	13	6	7
2	10	15	7	9	3	6
3	10	5	8	3	2	2
4	5	3	3	1	2	2
5	0	4	0	2	0	2
6	3	1	0	0	3	1
7	0	1	0	1	0	0
8	1	2	1	0	0	2
9	1	1	0	0	1	1
11	1	0	1	0	0	0
12	1	0	1	0	0	0
18	1	0	1	0	0	0

the analyses did not yield other significant sex differences in the durations of anger and sadness or latencies of sadness.

Primary Analyses. We tested whether maternal depressive symptoms predicted children's emotion expressions. Specifically, we examined whether maternal depressive symptoms predicted the latencies and durations of sadness and anger of boys and girls differently. The results from multilevel Cox Regression models for latencies and durations of emotion displays are shown in Table 2. Child sex moderated the association between maternal depressive symptoms and latencies of sadness ($b = -0.06$, $SE = 0.03$, $z = -2.06$, $p = .04$), but not for anger. In particular, maternal depressive symptoms predicted shorter latencies for girls (but not boys) to express sadness (girls: $b = 0.04$, $SE = 0.02$, $z = 2.04$, $p = 0.04$; boys: $b = -0.02$, $SE = 0.02$, $z = -1.06$, $p = .29$).[1]

To facilitate interpretation, we visualized the latencies and durations of each child's first emotion expressions. Figure 3a presents the predicted survival functions for boys and girls with mothers of high and low depressive symptoms. The observed survival functions are shown in Fig. 3b. We did not find effects

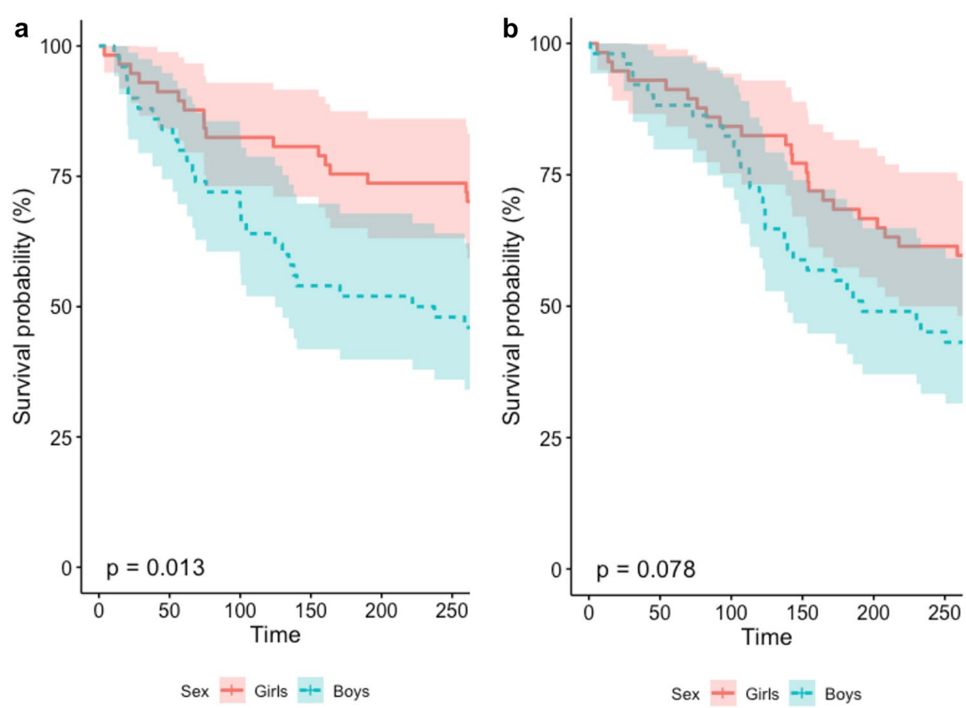

Fig. 2 Kaplan–Meier Estimator for the first anger expression **a** and sadness expression **b** in the task of attractive toy in transparent box by child sex. See the online article for the color version of this figure

[1] The results were not changed when the subset of children who displayed emotion was selected.

Table 2 Results for the Multilevel Cox Regression Models Predicting the Hazard Rates for the Latencies and Durations of Emotion Displays

	Latencies					Durations				
	b	exp (*b*)	SE (*b*)	*z*	*p*	*b*	exp (*b*)	SE (*b*)	*z*	*p*
Anger										
Child Sex	2.09**	8.10	0.74	2.82	.005	0.88*	2.42	0.43	2.05	.04
Maternal Depressive Symptoms	0.03	1.03	0.03	1.10	.32	0.02	1.02	0.02	1.27	.20
Child Sex × Maternal Depressive Symptoms	-0.07	0.93	0.04	-1.76	.08	-0.03	0.93	0.02	-1.17	.24
Child Negative Affectivity	0.10	1.11	0.08	1.28	.21	-0.07	0.97	0.04	-1.68	.11
Conditional Effects of Maternal Depressive Symptoms on Anger Latencies by Child Gender										
Girls	0.03	1.03	0.03	1.10	.32	—	—	—	—	—
Boys	-0.04	0.96	0.03	-1.42	.15	—	—	—	—	—
Sadness										
Child Sex	1.40*	4.05	0.60	2.35	.02	-0.81	0.92	0.47	-0.17	.86
Maternal Depressive Symptoms	0.04*	1.04	0.02	2.04	.04	0.01	1.01	0.02	0.85	.39
Child Sex × Maternal Depressive Symptoms	-0.06*	0.94	0.03	-2.06	.04	-0.01	0.99	0.02	-0.38	.70
Child Negative Affectivity	0.03	1.03	0.07	0.45	.65	0.05	1.05	0.05	1.07	.28
Conditional Effects of Maternal Depressive Symptoms on Sadness Latencies by Child Gender										
Girls	0.04*	1.04	0.02	2.04	.04	—	—	—	—	—
Boys	-0.02	0.98	0.02	-1.06	.29	—	—	—	—	—

$^{*}p < 0.05$, $^{**}p < 0.01$

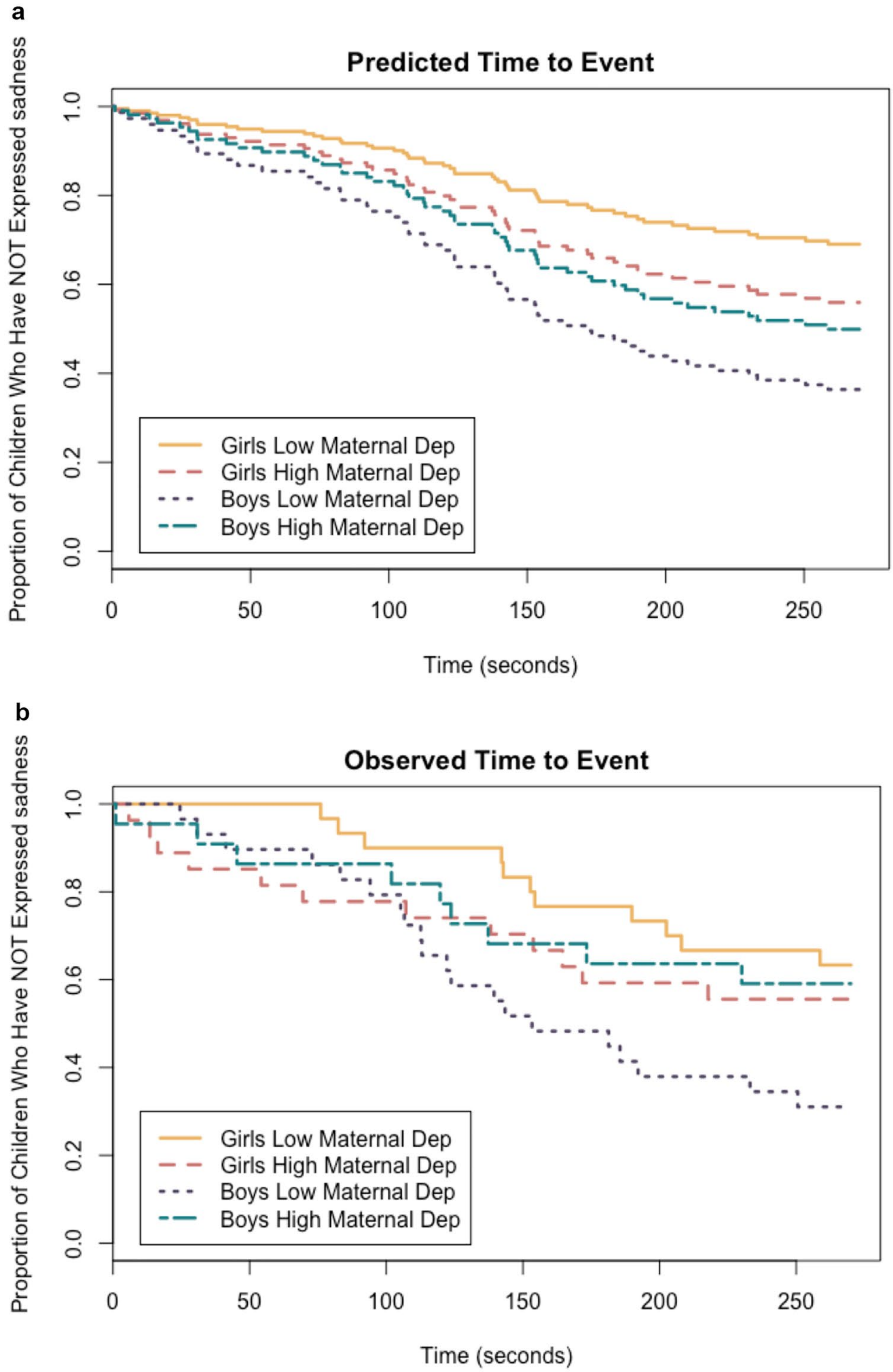

Fig. 3 Predicted **a** and observed **b** time-to-event function for the first sadness expression for boys and girls with high and low maternal depressive symptoms. See the online article for the color version of this figure

of maternal depressive symptoms on the durations of child anger or sadness, nor on latencies to anger expressions.

We used the demographic variables to checks on the specificity of hypothesis regarding maternal depressive symptoms by replacing maternal depressive symptoms in the final model with each demographic variable. Except for child sex, none of the demographic variables were significant predictors of children's latencies and durations of sadness and anger. The interaction terms of these variables with child sex were not significant either. Therefore, the findings of this study were specific to maternal depressive symptoms.

Discussion

This study focused on the temporal features of the dynamic emotion regulation processes in a micro-time scale, and studied the antecedent-focused and response-focused emotion regulation among young children using a moment-to-moment observational methodology. We tested the associations between maternal depressive symptoms and boys' and girls' regulation of anger and sadness, employing the intensive time-series data of emotional experiences. We found that boys transitioned into anger expressions more quickly than girls. Moreover, girls whose mothers showed higher depressive symptoms transitioned into sadness more quickly than girls with mothers low in depressive symptoms.

Maternal depressive symptoms were associated with impairment in girls' antecedent-focused emotion regulation for sadness. When sex differences are taken into account, our finding is consistent with previous literature in that daughters of depressed mothers were less likely to engage in effective antecedent-focused emotion regulation strategies (e.g., active distraction), and more likely to engage in ineffective emotion regulation strategies (e.g., passive waiting; Silk et al., 2006). The sex difference in vulnerability to maternal depression is particularly strong for internalizing problems, with girls being more vulnerable than boys (Goodman et al., 2011). Several reasons may explain the sex difference. Maternal depressive symptoms may affect gender-differentiated emotion socialization (Cassano et al., 2007; Sheeber et al., 2002). The genetic heritability of depression is greater among female than male offspring (Kendler et al., 2001). Boys and girls may also be differentially susceptible to maternal depressive symptoms (Belsky et al., 2007).

Given the deficits in antecedent-focused and response-focused emotion regulation associated with maternal depressive symptoms (i.e., lack of cognitive reappraisal and greater likelihood of rumination, LeMoult & Gotlib, 2019), daughters of depressed mothers may model such a pattern and also show deficits in antecedent-focused regulation, hence, shorter latency in displaying sadness. Regarding response-focused emotion regulation for depressed individuals, there is greater heterogeneity: some show prolonged sadness, whereas others show flat affect (Sohr-Preston, & Scaramella, 2006). Such divergence in symptoms may explain our lack of finding on the response-focused emotion regulation.

Consistent with previous findings (Chaplin & Aldao, 2013; Chaplin et al., 2005), we found that boys were more likely to display anger. Moreover, boys transitioned into angry states faster than girls did. Girls' reactivity to frustrating circumstances decline faster than boys' as they grow older, perhaps due to girls' increasing understanding of female gender roles (Chaplin & Aldao, 2013). Contrary to what was found in some of the previous studies (Chaplin & Aldao, 2013; Chaplin et al., 2005), however, we did not detect significant sex differences in the expression of sadness among preschoolers in a frustration-eliciting context.

We were surprised by the null findings in the gender differences in sadness expressions. One possible reason to explain why we did not observe girls to be more expressive of sadness may be that during our tasks, each child was sitting alone in the room. The way that children express emotions may be influenced by social context (Zeman & Garber, 1996). When children are alone, sadness expressions may not be as useful to promote relationship closeness or elicit help behaviors (Hackenbracht & Tamir, 2010). Therefore, the mechanism that encourage girls' sadness expression may be weakened. Furthermore, the task may not have evoked enough sadness to observe difference in groups of this size.

Several limitations of this study should be mentioned. First, approximately half of the children in our sample did not display anger or sadness expressions, and only those who displayed anger or sadness were included in the analysis for response-focused emotion regulation. Therefore, the null findings on response-focused emotion regulation may be due to reduced sample size and lower power. Beyond increasing sample size, future studies could consider using multiple tasks or a slightly more frustrating task or observe for a longer period. Second, we assumed that the children did not display negative emotions during those non-codable periods that were not immediately preceded by sadness and anger expressions. If this assumption was violated, our approach would have overestimated children's antecedent-focused emotion regulation ability. Future research can improve by using several cameras from different angles to avoid non-codable incidences. Third, we did not examine the mechanisms underlying the associations between maternal psychopathology and child emotion regulation. Fourth, this study focused on maternal psychopathology and did not consider the critical roles that fathers play in child development (e.g., Yan et al., 2019). Future studies should consider the contribution of fathers on children's emotion regulation dynamics. Finally, we do not have data on the complete history of maternal depression. Therefore, we could only infer about the association between maternal depressive symptoms at T1 and children's emotion regulation one year later. We were not able to investigate the effect of time of onset and duration of maternal depression on child emotion regulation.

Despite these limitations, this study has contributed to the literature on the genesis of sex differences in emotion expressions. This study connected the adult and child literature on emotion regulation by applying the adult model to children and promoted the understanding of antecedent-focused and response-focused emotion regulation strategies among preschoolers. From a developmental perspective, this study adds to our understanding of the effect of maternal psychopathology in early childhood, in that the association between maternal depression and child emotion regulation impairment may appear early in development, with girls being particularly vulnerable. This study also highlights child sex differences in susceptibility to parents' mental health conditions. Targeted interventions for this particularly vulnerable population—daughters of depressed mothers—may boost the social-emotional functioning and mental health of the next generation.

Compliance with Ethical Standards

Conflict of Interest The authors report no conflicts of interest.

Informed Consent All mothers provided informed consent and permission for their children to participate.

Ethical Approval All procedures were approved by The Ohio State University's institutional review board.

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