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RESEARCH ARTICLE

# A mother's touch: Preschool-aged children are regulated by positive maternal touch

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## Abstract

Positive maternal touch plays an important role in the development of children's physiological regulation and cognitive development in infancy, as well as the development of sociality in early childhood. However, few studies have looked beyond infancy to consider the possible continuing impact of positive maternal touch on child stress reactivity during early childhood. A diverse community sample of mothers ($N = 114$, $M_{age} = 33.52$ years, $SD = 5.33$) and their preschool-aged children ($M_{age} = 41.68$ months, $SD = 4.67$; 49.1% female) participated in the study. Basic demographics were reported by mothers. We coded maternal touch behaviors during an emotionally charged laboratory conversation task and assessed children's physiological reactivity to stressful laboratory tasks with salivary cortisol. Results reveal a significant negative association between positive maternal touch and child salivary cortisol reactivity. In addition, family income, adjusted for family size, and child sex were significantly associated with child cortisol stress reactivity. Findings are discussed in terms of persistent downregulating effects of positive maternal touch on child stress reactivity, as well as possible links of stress reactivity with family income, a proxy for economic stress, and child sex.

KEYWORDS
income, maternal touch, physiological reactivity, preschool-aged children

## 1 | INTRODUCTION

From the moment children are born, parents communicate with them through touch (Barnett, 2005). The skin, considered to be a social organ, facilitates bonding in infancy (Dunbar, 2010; Morrison et al., 2010) and can communicate comfort in childhood (Brummelman et al., 2019). For example, sensitive maternal touch regularly provided to premature infants, via a Kangaroo Care intervention (skin-to-skin contact with a parent), is associated with immediate benefits for infants' physiological regulation (attenuated stress response, improved respiratory sinus arrhythmia, more organized sleep) and cognitive outcomes (better cognitive control), as well as for stress physiology, executive function, and cognitive control a decade later (Feldman et al., 2014). Feldman et al. (2014) suggest that the mechanism for these benefits in premature infants may be improved neuromaturation. Likewise, for full-term newborns, greater skin-to-skin contact is correlated with reduced stress, as indexed by cortisol reactivity, and activated neuronal connections that produce new synapses and strengthen existing ones, as well as with improved health and development of secure attachment (Barnett, 2005).

Consistently, animal models also suggest the important regulating role of maternal touch (Hofer, 2006; Meaney & Szyf, 2005). Rat pups of mothers high in licking/grooming behaviors display epigenetic modification to the glucocorticoid receptor gene in the hippocampus resulting in altered hypothalamic–pituitary–adrenal (HPA) responses to stress (Meaney & Szyf, 2005). Furthermore, Hofer (2006) argues that beyond the psychological functions that relationships may support, the nuts and bolts of social interactions (e.g., play, touch, smell, warmth) may also serve to regulate essential functions of the young child's physiology; in the absence of these regulators, infant rodents become cold and their heart rates drop too low, pushing them into a state of dysregulation. Together, these data support the idea that parents serve as external regulators of their offspring's stress physiology, while they are learning to regulate independently (Zeytinoglu et al., 2017).

While the evidence is robust that maternal touch is beneficial for newborns, fewer studies have examined its importance in the later years. Given the significant increase in language competencies in young children, touch may become less important as the child develops. It is possible that the effects of touch wane as children become more verbal and parents use language as a primary means of expressing warmth or support to help children regulate. Nonetheless, some data suggest that touch continues to serve important functions past infancy. Sensitive maternal touch during early childhood is associated with better social adjustment including increased social orienting in 4–6-year olds (Reece et al., 2016), and higher levels of trusting behaviors with unfamiliar others and lower attentional bias for social threat among socially anxious 8–10-year olds (Brummelman et al., 2019). Importantly, certain touch actions, such as holding and intentional contact, as opposed to incidental touch, are more strongly associated with sociality than other actions, such as pushing or accidental touches (Reece et al., 2016). These effects on social behavior hold only through late childhood, a time when children still rely on their parents for safety and support, but not into early adolescence (ages 11–14) (Brummelman et al., 2019), a period when children become more socially independent, and when the meaning of touch may change.

The significance of understanding correlates of children's stress reactivity lies in the fact that reactivity is directly associated with behavioral development in childhood as indexed by behavioral problems (Kao et al., 2019). The ability to regulate behavior is in turn crucial for the development of social and academic abilities (Leerkes et al., 2008), as well as socioemotional competence and behavioral adjustment (Zeytinoglu et al., 2017). In the present study, to address the gap in the literature regarding maternal touch and stress physiology in the period of early childhood, we explore the association between positive maternal touch during an emotionally charged mother–child conversation, when positive touch could serve a regulatory function, and children's immediate physiological reactivity to laboratory stressors. We operationalize stress reactivity as increases in salivary cortisol over baseline in response to moderately challenging laboratory tasks, measured as AUCi (area under the curve with respect to increase, further described in Section 5).

## 1.1 | Cortisol as an indicator of child stress reactivity

The HPA axis is activated in the face of perceived threat or stress, culminating in the synthesis and release of cortisol, a primary stress hormone in humans. Salivary cortisol is often assayed to measure an individual's response to stress (Barrios et al., 2017). Salivary cortisol reactivity reflects an acute cortisol response to a stressor, but it also contributes to children's cumulative cortisol exposure (Kao et al., 2018). That is, although cortisol levels rise and fall daily following a circadian rhythm, repeated stress-induced elevations may add to children's biological risk for health problems later in life (Liu & Doan, 2019). In children, cortisol stress reactivity is associated with behavioral self-regulation in early childhood as indexed by externalizing behavior in boys (Tout et al., 1998) and depression in 8–13-year-old girls (Dockray et al., 2009). However, not all studies show that higher cortisol reactivity is associated with maladaptive outcomes. In 4–5-year-old children, higher cortisol reactivity is *positively* associated with executive function (Blair et al., 2005). Also, at-risk, dysphoric preschoolers and third graders exhibited cortisol *hyporeactivity* in response to a stressor, whereas dysphoric adolescents displayed hyperreactivity to the stressor, a switch that occurred as a function of pubertal development (Hankin et al., 2010). As such, cortisol reactivity's correlates have been demonstrated to be both adaptive and maladaptive, depending on context.

Associations between positive parenting behaviors (e.g., warmth) and child cortisol reactivity in the early years of life are also quite variable, with child age, temperament, and family resources as important moderators (Hackman et al., 2018). For example, maternal engagement was associated with greater cortisol reactivity in 7-month-old infants but with reduced overall cortisol levels in 15-month-old toddlers (Blair et al., 2008). In a study of older low-income children, higher levels of sensitive parenting were associated with higher cortisol output after exposure to a laboratory-based stressor for those high in emotional reactivity, but with lower cortisol output among those exhibiting low emotional reactivity. On the other hand, insensitive parenting behaviors are associated with children's increased cortisol levels in response to laboratory-based stressors (Doan et al., 2017; Dougherty et al., 2013; Hastings et al., 2011). Additionally, longitudinal data showed that intrusive or overcontrolling parenting at 30 months predicted higher levels of children's cortisol at 72 months of age (Taylor et al., 2012). Together, these findings suggest a role for parenting sensitivity, as well as for individual differences within children, in the development of a coordinated physiological cortisol response (Blair et al., 2015). Finally, past research has documented null associations between young children's cortisol reactivity and overall positive parenting (i.e., warmth; Hackman et al., 2018) and a lack of discernible associations between parent-training interventions (none of which expressly focused on touch) and child cortisol levels (Martins et al., 2020). These findings, in combination with the strong associations between stress physiology and the more targeted behavior of positive physical touch in infancy (Feldman et al., 2014), lead us to evaluate whether positive touch in particular is associated with lower cortisol reactivity to stressors in early childhood.

## 1.2 | Factors related to maternal touch or child stress reactivity

Neither maternal behavior nor child outcomes exist in a vacuum. Several important factors may affect these variables. First, aspects of child temperament, particularly negative emotionality, are associated with parental behavior; temperamental negativity has been shown to evoke harsher or more insensitive parenting (Clark et al., 2000; Jaffee et al., 2004; Martorell & Bugental, 2006), but also *more* responsiveness and involvement (Kochanska et al., 2004). Some recent research that specifically assessed mothers' physical behavior with their toddlers and preschoolers (i.e., "maternal negative regard" that included physically rejecting or disapproving behavior) found it was strongly linked to children's high negative emotionality, especially if mothers were stressed (Dalimonte & Brophy, 2019). Because previous research finds that child temperamental negativity is associated with variable parent responses, we control child temperament in the present study in order to isolate the possible effects of maternal positive touch.

At the same time, socioeconomic status (SES) has been associated with child stress reactivity, an association that might indirectly reflect the influence of children's home or neighborhood experiences. Children living in low-income households are not only subject to discrete negative life events (e.g., domestic violence, parent substance use, or mental health symptoms) at higher rates than children in higher-income households, but they may also experience chronic stress due to worries about their safety, having enough to eat or a place to live, all on a regular basis (Buckner et al., 2003). Even children living in households of modest means, that is, not living in poverty, might experience stress if their parents endure financial hardship (Conger et al., 2010).

In turn, experiences of stress due to low income have been associated with dysregulation of both the diurnal rhythm of cortisol and cortisol reactivity to laboratory stressors. However, dysregulation can manifest as both hypercortisolism (characterized by chronic over-activation) and hypocortisolism (chronic underactivation) (Gunnar & Vazquez, 2001). In examples of a blunted basal response, low income was related to lower morning cortisol levels and flatter diurnal slopes in children (Raffington et al., 2018; Zalewski et al., 2012), relationships that were mediated through maternal negativity (Zalewski et al., 2012) or earlier household chaos (Doom et al., 2018). Reduced baseline cortisol was also observed in toddlerhood in a low-income sample, even when maternal engagement during infancy was high (Blair et al., 2008). In comparison, basal cortisol levels mediated effects of income-to-need ratio on child cognitive ability, such that low-income status (relative to need) was negatively associated with basal cortisol levels, and basal cortisol levels were negatively associated with child cognitive ability (Blair et al., 2011).

Like baseline cortisol levels, dysregulation of cortisol reactivity can manifest as both under- and over-responsiveness to acute stressors. In terms of hyporeactivity, low income has been related to lower reactivity to the child version of the trier social stress test (TSST) in early childhood (Raffington et al., 2018). However, parenting appears to have an influence as well: in a sample of families experiencing poverty, positive parenting was associated with attenuated cortisol reactivity, a relationship that was especially strong for the most impoverished families (Brown et al., 2020). In terms of hyperreactivity, negative life events (often coincident with low income) measured at preschool predicted greater reactivity to the TSST in middle childhood (Doom et al., 2018). On the other hand, in a sample of low-income mother–infant dyads, maternal engagement was related to greater cortisol reactivity to a challenge (Blair et al., 2008). In order to advance our understanding of the possible role of family resources in children's stress reactivity, here we examine the main effect of family income, adjusted for number of persons in the household, on children's AUCi in response to laboratory stressors.

### 1.3 | The present study

In the present study, we examine the association between maternal touch and child stress reactivity. A better understanding of the association between maternal touch and child stress reactivity, as well as any effect of family income, could inform interventions to promote children's self-regulation and deepen our understanding of developmental processes in households with varied levels of financial resources.

Research shows an association between touch provided in infancy and stress physiology later in life (Feldman et al., 2014), but only between touch and sociality in early childhood (Brummelman et al., 2019). Our primary hypothesis is that the association between positive maternal touch and lower acute stress reactivity will hold when touch is provided in early childhood. At preschool age, children's physiological systems may not yet be fully established and may still be susceptible to outside input as children are still learning to regulate independently (Zeytinoglu et al., 2017). Thus, we expect a negative association between greater positive maternal touch and children's stress reactivity at preschool age. We will also examine the roles of child temperament and child sex.

An exploratory hypothesis is that household income will also be associated with child physiological reactivity. Prior research has shown that children in lower-income households are subject to more frequent discrete stressors and greater chronic stress (Buckner et al., 2003), but that SES is related to physiological dysregulation in the form of both underactivation and overactivation of the cortisol response system (Gunnar & Vazquez, 2001; Raffington et al., 2018; Zalewski et al., 2012). Because both types of dysregulations have been documented, we do not propose a specific hypothesis about the direction of association between adjusted family income and children's AUCi in response to laboratory stress tasks.

## 2 | METHODS

### 2.1 | Participants

Mothers ($n$ = 114, $M_{age}$ = 33.52 years, SD = 5.33) and their children (49.1% female, $M_{age}$ = 41.68 months, SD = 4.67) were recruited from the community via online postings and flyers. To be eligible to participate, mothers and children had to be proficient in English. The sample was diverse ethnically (40.7% White, 31.0% more than one race [including Latinx], 9.7% Latinx only, 10.6% Asian or Asian American, 5.3% more than one race [other than Latinx], 1.8% African American only, and 0.9% American Indian or Alaska Native only) and socioeconomically (40.2% reported annual income of less than $60,000). 36.8% had completed up to 2 years of education beyond high school. Most mothers (86%) were married or coresiding with the biological father of the child. Because no prior studies had considered the association between maternal touch and stress reactivity in young children

**TABLE 1** Description of maternal touch subcategories

| Maternal touch behavior | Description |
|---|---|
| Positive | Intentional touch with intent to soothe, lacking force. |
| Hug | Wrapping arms around child in an embrace. |
| Kiss | Touching lips to child's body. |
| Snuggle | Moving self to child or child to self to snuggle or nuzzle. |
| Caress | Using hand to caress or pat child's body or stroke hair. |
| Hold | Using hand to hold or grasp child, may be to keep from falling. |
| Put on lap to hug | Putting child on lap followed by instance of positive touch. |
| Continued contact | Sustaining contact with child's body following discrete positive touch. |
| Negative | Intentional touch with intent to restrict freedom or reprimand. |
| Restrain | Using hands to prevent child from moving in desired way. |
| Maneuver | Manipulating child's body with force. |
| Put on lap to restrain | Putting child on lap in order to restrain, may include force. |
| Neutral | Intentional touch with intent to facilitate task completion, lacking force. |
| Transport | Lifting or seating child in order to transport them back to task area. |
| Redirect | Tapping or patting child to redirect attention or move away from distraction. |
| Put on lap to redirect | Putting child on lap to redirect or move away from distraction. |

specifically, power analyses were based on effect size estimates. To adequately power an investigation (80%) in which we expect small (0.02) to medium (0.15) effect sizes, we aimed to collect data from 120 dyads. A small effect size was used to conservatively calculate power.

## 2.2 | Procedure

Prior to data collection, the study protocol was approved by the Institutional Review Board (#4292016JB-MP). Upon arriving at the laboratory, mothers provided informed consent for themselves and for their children to participate in the study, and children provided informed assent. Standardized laboratory tasks were used to elicit maternal touch and to induce children's acute stress response, assessed with salivary cortisol. Maternal touch was coded from videotapes of a negative conversation task about a time when the mother felt rejected by her child. Children were shown a neutral and a scary video, followed by two frustrating tasks, and saliva was collected at four time points, including at baseline before the videos were presented. Mothers provided demographic information, including household income and race, and completed a questionnaire about their child's temperament. At the end of the session, dyads were compensated for their participation.

## 2.3 | Measures

### 2.3.1 | Maternal touch

Maternal touch was coded from videos of a mother–child conversation. Each mother was given time to think of a time when her child had hurt her feelings or made her feel rejected, and then to discuss what happened with her child, including how they each felt during the experience. They were asked to indicate when they were finished; videos were coded for 9 min if mothers neglected to indicate when they were finished. This task was selected because touch might be more frequent during an emotionally arousing task; touch has been shown to be more frequently provided in times of child distress (Peterson et al., 2007). Positive, negative, and neutral touch were coded in 15-s intervals. The scheme was based on the maternal touch coding scheme used by Reece et al. (2016) with some adaptations necessary for the negative orientation of the conversation. The original "hold" code was defined as "grasping with hand" (Reece et al., 2016), but we further subclassified such touch instances into four behaviors, as "hold or support—to keep from falling," "continued contact (e.g., hand resting on child's body)," "maneuver—move child's body with force," or "restrain—use force to prevent from escape." Continued contact (not just instances of discrete touch) was included in positive touch, as the literature has shown that skin-to-skin contact between mother and child has a regulating effect (Brummelman et al., 2019). Durative touch that spanned intervals was counted as one discrete instance in each interval in which it occurred.

Each touch event was tallied as positive (e.g., hug), negative (e.g., maneuver, restrain), or neutral (e.g., reposition) (see Table 1). Sums of frequencies for positive, negative, and neutral touch events were calculated. Three coders divided coding responsibilities evenly and demonstrated inter-rater reliability estimates of ICC = .99, ICC = .98, and ICC = .96 for positive, negative, and neutral touch, respectively. Because the number of 15-s intervals varied across dyads, the number of intervals coded was controlled in analyses.

### 2.3.2 | Collection of saliva and measurement of salivary cortisol

Saliva was collected from children using a 6-in. sterile cotton rope placed underneath the tongue. The saturated end was cut and placed in a needleless 10-cc plastic syringe, expressed into a plastic vial, and stored in a portable cooler. Samples were then stored at −40°C. When data collection was complete, all saliva samples were sent to the University of Trier for assay. Salivary cortisol concentrations were determined by employing a competitive solid phase time-resolved fluorescence immunoassay with fluorometric end point detection (Dressendörfer et al., 1992). The intra- and inter-assay variation coefficients computed for the mean of average duplicates was less than 5.71%. Saliva was collected at four time points: T1 was collected approximately 30 min after the dyad arrived at the laboratory, just before the child watched a neutral video of fish for 3 min. (The first 30 min in the laboratory consisted of consent and calming activities such as reading a book with the mother.) After baseline, there was a series of stressor tasks that lasted on average 15 min. T2 was taken at the end of the stressor tasks (15 min from T1), T3 was taken 30 min after onset of the stressor tasks, and T4 was taken 45 min after the onset of the stressor tasks.

Immediately after the neutral video, the series of stressful events began: first, children watched a scary clip from the movie *Fantasia* for 4 min, then they participated in two other frustrating tasks, drawn from the Laboratory Assessment Battery—Preschool (Goldsmith & Reilly, 1995), namely, perfect green circle (children are asked to repeatedly attempt to draw a perfect circle for 3.5 min) and attractive toy in transparent box (children are asked to use an incorrect key to open a box that contains a desired toy for 4.0 min). Mothers were not present for the scary movie or LabTAB-PS tasks. No one paradigm has been consistently shown to elicit a stress response in preschool-aged children (Gunnar et al., 2009). As such, we used a series of tasks as suggested by Gunnar et al. (2009), including separation from the primary caregiver, to elicit arousal in children. Note that the TSST, the gold standard for inducing stress in a laboratory setting among adults, also uses two different tasks (speech and math tasks) to induce stress (Allen et al., 2017).

Cortisol computations were based on previously validated formulas (Pruessner et al., 2003). AUCg (area under the curve with respect to ground) reflects the total area under the curve of all cortisol measurements charted over time. AUCg reflects both sensitivity (the difference of single measurements from one another) and intensity (the height of these measures from ground). AUCi (area under the curve with respect to increase) is computed with reference to the participant's baseline measurement and assesses increase across all measurements. While AUCg is often used as a measure of total hormonal output, AUCi emphasizes the change over time and is more related to sensitivity of the individual's system (Fekedulegn et al., 2007). Here, we use AUCi as a measure of stress reactivity. In analyses, we controlled the time at which the first saliva sample was collected to account for the diurnal rhythm of cortisol (Karlamangla et al., 2019).

#### 2.3.3 | Adjusted income

Mothers provided information regarding yearly household income and the number of people residing in their household. The income variable was coded into 9 discrete increments, such that a score of 1 signified a yearly income less than $20,000 and a score of 9 signified a yearly income above $175,000. In order to create an index of resources available to a child, we divided income by the number of people residing in the household, which we refer to as "adjusted income."

#### 2.3.4 | Child temperament

Mothers rated their child's temperament on the child behavior questionnaire short form (CBQ-SF), a widely used instrument to measure temperament in children (Putnam & Rothbart, 2006). To capture negative emotionality, we calculated the mean of the anger/frustration (e.g., "While having trouble completing a task [e.g., building, drawing, dressing], how often did your child get easily irritated?") and falling reactivity/soothability scales (six items, e.g., "Is easy to soothe when s/he is upset"), after reverse-scoring the latter. These two subscales were strongly correlated in our sample, $r(104) = -.54$, $p < .001$, and are two of the highest rated contributors to the negative affectivity dimension of the CBQ (Rothbart et al., 2001). Mothers rated the degree to which behaviors characterized their child over the past 6 months on a 7-point Likert-type scale (1 = extremely untrue of your child to 7 = extremely true of your child). For this sample, Cronbach's alpha = .73 for anger/frustration and .72 for falling reactivity/soothability.

### 2.4 | Data analytic plan

Analyses were conducted in SPSS version 27. Prior to conducting hypothesis-testing analyses, frequency distributions of study variables, including positive, negative, and neutral maternal touch, child stress reactivity (assessed as AUCi), adjusted income, and CBQ combined anger/frustration and falling reactivity/soothability were examined. Of the 114 cases with maternal touch data, 14% were missing corresponding child AUCi data; 14% were missing the time of the first cortisol sample; 7% were missing CBQ falling reactivity/ soothability and anger/frustration scores; and 2% were missing income data. AUCi data were missing because some children were not amenable to having the saliva swab in their mouths for 60 s, and others contributed a sample that was insufficient for analysis. In order to impute missing data, we ran the SPSS Multiple Imputation function, using 40 rounds of imputation, requesting imputed data for AUCi, time of first data collection, and temperament (CBQ falling reactivity/soothability and anger/frustration), using these and positive maternal touch, negative maternal touch, child sex, adjusted income, and the number of touch intervals coded in the model as predictors. Little's MCAR test, Chi-square = 34.18, df = 29, $p = .23$ indicated that data were missing completely at random. The aggregated data from these 40 imputations were used to test hypotheses.

To identify covariates, bivariate correlations and independent sample *t*-tests were run with the imputed data, considering associations of child age, sex, and temperament as well as mothers' age and

**TABLE 2** Descriptives (*M*, SD) for key variables by child sex and overall

| | Child sex | | | | Overall | |
|---|---|---|---|---|---|---|
| | Male | | Female | | | |
| Variable | *M* | SD | *M* | SD | *M* | SD |
| Ch age | 41.64 | 4.93 | 41.73 | 4.42 | 41.68 | 4.67 |
| M age | 33.15 | 5.41 | 33.89 | 5.23 | 33.51 | 5.31 |
| M pos touch | 5.98 | 5.16 | 6.21 | 4.91 | 6.09 | 5.02 |
| M neg touch | 1.23 | 2.07 | 1.25 | 2.09 | 1.24 | 2.07 |
| M neut touch | 1.37 | 1.56 | 1.59 | 2.12 | 1.48 | 1.85 |
| Ch AUCi | .43 | 46.31 | 23.17* | 67.09 | 11.60 | 58.33 |
| Adj. income | 1.23 | .70 | 1.24 | .67 | 1.24 | .68 |
| Ch temp. | .10 | .87 | .06 | .79 | .08 | .83 |
| T0 | 709.82 | 128.81 | 742.28 | 133.79 | 725.76 | 131.71 |
| Ints coded | 13.59 | 5.83 | 14.11 | 7.68 | 13.84 | 6.78 |

*Note*. Ch age, child age in months; M age, mother age in years; M pos touch, positive maternal touch; M neg touch, maternal negative touch; M neut touch, maternal negative touch; Ch AUCi, child AUCi; Adj. income, adjusted income; Ch temp., mean of child CBQ falling reactivity/soothability and anger/frustration *Z* scores; T0, time since midnight of the first cortisol sample; and Ints coded, number of touch intervals coded for the mother–child pair.
$^{*}p < .05$.

self-identified race with the dependent variables. To test our primary and exploratory hypotheses, we conducted a hierarchical linear regression; after entering control variables, we entered maternal positive touch and adjusted income in Step 2 to determine their associations with children's stress reactivity scores.

## 3 | RESULTS

### 3.1 | Preliminary analyses

Regarding cortisol output, across children, distributions of values at T1 through T4 were positively skewed, as is common among children sampled in the morning and at midday (Kiess et al., 1955). Cortisol values (AUCi) were subjected to a natural log transformation to normalize the distributions. After the transformation, one remaining high outlier in the distribution of T2 cortisol was Winsorized (changed to the next highest score +1) to reduce skew (Tabachnick & Fidell, 2013); this technique allows researchers to keep participants in the dataset, in their original rank order. An increase in mean cortisol levels was seen in response to the stressors over the first three time points (T1–T3), followed by a decrease (recovery) at T4. Means (SE) for T1, T2, T3, and T4 were 3.16 (.21), 3.32 (.22), 3.55 (.24), and 3.27 (.19), respectively. A repeated measures ANOVA revealed a significant quadratic function, $F(1, 115) = 4.50$, $p = .04$. Pairwise contrasts showed that the mean at T3 was marginally higher than at T2, $F(1, 115) = 2.64$, $p = .11$; the mean at T4 was significantly lower than at T3, $F(1, 115) = 4.54$, $p = .04$.

Means and standard deviations for continuous variables, after imputation, are shown in the rightmost columns of Table 2. All variables were normally distributed with the exceptions of mother negative and neutral touch and AUCi. Skew in touch variables was not corrected; instead, the number of intervals coded was controlled. One low outlier

**TABLE 3** Correlations among major study variables

| Variable | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| 1. Ch age | – | | | | | | | |
| 2. M age | –.01 | – | | | | | | |
| 3. M pos touch | –.04 | .09 | – | | | | | |
| 4. M neg touch | –.04 | .09 | .48** | – | | | | |
| 5. M neut touch | –.04 | –.08 | .47** | .50** | – | | | |
| 6. Ch AUCi | .03 | .08 | –.10 | .00 | –.05 | – | | |
| 7. Adj. income | –.14 | .03 | .10 | .01 | .01 | .22* | – | |
| 8. Ch temp. | .03 | –.19* | .09 | .17+ | .12 | –.14 | –.07 | – |

*Note*. Ch age, child age in months; M age, mother age in years; M pos touch, positive maternal touch; M neg touch, negative maternal touch; M neut touch, negative maternal touch; Ch AUCi, child AUCi; Adj. income, adjusted income; Ch temp., mean of child's CBQ falling reactivity/soothability and anger/frustration *Z* scores.
$^{+}p < .10$. $^{*}p < .05$. $^{**}p < .01$.

in the AUCi variable was Winsorized before imputation as described previously. As shown in left hand columns of Table 2, child sex was related to AUCi, $t(112) = -2.11$, $p = .037$, with females' AUCi greater than males'; child sex was controlled in analyses. Independent samples *t*-tests were also used to assess differences by mother-reported race/ethnicity ($n = 46$ White; $n = 46$ Latinx or mixed Latinx) in key variables. Only adjusted income differed by race/ethnicity, with White families reporting more income per family member on the adjusted income metric ($M = 1.48$, SD $= .64$) than Latinx families ($M = .93$, SD $= .58$), $t(89) = 4.28$, $p < .001$.

Correlations among major study variables are shown in Table 3. Positive, negative, and neutral touch were positively intercorrelated. Therefore, in analysis, negative touch was covaried. In addition, child temperament was negatively correlated with mother age and

**TABLE 4** Hierarchical regression for child AUCi

| Variable | *B* | 95% CI for *B* LL | UL | SE *B* | *β* | $R^2$ | $\Delta R^2$ |
|---|---|---|---|---|---|---|---|
| Step 1 | | | | | | .12 | .12* |
| Constant | −34.03 | −128.90 | 60.87 | 47.86 | | | |
| M age | .48 | −1.55 | 2.52 | 1.03 | .04 | | |
| Ch sex | 21.24* | .10 | 42.39 | 10.67 | .18 | | |
| T0 | −.01 | −.10 | .07 | .04 | −.03 | | |
| Ints coded | 2.19** | .56 | 3.82 | .82 | .25 | | |
| M neg touch | −1.26 | −6.79 | 4.26 | 2.79 | −.05 | | |
| Ch temperament | −9.35 | −22.49 | 3.80 | 6.63 | −.13 | | |
| Step 2 | | | | | | .19 | .07* |
| Constant | −44.85 | −139.02 | 49.31 | 47.49 | | | |
| M age | .58 | −1.40 | 2.56 | 1.00 | .05 | | |
| Ch sex | 21.77* | 1.22 | 42.32 | 10.36 | .19 | | |
| T0 | −.01 | −.09 | .07 | .04 | −.03 | | |
| Ints coded | 2.21** | .58 | 3.83 | .82 | .26 | | |
| M neg touch | 1.56 | −4.39 | 7.51 | 3.00 | .06 | | |
| Ch temperament | −8.10 | −20.91 | 4.72 | 6.46 | −.12 | | |
| M pos touch | −2.56* | −4.94 | −.19 | 1.20 | −.22 | | |
| Adj. income | 16.28* | 1.05 | 31.51 | 7.68 | .19 | | |

*Note*. CI, confidence interval; LL, lower limit; UL, upper limit; T0, time since midnight of the first cortisol sample; Ints coded, number of touch intervals coded for the mother–child pair; Ch temperament, mean of child's falling reactivity/soothability and anger/frustration *Z* scores; M neg touch, negative maternal touch; M pos touch, positive maternal touch; Adj. income, adjusted income.
**p* < .05.
***p* < .01.

marginally positively associated with maternal negative touch. Mother age and child temperament were controlled in hypothesis testing. Adjusted income was positively associated with AUCi.

### 3.2 | Hypothesis tests

#### 3.2.1 | Are positive maternal touch and adjusted income associated with child physiological reactivity?

As shown in Table 4, mother age, child sex, time when the first saliva sample was collected, negative touch, number of intervals coded, and child temperament were entered as controls in Step 1. The addition of positive maternal touch and adjusted income in Step 2 accounted for additional variance in child AUCi, $\Delta R^2 = .065$, $F(2, 105) = 4.21$, $p = .017$, a medium effect size. The more positive touch mothers exhibited in the coded interaction, the lower children's AUCi scores, $b = -2.56$, SE = 1.20, $p = .035$. In addition, adjusted income was positively associated with child AUCi, $b = 16.28$, SE = 7.68, $p = .036$, indicating that when adjusted income is low, AUCi is also low, and that when adjusted income is high, AUCi is high as well. When child temperament was not included in the model, results were the same, $\Delta R^2 = .069$, $F(2, 106) = 4.45$, $p = .014$. In the final model, child sex (0 = male, 1 = female) was positively associated with AUCi, $b = 21.77$, SE = 10.36, $p = .038$, with females exhibiting higher AUCi than males. (When performed with the nonimputed data, with fewer participants and the same covariates, results were similar but only marginally significant; entering adjusted income and positive maternal touch in Step 2 accounted for additional variance in child AUCi, $\Delta R^2 = .054$, F(2, 79) = 2.56, $p = .08$. Regression coefficients for adjusted income and positive maternal touch were in the same direction as with the imputed data: for adjusted income, $b = 14.40$, SE = 9.31, $p = .13$; for maternal positive touch, $b = -3.00$, SE = 1.73, $p = .09$.)

## 4 | DISCUSSION

We examined associations between levels of positive maternal touch behaviors and children's physiological stress reactivity as indexed by salivary cortisol and considered the role of adjusted household income in accounting for levels of AUCi in response to laboratory stressors. We tested for an association between positive maternal touch and children's physiological reactivity because this association has been found in infancy (Feldman et al., 2014) but not yet in early childhood, and because an association between maternal positive touch and *social outcomes* has been documented with young children (Brummelman et al., 2019; Reece et al., 2016). We also examined the regression model for effects of adjusted income on child AUCi, as research has suggested that family SES is related to children's stress reactivity (e.g., Gunnar & Vazquez, 2001).

Our primary hypothesis was supported. We demonstrated a negative association between positive maternal touch and children's physiological stress reactivity, after controlling demographics, negative maternal touch, and child temperament (negative affectivity). Children receiving higher levels of positive touch from their mothers during a conversation about an emotionally negative event had lower physiological reactivity in response to laboratory stressors, and those receiving lower levels of positive touch showed higher reactivity. This correlation is consistent with prior research on touch in infancy, when positive touch has a downregulating effect on infants' physiology (Barnett, 2005; Dunbar, 2010; Feldman et al., 2014; Morrison et al., 2010).

This finding is also broadly consistent with research showing associations between negative parenting behaviors and children's stress reactivity. For example, children subject to overcontrolling or hostile parenting showed increased levels of cortisol from baseline following a laboratory stressor (Doan et al., 2017; Dougherty et al., 2013). In related work, positive parenting behaviors (including some touch behaviors) and child behavioral self-regulation were indirectly linked, through neural responses that are indicative of child inhibitory control (Swingler et al., 2018), suggesting that there could be a neurally mediated effect of positive maternal touch on child physiological reactivity as well. Because a recent meta-analysis reports inconsistent associations between positive parenting, broadly construed, and cortisol stress reactivity (Hackman et al., 2018), our approach of assessing associations between particular parent behaviors that have been shown to be or are theorized to be physiologically regulating, such as positive touch, and child cortisol reactivity might be particularly informative in understanding the development of child stress responses.

More specifically, our finding is in line with the theory that parents continue to serve as external regulators of their children's physiological systems through the preschool years (Zeytinoglu et al., 2017). In this regard, the maternal touch–child reactivity link we observed is aligned with research in the attachment tradition. Positive touch is one aspect of sensitive responding that promotes secure attachment relationships, largely established by the seventh or eighth month of life (Prior & Glaser, 2006). Indeed, infant attachment security, particularly with mother, is associated with more normative cortisol reactivity patterns in response to the Strange Situation (Kuo et al., 2019). That is, along with a sense of psychological security, positive bodily contact appears to help infants regulate physiologically. As we have shown, positive maternal touch appears to be important for supporting physiological regulation into the preschool years. However, due to the correlational nature of some of these studies, including ours (Brummelman et al., [2019] is an exception), we may be seeing the ongoing effects of stable positive parenting that began early in life.

We wish to comment on the simple positive correlation between positive touch and negative (as well as neutral) touch observed in our results; we posit that this correlation is an artifact of the way that touch was measured. Some participant dyads were not proximate during the rejection conversation (e.g., the mother was sitting while the child was moving about the room). In these cases, positive and negative touch were both low simply because touch opportunities were fewer. Other dyads were in physical contact throughout the task (e.g., the mother's hand was resting on the child's leg). Included in our code for positive touch was continued contact (e.g., a hand resting on the leg of a child seated in the mother's lap); by and large, this was a positive action, but it also had the potential to turn into a negative touch as when the mother roughly maneuvered the child's body. In cases such as these, dyads could be high in both positive and negative touch, as a function of opportunity. Alternatively, it is possible that some individuals communicate more often via touch. Given the relationship between positive and negative touch, it was important to covary negative touch incidents as we evaluated the association between positive maternal touch and child stress reactivity. We also wish to note that in the present study, touch and cortisol reactivity are measured on different tasks; this design reflects our assumption that they are each indices of trait-like properties—touch as a stable aspect of parenting and cortisol reactivity as a persistent quality of the child's stress response system.

Second, our data suggested that adjusted family income was positively associated with child stress reactivity; that is, lower income was associated with a blunted cortisol response to the laboratory stressors, and higher income with a more reactive response. To define "low-income" more clearly in our sample, based on our 9-category income levels and the average number of persons in households (Mdn. = 4.0), the mean adjusted income ($M$ = 1.24, SD = .68) represents about \$20,000 to \$25,000 per person in the household. By U.S. Department of Housing and Urban Development standards (Income limits, 2017), nearly half of the families in our sample (48.7%) have adjusted incomes at 1.00 or below and would qualify as low income.

This finding—that lower income was associated with lower, or blunted, reactivity to the laboratory stressors and that higher income was associated with stronger reactivity to the stressors—is consistent with prior research demonstrating a positive association between family income level and cortisol reactivity in children (e.g., Blair et al., 2008; Raffington et al., 2018). Relatedly, in a meta-analysis of studies of positive parenting and cortisol reactivity, SES was shown to be a moderator of the association between parenting and reactivity, with a small positive association between responsive parenting and cortisol reactivity in higher SES families and a small negative association in lower SES families (Hackman et al., 2018). Because the number of day-to-day stressors is higher in lower-income households (Buckner et al., 2003; Evans et al., 2013), children in these contexts may be faced with repeated activation of the HPA axis, over time developing hyporeactivity to stressors, including those of moderate intensity in laboratory settings (e.g., Badanes et al., 2011; Raffington et al., 2018). Children's blunted stress responses can be seen as attempts to regulate themselves in a context of repeated activation. In comparison, in higher-income contexts, children confront fewer major stressors and may also have sufficient personal and interpersonal resources to self-regulate, exhibiting an appropriate (not blunted) response to challenging stimuli (Hackman et al., 2018). Research that simultaneously examines both specific parenting behaviors and the larger socioeconomic context is important to consider going forward.

Although we did not hypothesize an effect of child sex, our regression model indicated that child sex was significantly associated with AUCi levels, with females showing more cortisol reactivity than males. Although some prior studies have shown no effect of sex on cortisol reactivity in children aged 9–15 years (e.g., Kudielka et al., 2004), there is also a competing report that 10–12-year-old girls are more highly reactive to a laboratory stressor than boys (Hardie et al., 2002). There are very few studies of preschool-aged children that focus on sex differences, but one study of 3-year olds showed that females but not males, with the lowest cortisol reactivity scores, were more prone to depressive symptoms at 5 years of age (Daoust et al., 2018), suggesting that greater reactivity to laboratory stressors is more normative for females.

## 4.1 | Strengths and limitations

The study has several significant strengths. First, the literature on associations between maternal touch and cortisol reactivity in early childhood is quite limited, as is research on relations between income and cortisol reactivity in young children. Second, the context in which touch was assessed is an apt one. The emotionally arousing rejection conversation provided an optimal laboratory situation in which to examine touch, as heightened arousal in both mother and child may have increased the frequency of touch behaviors—although this is speculative and could benefit from a direct examination of arousal in different mother–child contexts. Further, the way we measured positively valenced touch included both discrete touch and durative touch (counted once in each interval in which it was sustained), capturing a greater breadth of types of touch. Third, controlling for temperament and negative touch in our analyses allowed us to separate child temperament (Clark et al., 2000; Jaffee et al., 2004; Martorell & Bugental, 2006) and mothers' overall propensity to touch as factors that could explain variance in the association between maternal positive touch and children's physiological reactivity.

The contributions of our findings to the literature must be also contextualized in terms of study limitations. While our assessment of touch derived from a naturalistic interaction, it was conducted in the laboratory and therefore might not accurately capture maternal touch behaviors in the home. The inclusion of an observational measure of touch in a non-laboratory context would be desirable. Relatedly, hugs, kisses, snuggles, caresses, and so on were each recorded as instances of positive touch in our coding scheme, despite the fact that it is possible that a warm hug may be "worth more" than a pat on the back. Another limitation is the way in which stress was induced in the laboratory. Children watched a 4-min scary clip from the movie *Fantasia* and engaged in two frustrating tasks. While we used a series of events to induce mild stress in preschool-aged children, as no one task on its own had previously been shown to consistently elicit a stress response in this age group (Gunnar et al., 2009), it is unclear the extent to which these would generalize to real world stressors. Furthermore, the degree to which stress was induced in any individual child could depend on various factors, including the child's previous exposure to scary videos, television or movies, the amount of attention they paid to the clip, or temperamental differences in response to novelty. These factors could have had impacts on cortisol secretion that we did not control. In addition, maternal touch and child stress reactivity were each measured at a single point in time leading us to a correlational, not causal finding. As such, we cannot say whether these effects are consistent across development or only just became apparent. Finally, this study focused on the effects of maternal touch, leaving out the potentially similar, distinct, or complementary effects of paternal touch, or effects of touch by other primary caregivers, regardless of whether they carried and birthed the child. Consideration should be given to families in which partners, grandparents, older siblings, and others are primary caretakers of infants and young children.

## 5 | CONCLUSIONS

Our findings contribute to a deeper understanding of the role of maternal touch on children's physiological regulation in early childhood, and on the role of family income in children's cortisol reactivity. The main effect of positive touch on children's lowered physiological reactivity suggests that positive maternal touch is profoundly valuable not only in infancy but also into the early childhood years. The main effect of family income suggests that for young children, fewer household resources and the likely greater frequency of stressors are associated with blunted cortisol response. The main effect of sex suggests that female children might be more reactive to laboratory stressors than male children. Because cortisol hyperreactivity renders children vulnerable to negative behavioral and mental health outcomes (Barrios et al., 2017; Cruz et al., 2018; Kopala-Sibley et al., 2017), it is crucial to better understand the predictors of cortisol reactivity and the contexts in which cortisol reactivity is particularly affected. However, it is also important to be conservative in our interpretation as the literature on stress reactivity is mixed, with some studies showing maladaptive associations (Dockray et al., 2009; Kao et al., 2017; Tout et al., 1998) and others showing adaptive ones (Blair et al., 2005; Hankin et al., 2010) in early childhood. As suggested by Hackman et al. (2018), future research needs to include a broader range of family backgrounds (e.g., income levels) as well as prospective designs in order to identify moderated effects and causal connections between microsystems in which children develop (e.g., income, parenting) and cortisol reactivity. Our findings suggest that effects of specific parenting practices are also critical to establish. Prior research with infants and our findings point to the importance of positive touch beginning directly after birth and continuing into the early years of their children's lives to support healthy stress regulation.

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## CONFLICT OF INTEREST

The authors declare no conflict of interest.

## DATA AVAILABILITY STATEMENT

Data are available on request from the second and last authors (Smiley & Doan, 2021).

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