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Empirical Article

Unpredictable maternal behavior and infant emotional reactivity in the context of high maternal adversity

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Abstract

The impact of maternal adverse experiences on early parent–infant interaction and child development is widely acknowledged. Yet, the underlying mechanisms of intergenerational transmission remain poorly understood, especially in samples facing high adversity. This study explored the unpredictability of maternal (auditory, tactile, and visual) sensory signals as a mediator between maternal childhood maltreatment and infant emotional reactivity in a sample from southwestern Uganda. In 115 mother–infant dyads ($M = 28.70$ years, $SD = 6.68$, and $M = 7.87$ months, $SD = 0.81$), both maternal trauma exposure and unpredictability were associated with reduced infant emotional reactivity. However, no mediation effect was found. These findings suggest that infants adjust dynamically to their mothers' unpredictable behavior, helping them adapt to challenging environments.

Keywords unpredictability of maternal sensory signals, maternal childhood maltreatment, low- and middle-income countries, infant emotional reactivity, intergenerational transmission

Lay summary

This study examined how mothers' experiences of childhood maltreatment influence their infants' emotional responses, and whether unpredictable maternal behaviors, reflected in how mothers shifted between touch, voice, and visual cues during interactions, help explain this link. To better understand these processes in a context characterized by high rates of childhood maltreatment, the research was conducted with mothers and infants in southwestern Uganda. Both maternal maltreatment history and more unpredictable caregiving patterns were linked to infants showing lower negative emotional responses. However, unpredictability did not explain the link between mothers' early experiences and infants' responses. These findings suggest that infants may flexibly adjust their emotional reactions to their mothers' behavior, possibly as an adaptation to challenging environments.

Childhood maltreatment poses significant global health concerns due to its enduring adverse effects on cognitive, psychological, and physical development (Hughes et al., 2017). These effects extend beyond the individual, potentially impacting the next generation—a phenomenon termed intergenerational transmission (Bowers & Yehuda, 2016; Moog et al., 2023). Understanding how such experiences and their effects are transmitted across generations requires studying contexts with high prevalence of maltreatment, as they provide critical opportunities to examine the mechanisms underlying these processes. Sub-Saharan Africa, where childhood maltreatment prevalence is among the highest globally (Moody et al., 2018; United Nations Children's Fund, 2014), is a critical context for such investigations. Evidence indicates a dose-response relation, where greater severity and multiple exposures to childhood maltreatment are associated with worse developmental outcomes in offspring (Moog et al., 2023). Elevated adversity levels may amplify intergenerational effects through altered caregiving behaviors influenced by maternal maltreatment and further compounded by socio-economic challenges (Ministry of Gender, Labour & Social Development

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[MGLSD], 2015). By exploring these pathways in high-adversity contexts, this research contributes to advancing theoretical models of intergenerational transmission in understudied populations and it informs the development of culturally sensitive and targeted interventions.

While the precise mechanisms underlying the intergenerational transmission of maternal childhood maltreatment still need to be elucidated, one key pathway in the context of maternal childhood maltreatment is altered maternal behavior (Greene et al., 2020; Lomanowska et al., 2017). During the postnatal period, consistent and responsive maternal behavior is essential for infants' early development, promoting mother–child bonding and facilitating the offspring's adaptation to and development within their cultural and social context (Bornstein, 2012; Bornstein et al., 2015). Conversely, maternal exposure to childhood maltreatment has been associated with suboptimal maternal behavior, such as intrusive, disengaged, abusive, or harsh parenting (Greene et al., 2020; Moehler et al., 2007). These behaviors, in turn, may interfere with the emergence of a secure mother–infant attachment and hinder offspring socioemotional development (Cerezo et al., 2008; Cui et al., 2018; Groh et al., 2017). For example, offspring of childhood maltreatment-exposed mothers face heightened risks of internalizing problems (Moog et al., 2023) and insecure attachment (Kwako et al., 2010). This research has been conducted primarily in high-income Western countries, focusing on the quality of maternal behavior as a mediator between maternal childhood maltreatment and offspring developmental trajectories (Greene et al., 2020; Lomanowska et al., 2017).

In addition to the quality of maternal behavior, the role of *patterns* of maternal behavior has garnered significant attention (Davis & Glynn, 2024). Recent studies have explored the unpredictability of maternal sensory signals as a critical component of maternal behavior due to its impact on child development (Davis et al., 2017, 2019, 2022; Glynn & Baram, 2019; Holmberg et al., 2022). It is conceptualized as the degree of consistency in the sequences of maternal auditory, tactile, and visual signals during interactions with an infant (Glynn & Baram, 2019), which can be quantified by means of an entropy rate (Vegetabile et al., 2019). This measure has been derived from an animal model, which simulates the effects of environmental stress on offspring development through stress-induced fragmentation in maternal behavior (Rice et al., 2008). Across species and western populations, exposure to unpredictable patterns of maternal sensory signals during infancy contributes to impaired offspring self-regulation, cognitive development, and stress responsivity (Davis et al., 2017, 2019; Glynn & Baram, 2019; Granger et al., 2021; Holmberg et al., 2022). In line with the concept that predictable environmental characteristics are a crucial factor in early human development (Davis & Glynn, 2024; Köster et al., 2020), this maternal phenotype likely represents a particularly plausible mechanism through which the intergenerational mother-to-child transmission of stressful experiences (e.g., maternal childhood maltreatment) may occur. Furthermore, the unpredictability measure can be applied independent of cultural setting; however, it has not yet been studied in mother–infant interactions within low- and middle-income countries (LMICs), particularly in contexts characterized by high childhood maltreatment rates.

Maternal caregiving in non-Western settings often reflects distinct cultural values, such as a focus on interdependence, physical proximity, and shared caregiving responsibilities, contrasting with the more independence-oriented and verbally mediated caregiving styles common in high-income, industrialized Western societies (Greenfield et al., 2003; Keller, 2007; Morelli et al., 2018). In rural Ugandan contexts, where subsistence farming and communal living are prevalent, caregiving is often distributed among extended family members, and nonverbal, tactile forms of engagement are frequently used with infants (Lancy, 2015). These practices represent adaptive responses to local, social and environmental conditions, emphasizing community cohesion and interpersonal responsibilities (Keller, 2007; Köster et al., 2016; Morelli et al., 2018). While the present study did not assess cultural models of caregiving directly, situating the research within this broader context can help inform the interpretation of maternal behavioral patterns such as unpredictability.

While prior studies from Western contexts have indicated the significance of maternal sensitivity (i.e., maternal behavior quality) in fostering normative socioemotional development (Deans, 2020; Spinrad & Stifter, 2002), the influence of maternal unpredictability on emotional reactivity remains unexplored. Emotional reactivity is a crucial early indicator of infant maladjustment (Spry et al., 2020). It can be described as an individual's differential affective, behavioral, and attentional response to stimuli (Gross & Jazaieri, 2014; Rothbart, 2012; Rothbart & Bates, 2006), whereby heightened or diminished responses may denote problematic attributes for development (Gross & Jazaieri, 2014). Influenced by both biological and environmental factors (Lang & Gartstein, 2018; Rothbart & Derryberry, 1981), emotional reactivity illustrates the central importance of mother–child interactions in early development. These experiences serve as a dynamic platform (cf. Kärtner & Köster, 2024), guiding the child's progression toward optimal emotional regulation strategies, which are crucial for lifelong adaptation and well-being (Morelen et al., 2016 ; Schore & Schore, 2014; Tronick, 2017).

Taken together, available literature supports the idea that maternal behavior may serve as a key pathway linking maternal childhood maltreatment to offspring development. Yet, this research primarily focuses on high-income contexts, overlooking LMICs where childhood maltreatment is notably widespread. This omission may inadvertently introduce a western-centric bias into our understanding of these transmission pathways. To address this gap, our study explores whether unpredictable maternal sensory signals mediate the link between maternal childhood maltreatment and infant socioemotional development in southwestern Uganda, a region with high childhood maltreatment prevalence (Olema et al., 2014). Furthermore, we pioneer the examination of unpredictable maternal care's impact on infant negative emotional reactivity in these cultural and socio-economic settings.

The primary aim of this study was to understand the intergenerational transmission of maternal childhood maltreatment and its impact on infant emotional development, a pivotal marker for infants' adjustment, within a milieu of heightened maternal adversity. Toward this end, in the present study, we investigated 115 mother–infant dyads in southwestern Uganda. Mothers provided self-reports of childhood maltreatment, and unpredictable maternal signals were coded based on a 10-min-long semistructured free play session videotaped during study visits in community health centers. Infant negative emotional reactivity was

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assessed via micro-level coding of infant responses to the Still-Face Paradigm (SFP; Tronick et al., 1978), one of the most frequently used tools to assess infant emotion regulatory ability in the context of a standardized stressor in the laboratory. We hypothesized an association between both maternal childhood maltreatment and unpredictable maternal behavior with infant negative emotional reactivity. Furthermore, we expected that unpredictable maternal care may act as a mediator between maternal childhood maltreatment and infant negative emotional reactivity.

Methods

Sample

The study included 115 mother–infant dyads from Kisoro and Kabale districts in southwestern Uganda, recruited over four months (February to May 2020) via four health centers (Kamuganguzi, Kamukamira, Yard, and Heal Health Centers). Kisoro, with a population of approximately 281,700, and Kabale, with about 528,200 residents, are predominantly rural districts where 90% and 86% of their populations reside in rural areas, respectively. They are characterized by their reliance on subsistence farming, benefiting from hilly terrain and fertile volcanic soils conducive to agriculture (Uganda Bureau of Statistics, 2016).

Mothers in the study averaged 28.7 years of age ($SD = 6.68$, range: 18–50), and they had an average of 2.58 children ($SD = 1.64$, range: 1–8). Infants were on average 7.87 months ($SD = 0.81$, range: 5.64–10.39, 54.8% male). Most mothers were married (90.4%) and exhibited a high literacy rate (92.1%). Monthly household incomes averaged 144,375 Ugandan Shillings ($SD = 180{,}589$, range: 10,000–1,000,000), which corresponds to approximately $39.55 (range: $2.74–$273.97) based on the exchange rate during February to May 2020, the period of assessment. As a reference, 1 kg of maize, a staple food in the region, cost approximately $0.30 during this time (World Food Programme, 2024). Inclusion criteria for mothers comprised being 18 years or older, without acute or chronic severe medical conditions, and reporting no regular alcohol or drug use. Infants were healthy and born full term.

Data collection was conducted by two female research assistants fluent in the local languages Rufumbira, Runyankore, and English. Participants provided written informed consent and received monetary compensation of 12,000 Ugandan Shillings plus transportation costs. Procedures adhered to APA standards and were approved by the Ugandan National Council for Science and Technology (Ref. HS2060ES) and the local ethics committee at Mbarara University of Science and Technology (Ref. MUREC 1/7).

Forty-nine additional dyads were assessed but not included due to missing questionnaire and video data ($n = 23$), given the difficult conditions of the data assessments, and noncompliance with the SFP protocol by the mothers ($n = 26$). See detailed exclusion criteria below.

Procedure

Assessments occurred in testing rooms at community health centers in urban and rural areas. The free play episode preceded the SFP, and assessments concluded with clinical and sociodemographic questionnaires. All questionnaires were translated and administered as interviews in the mothers' native language.

The coding for maternal unpredictability and infant negative emotional reactivity was conducted by research assistants in Finland and German, respectively. Throughout the coding process, communication with Ugandan researchers was maintained to address any cultural nuances or questions.

The Childhood Trauma Questionnaire—short form

The Childhood Trauma Questionnaire—short form (CTQ-SF) is a reliable self-report tool used to retroactively assess various forms of childhood abuse and neglect (Bernstein et al., 2003). It consists of items rated on a 5-point Likert scale (1 = *Never true*, 5 = *Very often true*), with higher total scores indicating more severe maltreatment experiences. The CTQ-SF has proven good internal consistency ($\alpha = 0.66–0.92$) and test-retest reliability ($r = 0.79–0.86$) and has been validated in African countries, including Uganda (Bernstein et al., 2003; Charak et al., 2017; Olema et al., 2014). The maternal CTQ score is commonly computed as a summed score, ranging from 25 to 125. To account for missing data, an overall CTQ score was calculated by averaging responses, allowing one missing entry per subscale (out of 5). Missing entries were present for 19 participants, with an average of 2.8 and a maximum of 4 (out of 25 items).

Unpredictability of maternal sensory signals during free play

Research assistants instructed mothers to freely interact with their child for 10 min using standard age-appropriate toys commonly found in Ugandan families (e.g., rattle, ball, doll), following the protocol by Davis et al. (2017, 2019).

Video data of the free play interactions were analyzed to quantify unpredictability of maternal sensory signals. This involved coding of maternal tactile, visual, and auditory interactions with the child, examined in real-time using the Noldus Observer XT software. Following Davis et al. (2017), this measure focuses exclusively on maternal sensory signals. While incorporating dyadic interactions would undoubtedly provide additional value, we adhered to the original coding protocol for this initial application to a novel population. This ensures comparability with prior research on unpredictability. Auditory signals encompassed all vocalizations made by the mother, spanning speech and laughter. Visual cues comprised instances where the mother presented a toy while the infant was visually attending. Tactile signals included all physical contact initiated by the mother, such as touching and holding. Coding for maternal unpredictability was conducted by three independent research assistants at Turku University, Finland. Fifteen videos were double coded, achieving a high average inter-rater agreement of 82.49%. Discrepancies in video coding were discussed by the coders and a consensus was reached.

The unpredictability of maternal sensory signals was then calculated based on all transitional probabilities between maternal auditory, visual, and tactile sensory signals, considering all eight potential combinations. For instance, if combined touch and visual signals always preceded verbal signals, the transition probability would be 1 (highly predictable). Conversely, if one behavior following another occurred randomly, with all possible transitions

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being equally likely, this would indicate high unpredictability. Transition probabilities were then summarized into a single metric. Transitions were modeled as changes in the state of a discrete-state first-order Markov process, with the entropy rate determining sensory input unpredictability. The entropy rate ranges from 0 to 2.807, with higher values indicating greater unpredictability. While one may presume that maternal unresponsive behavior in the SFP would mimic unpredictable parenting behavior, it is critical to note that the entropy rate captures predictability through the probability of transitions between sensory signals, which is independent of the quantity of maternal behaviors (Davis et al., 2017). This was also the case in the present study, where neither entropy rate nor infant emotional reactivity was significantly correlated with the frequency of maternal sensory signals. Detailed materials on the coding system and entropy rate calculation are provided by Davis et al. (2017) and Vegetabile et al. (2019), accessible at https://contecenter.uci.edu/shared-resources/.

Infant emotional reactivity in the still face paradigm

The SFP is a well-established method for assessing infant behavioral and affective responses to the violation of contingent mother–infant interactions (Tronick et al., 1978). In this study, the SFP comprised three 2-min episodes: initial play, still-face episode (SFE), and reunion. Mothers positioned their infants in an infant seat facing them, with a mirror behind for visibility of the mothers' facial expressions.

During the initial play, mothers were instructed to interact naturally with their children. In the SFE, mothers were directed to maintain eye contact with their infants without facial, vocal, or tactile expression. These instructions were provided before the SFP, and mothers practiced the still-face interaction beforehand. Following the SFE, mothers returned to a 2-min natural play interaction with their children.

Infants' negative emotional responses during the SFE were analyzed using a micro-level coding system focusing on duration, intensity, and latency of negative affect (cf., Moore et al., 2009; Sullivan et al., 2015). Negative affect, comprising expressions like anger, sadness, and frustration (e.g., frowning), was coded in 5-s intervals. Instances of multiple emotional expressions resulted in negative affect outweighing neutral and positive affect. Due to assessment conditions, disturbances such as maternal touch, loss of eye contact, or external distractions (e.g., loud noises) were observed in 1.59% of all coded intervals and 22.61% of dyads. Time windows impacted by these events, including those extending across consecutive intervals or continuing to influence infant behavior, were excluded from the analysis.

The duration score of negative affect was calculated as a percentage of the total SFE time length in which negative affect was present. For intervals with negative affect, intensity was rated on a three-point scale (1 = *mild fussing*, 2 = *moderate crying*, 3 = *intense crying* or *screaming*), reflecting the highest intensity within the interval. The intensity score accounted for disturbances by capturing the maximum intensity shown by the infant during the 2-min episode. Latency was measured as the time (in seconds) until infants exhibited negative vocalizations but was transformed into a binary variable indicating presence or absence of negative vocalizations due to time windows excluded from the coding. Duration, intensity, and latency were highly correlated: latency—intensity ($r = .893$, $p < .001$), intensity—duration ($r = .800$, $p < .001$), and duration—latency ($r = .725$, $p < .001$). Due to the suboptimal testing conditions, variables were transformed into *z*-scores and averaged, forming a robust composite score for infant negative emotional reactivity.

The SFE was coded using Avidemux (version 2.7.0). Inter-rater reliabilities for 24% ($n = 39$) of the original video samples were high: affect ($\kappa = .76$), intensity ($\kappa = .79$), and disturbances ($\kappa = .72$).

Analyses

This study is a confirmatory analysis, testing the hypothesis that unpredictable maternal sensory signals mediate the relation between maternal childhood maltreatment and infant negative emotional reactivity. Statistical analyses were performed using SPSS version 27(IBM). Bivariate correlations were also conducted to assess potential covariates. A mediation analysis was carried out using the PROCESS Macro (Hayes, 2022) with a 95% confidence interval and 10,000 bootstrap samples.

Results

To identify potential covariates, bivariate analyses were conducted between the three model variables (maternal childhood maltreatment, maternal unpredictability, and infant emotional reactivity) and seven sociodemographic variables (maternal age, child age, child sex, number of children, relationship status, monthly income, and literacy; see Table S1). Out of those 21 correlations, only relationship status, $r = .202$, $p = .03$, and literacy, $r = .213$, $p = .02$, where significantly associated with maternal childhood maltreatment. These variables were therefore considered as potential covariates in follow-up analyses.

Analyses of the main model variables revealed that maternal childhood maltreatment and maternal unpredictability were both significantly correlated with infant negative emotional reactivity, $r = -.226$, $p = .015$; $r = -.195$, $p = .037$, respectively. However, no significant correlation was found between maternal childhood maltreatment and unpredictability, $r = -.086$, $p = .36$. Table 1 provides descriptive statistics for the study variables, while Figure S1 includes visualizations of main distributions and bivariate associations.

Although an association between the predictor and mediator is commonly considered a prerequisite for a mediation analysis, recent evidence indicates that indirect effects can occur even in the absence of such direct links (Hayes, 2022). Accordingly, a mediation analysis was employed to investigate subtle intergenerational influences on child development that might not be captured through direct associations alone. This approach also allowed us to test both variables within a single regression model to evaluate their robustness as independent predictors.

The mediation model (Figure 1) with maternal unpredictability as a mediator revealed a negative total, $\beta = -.226$, t (113) = −2.46, $p = .015$, 95% CI [−.500, −.054], and direct effect of maternal childhood maltreatment on infant emotional reactivity, $\beta = -.244$, t (112) = −2.71, $p = .008$, 95% CI [−.519, −.081], indicating that higher levels of maternal childhood maltreatment were associated with lower levels of infant negative emotional reactivity. Additionally, maternal unpredictability of sensory signals showed a significant negative effect on infant negative emotional reactivity, $\beta = -.216$, t (112) = −2.40, $p = .018$, 95% CI [−1.57, −.149], indicating that infants displayed less negative emotional reactivity, the more unpredictable mothers behaved during the free play session. However, the analysis revealed no significant association

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Table 1 Descriptive statistics and CTQ score distribution by ccutoff categories.

Variables	CTQ cutoff scores[a]	*N* (%)	*M* (*SD*)	Range
Maternal unpredictability			.92 (.23)	.40–1.44
Emotional reactivity			.012 (.93)	−1.14–1.39
CTQ total score			2.26 (.76)	1.54–4.15
None to minimal	≤1.44	0 (0)		
Low to moderate	>1.44 ≤ 2.04	72 (62.60)	1.74 (.09)	1.54–2.04
Moderate to severe	>2.04 ≤ 2.75	12 (10.40)	2.44 (.22)	2.11–2.75
Severe to extreme	≥2.76	31 (27)	3.40 (.38)	2.76–4.15

Note. CTQ = Childhood Trauma Questionnaire.
[a]CTQ cutoff scores were calculated by averaging across items to align with the use of mean scores in this study.

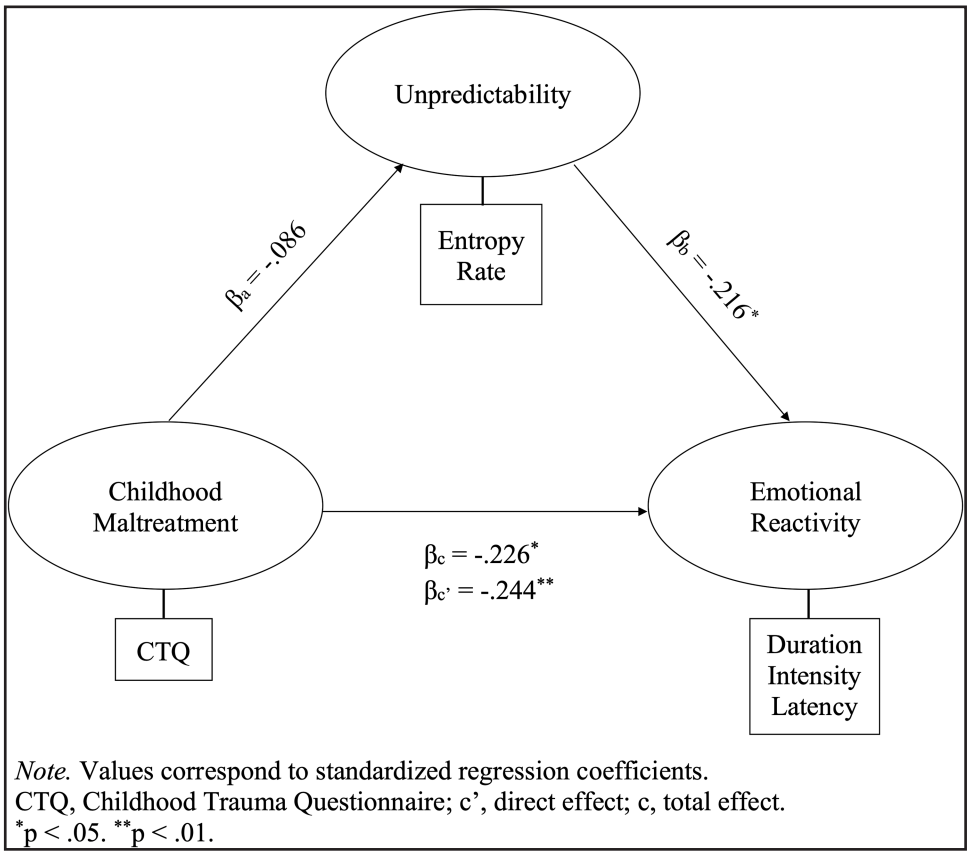


Figure 1 Mediation model. *Note.* Values correspond to standardized regression coefficients. CTQ = Childhood Trauma Questionnaire; c′ = direct effect; c = total effect. *$p < .05$. **$p < .01$.

between maternal childhood maltreatment and the unpredictability of maternal sensory signals, $\beta = -.086$, t (113) = −.920, $p = .36$, 95% CI [−.084, .031]. Moreover, the mediation analysis results were non-significant, indirect effect: $\beta = .019$, 95% CI [−.031, .098].

As a sensitivity analysis, the mediation model was reestimated including maternal literacy and relationship status as covariates, based on their associations in preliminary bivariate analyses. The results remained consistent, with the total effect of maternal childhood maltreatment on infant emotional reactivity remaining statistically significant, β = −.210, t(113) = −2.18, $p = .032$, 95% CI [−.500, −.020], as did the direct effect, β = −.226, t(113) = −2.37, $p = .020$, 95% CI [−.510, −.050]. The association between maternal unpredictability and infant emotional reactivity also remained significant, β = −.210, t(113) = −2.33, $p = .022$, 95% CI [−1.570, −.130]. These findings suggest that the observed effects are robust to the inclusion of key sociodemographic covariates.

Additionally, a reduced sample excluding infants who did not show an emotional response to the SFP (i.e., *z*-scores ≤ −1.14) was examined. In this subsample, the previously observed associations between maternal childhood maltreatment and infant emotional reactivity, as well as between maternal unpredictability and infant emotional reactivity, were non-significant (both $p > .05$). These findings suggest that infants who did not emotionally respond to the sudden disengagement of their mothers during the SFP contributed meaningfully to the associations identified in the primary analysis.

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Given the significant total and direct effects of childhood maltreatment on emotional reactivity, this pathway was further examined by a correlation analysis between the mediation model variables (maternal childhood maltreatment and unpredictability) and each emotional reactivity component. This revealed negative correlations between maternal childhood maltreatment and all three composite variables: duration, $r = -.212$, $p = .023$, intensity, $r = -.232$, $p = .013$, and latency, $r = -.188$, $p = .045$. Entropy rate showed significant correlations with intensity, $r = -.197$, $p = .035$, and latency of negative affect, $r = -.210$, $p = .024$, but did not significantly correlate with duration, $r = -.139$, $p = .139$.

Discussion

The present study investigated unpredictable maternal sensory signals as a potential intergenerational transmission mechanism between maternal childhood maltreatment and infant socio-emotional development in the early postpartum period in a context with high levels of maternal adversity in southwestern Uganda. Both unpredictable maternal sensory signals and higher maternal childhood maltreatment were associated with lower levels of infant negative emotional reactivity, remaining stable as direct effects in a joint mediation model. However, maternal unpredictability did not mediate the association between maternal childhood maltreatment and infant emotional reactivity, suggesting that maternal childhood maltreatment and unpredictability of maternal sensory signals may independently impact infant emotional reactivity.

Here, we report first evidence for an effect of maternal unpredictable behavior on infants' early emotion regulation system. This finding aligns with prior research linking maternal unpredictability to adverse child development outcomes (Davis et al., 2017 , 2019, 2022), such as altered stress responses (Noroña-Zhou et al., 2020) and changes in brain circuit maturation (Granger et al., 2021). Animal studies further corroborate these findings, showing depression-like behaviors in offspring (Molet et al., 2016). Although our hypotheses and interpretations focus on maternal behaviors as an intergenerational pathway, the current findings also leave open the possibility of shared genetic components underlying maternal unpredictability and infant emotional reactivity. Investigating genetic contributions would be an intriguing direction for future research. In addition, we found a negative association between maternal childhood maltreatment and infant negative emotional reactivity, which supports existing literature on the lasting impact of childhood adversity across generations (Moog et al., 2023). Infants of mothers who experienced abuse during their own childhood have shown to exhibit lower negative reactivity during a violation of face-to-face contingent interaction (Hipwell et al., 2019), higher recovery rates following a stressor (Lang et al., 2010), and an increased risk of internalizing problems (Moog et al., 2023). Consequently, it has been proposed that decreased negative affective responses in infants of mothers with significant childhood maltreatment may indicate an intergenerational blunting of the physiological stress response (Brand et al., 2010), potentially setting the stage for maladaptive developmental outcomes (Bunea et al., 2017). Furthermore, childhood maltreatment scores in the Ugandan sample reflect a higher prevalence and severity of maltreatment compared to those observed in a study conducted in high-income countries (HICs; MacDonald et al., 2016). MacDonald et al. (2016) found that the average CTQ score for HIC community samples fell within the "Low to Moderate" category, whereas the Ugandan sample's average in this study was categorized as "Moderate to Severe." Moreover, while 59% of participants in the HIC sample were classified as experiencing little to no maltreatment, none of the participants in the Ugandan sample fell within this range, stressing the substantial adversity faced by populations in LMICs.

Importantly, both maternal childhood maltreatment and maternal unpredictability have been associated with reduced expression of negative affect in infants. This reduced expression of negative affect could be interpreted as an adaptive infant behavioral strategy in the context of high maternal childhood maltreatment or unpredictable patterns of maternal behavior (Cassidy, 1994). In other words, when infants exhibit less negative emotional reactivity during stress, it may offset the adverse effects of maternal childhood maltreatment exposure or unpredictable maternal behavior. Infants' reactions in stressful situations with their mothers could serve as a protective factor. From an attachment theory perspective, diminished negative emotional reactivity in challenging situations is characteristic of infants with insecure-avoidant attachment patterns. Indeed, a blunted response to the stress-inducing task of the SFP has also been linked to insecure-avoidant attachment style later in life. Infants showing a lack of eliciting behaviors toward their mothers (Tronick et al., 1982) or a lack of positive expressions during the SFP (Cohn et al., 1991) have been found to predict insecure attachment styles at 12 months. This attachment style, observed in infants exposed to inconsistent or insensitive parental responses (Ainsworth et al., 1978), may aid in maintaining caregiver proximity and emotional balance (Cassidy, 1994). Thus, the interaction between maternal childhood maltreatment, unpredictable maternal behavior, attachment styles, and diminished emotional reactivity underscores the intricate mechanisms through which infants respond and adapt to their caregiving environment.

However, low infant negative emotional reactivity, as observed behaviorally, may not indicate the absence of physiological stress or arousal. According to Cassidy (1994), the affective inhibition seen in avoidant infants may imply ongoing physiological responses to stress, despite their outwardly composed behavior (Nachmias et al., 1996). Thus, the results of this study could be complemented by incorporating direct measurements of physiological indicators, such as heart rate or cortisol levels in subsequent studies.

The observed low negative emotional reactivity in infants during the SFP may also be attributed to individual differences within the assessment. Notably, more than 30% of infants in this study did not demonstrate negative affect during the SFP, consistent with literature highlighting diverse individual response patterns, including a lack of change in negative affect across still-face episodes or the absence of negative affect altogether (Mesman et al., 2013). When these infants were excluded, associations between maternal factors and infant emotional reactivity were no longer significant, suggesting that variation in observable reactivity, including its absence, may be central to understanding the reported findings. Such behavioral differences could reflect important contextual influences, particularly high maternal adversity and unpredictable behavior. Additionally, cultural variations in emotional desirability and expressiveness may significantly influence infants' reactions to the SFP, which relies heavily on interactional emotional cues and displays (Michalska & Davis,

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2019). While certain cultures prioritize emotional expression (e.g., western-Europeans), others, like collectivistic cultures, emphasize emotional restraint and suppression, particularly concerning negative emotions (Huwaë & Schaafsma, 2018; Li et al., 2019; Matsumoto et al., 2008). For instance, studies from Asian cultures have shown differing patterns of infants' negative affect and recovery during the SFP compared to Western samples, potentially reflecting cultural values that influence caregiver behaviors and infant emotional expressiveness (Hsu & Jeng, 2008; Kisilevsky et al., 1998; Yato et al., 2008). Thus, while the SFP is valuable for evaluating infant socioemotional competencies, its interpretation must consider the broader cultural context. Yet, as our coding scheme was slightly adjusted to address data quality issues (see Methods section for details), our data could not be reasonably compared to the scores of former studies.

The current study did not find evidence supporting unpredictable maternal sensory signals as a mediator between maternal childhood maltreatment and infant negative emotional reactivity. However, both maternal childhood maltreatment and unpredictability remained significant as independent predictors in the mediation model. The absence of mediation may reflect that maternal unpredictability is not the primary pathway linking maternal childhood maltreatment to infant outcomes in this context. Instead, other factors and mechanisms, such as genetics, maternal mental health, ongoing life stressors, or caregiving quality, may play a more central role contributing to unpredictable patterns in maternal behavior (Goodman, 2007; Koverola et al., 2005; Miranda et al., 2011; Su et al., 2022). Additionally, specific cultural factors in the current sample may also influence how maternal unpredictability interacts with the relation between childhood maltreatment and infant emotional reactivity.

Furthermore, although animal studies have consistently linked early life adversity to fragmented and unpredictable maternal behaviors (Baram et al., 2012; Molet et al., 2016), this association was not observed in our high-adversity human sample. This discrepancy may be attributed to the influence of other immediate environmental or personal factors, as previously mentioned. At the same time, protective factors, such as resilience, adaptive coping strategies, and strong social support networks, could contribute to maintaining consistent caregiving behaviors despite exposure to early adversity (Chamberlain et al., 2019). Further research is needed to disentangle these dynamics and to explore how the interplay between maternal childhood maltreatment, parenting behavior, and child outcomes manifests across diverse cultural and socio-economic contexts.

The present study has significant strengths. It recruited a sample from an understudied population with a high prevalence of violence against children (MGLSD, 2015). Moreover, to the best of our knowledge, this was one of the first studies to conduct the SFP in an African country (Gago Galvagno et al., 2021), and the first to examine the effects of unpredictability of maternal sensory signals on infant emotional reactivity in a non-western, non-White and LMIC sample. Finally, this was the first study to investigate the role of patterns of maternal care as a potential key pathway in intergenerational transmission.

Limitations include reliance on retrospective self-report questionnaires for childhood trauma scores. While the CTQ is standardized and validated in sub-Saharan African contexts, future research could benefit from incorporating a mix of self-report measures and clinical assessments. Additionally, experiment procedures, like the SFP, were conducted in various health centers, introducing challenges like background noises and suboptimal lighting, contributing to relatively high exclusion rates. However, addressing these issues involved adding a disturbance category to the coding system and accounting for disturbances with an integrated score for infant emotional reactivity. Lastly, this study focused on the unpredictability of maternal sensory signals in a context of high childhood maltreatment prevalence, prioritizing this measure as an objective and comparable method for quantifying maternal behaviors across diverse settings. Interestingly, the entropy rate in our Ugandan sample was descriptively higher than that observed in a U.S. sample (Davis et al., 2017). Future research should build on these findings by exploring culturally specific parenting practices in non-Western contexts to better understand maternal behavior patterns and their implications for child development (cf. Köster et al., 2022, 2025). In parallel, extending unpredictability-based frameworks to incorporate infant behavior could offer a more comprehensive view of dyadic regulation and the interactive processes that shape early caregiving environments.

In conclusion, this study highlights the impact of maternal childhood maltreatment and unpredictable maternal sensory signals on infant negative emotional reactivity in a non-western, LMIC with a high childhood maltreatment prevalence. These findings contribute to the expanding literature on intergenerational consequences of maternal childhood adversity and provide further support for the detrimental effects of unpredictable patterns of maternal care on child development. Specifically, maternal childhood maltreatment and unpredictability can lead to low infant negative emotional reactivity, with potential long-term ramifications for the child's emotional and behavioral well-being. More research is needed to understand how these maternal factors impact infant socioemotional development, and to devise effective trauma screenings and interventions. This is particularly important in non-Western contexts, where childhood maltreatment is highly prevalent, to help break the cycle of adverse outcomes across generations.

Supplementary material

Supplementary material is available at *Child Development* online.

Data availability

The data underlying the main analyses of this study are publicly available via the Open Science Framework at https://osf.io/wk48m/. Detailed materials on the coding system and entropy rate calculation are available from the Conte Center at the University of California, Irvine at https://contecenter.uci.edu/shared-resources/. The analyses presented here were not preregistered.

Author contributions

María José Garzón (Formal analysis, Writing—original draft, Writing—review & editing), Riikka Korja (Formal analysis, Writing—review & editing), Herbert Ainamani (Investigation, Writing—review & editing), Eunice Ndyareeba (Investigation, Writing—review & editing), Philipp Töpfer (Conceptualization, Investigation, Writing—review & editing), Eeva Holmberg (Formal analysis), and Moritz Köster (Conceptualization, Investigation, Formal analysis, Writing—original draft, Writing—review & editing)

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Conflicts of interests

None declared.

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