Infant Behavior and Development 84 (2026) 102230

Contents lists available at ScienceDirect

Infant Behavior and Development

journal homepage: www.elsevier.com/locate/inbede

Full length article

Self-regulation during a modified still-face paradigm with a mobile device as a predictor of early internalizing and externalizing problems

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ARTICLE INFO

Keywords:
Self-regulation
Maternal depression
Internalizing problems
Externalizing problems
Still-face paradigm
Technoference

ABSTRACT

Examining how toddlers' emerging self-regulatory capabilities relate to later behavioral outcomes is important for understanding internalizing and externalizing problems during early childhood. Child self-regulation may serve as a promotive factor, with children demonstrating stronger self-regulation showing resilience against adverse environmental influences. In the current study, we examined the longitudinal relations between toddler temperament, self-regulation, and maternal internalizing symptoms assessed at 18 months, and toddler internalizing and externalizing problems at 24 months. Data were drawn from a longitudinal study on attention and temperament (name masked for review; 24-month follow-up sample: $n = 52$; 55.8% girls and 44.2% boys; complete-case analytic sample: $n = 44$). Toddler self-regulation was assessed using a modified Still-Face Paradigm designed to reflect technoference, capturing regulatory behaviors in the context of modern digital parenting. We found that specific temperamental dimensions differentially predicted internalizing and externalizing problems, while maternal internalizing symptoms and toddler behavioral regulation were associated with both internalizing and externalizing problems at 24 months of age. Importantly, toddler self-comforting behaviors during the modified still-face task remained a significant negative predictor of internalizing and externalizing problems at 24 months, even after accounting for maternal internalizing symptoms. Our findings support the role of toddler behavioral regulation as a potential protective factor against emotional and behavioral difficulties in early childhood above and beyond the contribution of maternal mental health.

The first two years of life represent a critical period of development in which rapid brain growth and early experiences form the foundation for later cognitive, emotional, and social functioning. During this time, psychological processes across multiple domains contribute to individual differences in adaptive functioning that are linked to later socioemotional outcomes (Bornstein, 2014). Although parental factors, especially maternal internalizing symptoms, have been extensively examined for their contribution to children's behavioral and emotional difficulties in early childhood (Goodman, 2020), relatively few studies have focused on the child's

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https://doi.org/10.1016/j.infbeh.2026.102230
Received 2 March 2026; Received in revised form 20 July 2026; Accepted 17 August 2026

own role in these processes. A growing body of work has begun to address this gap by examining infant regulatory problems such as excessive crying, sleeping difficulties, and feeding problems, and their links to later internalizing and externalizing symptoms (Bilgin et al., 2025; Winsper et al., 2020). This work indicates that early difficulties in regulating basic physiological and emotional states are associated with behavioral problems well into childhood. These studies, however, have relied on parent-reported regulatory problems rather than on directly observed regulatory behavior. Less is known regarding how toddlers actually regulate distress when caregivers are unavailable, and whether these observed behaviors predict later outcomes.

Maternal internalizing symptoms, such as depression and anxiety, are risk factors for behavioral and emotional difficulties in early childhood (Wagner & Valdez, 2020; Zhou & Buss, 2021). A recent meta-analysis reported that maternal anxiety and depression are linked with internalizing and externalizing problems from infancy through middle childhood, highlighting how maternal mental health contributes to children's behavioral and emotional difficulties during early childhood (Rogers et al., 2020). The significance of maternal symptoms on child functioning is pronounced during early childhood, as young children are fundamentally dependent on their caregivers for emotional and physical support (Canfield et al., 2023; Goodman et al., 2011). Beyond genetic transmission, these maternal symptoms can pose significant developmental risks to young children through altered parenting practices (Bernard et al., 2018). Depression in mothers is associated with diminished sensitivity during interactions, inconsistent responsiveness to children's needs, and patterns of disengagement or hostility (Hoffman et al., 2006). Children of mothers with depression show higher internalizing difficulties in early childhood (Barker et al., 2011), and maternal depressive disorder is associated with toddlers' behavioral problems and higher negative emotionality (Prenoveau et al., 2017).

Mothers with higher levels of anxiety tend to limit children's independent exploration through excessive control and overprotective behaviors (Song et al., 2022). Such compromised emotional availability and inadequate scaffolding during critical developmental periods may contribute to both internalizing and externalizing problems in children. This is particularly significant during toddlerhood, when behavioral and emotional processes are especially open to environmental input. Indeed, children of mothers with depression show higher internalizing difficulties specifically during this stage (Barker et al., 2011), and maternal depressive disorder and generalized anxiety disorder are linked to toddlers' behavioral problems and higher negative emotionality (Prenoveau et al., 2017).

Although children develop within specific and unique contexts, individual differences in temperament and self-regulation are fundamental to understanding variability in the emergence of internalizing and externalizing difficulties in early childhood. Child temperament, defined as individual differences in behavioral and emotional reactivity and regulation (Rothbart & Bates, 2006), may alternately indicate vulnerability to, or resilience in relation to psychological challenges. A temperamental profile characterized by high negative affect, high activity levels, and poor regulatory abilities may increase susceptibility to psychopathology (Engle & McElwain, 2011; Nielsen et al., 2019). For example, longitudinal research has demonstrated that higher levels of anger during toddlerhood predicted higher internalizing and externalizing behavior, and lower prosocial behavior at school entry (Sirois et al., 2019). Similarly, toddlers with low inhibitory control displayed more externalizing behaviors during kindergarten (Buss et al., 2014).

While temperamental regulation reflects relatively stable, biologically based individual differences, or trait-like tendencies across contexts (Rothbart & Bates, 2006), self-regulatory strategies capture specific behavioral responses that children use to manage their emotional or attentional state in the moment, indicating how to cope with the challenging context. Child self-regulation, which includes the abilities to manage attention and behavior, has been identified as an important predictor of children's socioemotional adjustment. A meta-analysis reported that childhood self-regulation predicted later internalizing problems, interpersonal behaviors, and achievement (Robson et al., 2020), and children with stronger self-regulatory skills tend to show greater resilience even in the face of adverse environmental influences (Blair & Raver, 2012). As self-regulation develops during toddlerhood, children begin to employ simpler, immediate self-regulatory strategies such as distraction and self-comforting. These approaches are effective in alleviating negative emotions (Ekas et al., 2013; Gilliom et al., 2002) and often develop through social learning from caregivers (Kiel & Kalomiris, 2015; Morris et al., 2007). These strategies can be precursors to more sophisticated regulatory abilities that emerge later (Feldman, 2015) and contribute to adaptive socioemotional functioning (Graziano et al., 2011). Conversely, ineffective self-regulatory behaviors have been linked to both internalizing and externalizing problems in early childhood (Bowie, 2010; Halligan et al., 2013; Mihic & Novak, 2018). However, much of the existing research either examines temperament and self-regulation separately or does not distinguish between trait-like regulatory tendencies and the specific, in-the-moment strategies toddlers deploy during a challenge. By considering both temperament and self-regulation in the current study, we aim to advance our understanding of how early childhood self-regulation independently contributes to later internalizing and externalizing problems.

Children's capacity to self-regulate their emotional and physiological states may play an important role in supporting adaptive functioning and may be particularly important when caregivers are struggling to provide emotional support or co-regulation. Infants have limited capacity to self-regulate and depend on caregivers to co-regulate their arousal and distress. Over the first two years, this co-regulatory scaffolding gives way to self-initiated strategies. As their self-regulation abilities mature, toddlers can manage specific emotional situations autonomously through emerging self-regulation skills (Schoppmann et al., 2019). A recent study showed that 24-month-old toddlers can learn to use distraction by observing another person, indicating that children begin to learn and use strategies more independently (Schoppmann et al., 2022). This transition from relying solely on caregiver support to managing emotions through self-initiated strategies represents a significant developmental milestone (Friedlmeier & Holodynski, 1999).

Importantly, this developmental process does not unfold uniformly, but it varies with children's temperamental characteristics. Toddlers who are more reactive, fearful, or easily dysregulated experience stronger emotional arousal and may need more caregiver support to manage their behavior (Maag et al., 2021). Children high in negative affect or low in inhibitory control may rely on caregiver co-regulation longer than their peers, and when this support is limited or inconsistent, they may turn to self-directed strategies to manage distress.

During the second year of life, children actively explore multiple strategies, including object engagement and self-soothing behaviors, to regulate their emotional challenges independently (Roque & Veríssimo, 2011). Prior studies suggest that infants and toddlers also show increased self-soothing behaviors in response to limited caregiver co-regulation, particularly in contexts of maternal internalizing symptoms. For example, infants of mothers with depression showed increased self-soothing behaviors, particularly in a high-arousal fear situation (Granat et al., 2017; Manian et al., 2025). Similarly, among toddlers with high dysregulated fear, lower levels of maternal comfort behavior were associated with higher levels of self-focused regulation (Kiel, Price & Premo, 2020). These findings suggest adaptive compensation occurs when caregiver support is inconsistent or unavailable, leading young children to increasingly depend on self-initiated strategies, such as self-soothing, as their primary means of emotion regulation (Schoppmann et al., 2019).

Children's self-regulation abilities also allow them to navigate disruptions in parent-child interactions that are commonplace in daily life. The classic still face paradigm (SFP; Tronick et al., 1978) simulates such disruptions by instructing parents to cease emotive and interactive behavior (i.e., still face phase) during an ongoing interaction with their child. The classic SFP has been investigated as an analogue to maternal behaviors linked to internalizing concerns, specifically depression, such that the lack of responsiveness induced in the still face phase may replicate reduced maternal responsiveness and expressivity associated with depressive symptoms. Some studies have found that infants of mothers with a history of depression exhibit atypical behavior during the still face phase (e.g., less negative affect in comparison to controls; Field et al., 2007), however findings from other studies have been mixed (see Mesman et al., 2009 for review). Individual differences in self-regulation and/or temperament may underlie how children respond to these interactional disruptions. Much of this prior work has also focused on infants younger than 12 months, whereas less is known about self-regulatory behavioral patterns during the SFP with older infants and toddlers who have expanding repertoires made possible by motor (e.g., room exploration, object engagement) and cognitive (attention shifting, self-talk) development. In addition, while temperamental traits have been linked to SFP responses (Yoo & Reeb-Sutherland, 2013), few studies have longitudinally examined how these specific, in-the-moment regulatory behaviors during a challenging interaction involving mobile devices predict later internalizing and externalizing problems, especially after accounting for known risk factors such as maternal internalizing symptoms.

Further, recent research has incorporated a modified SFP with mobile devices (Myruski et al., 2018) to reflect a ubiquitous type of interaction disruption, “technoference” (e.g., McDaniel & Radesky, 2018a), defined as interference in social interactions caused by the use of technology. Parent-report of technoference frequency is positively associated with child internalizing and externalizing symptoms (McDaniel & Radesky, 2018a, 2018b). In this modified SFP, parents engage with a mobile device (e.g., smartphone) as the still face phase, while also maintaining non-responsivity as in the classic SFP. The use of a modified Still-Face Paradigm (SFP) involving caregiver smartphone use has been proposed as a developmentally appropriate and ecologically valid adaptation to reflect commonplace disruptions in modern caregiving contexts (Myruski et al., 2018). Toddler observed behavior during the modified SFP mirrors the patterns observed in the classic paradigm, characterized by increased negative affect, dampened positive affect, and greater regulatory behaviors during the still face phase (Myruski et al., 2018; Stockdale et al., 2020). Further, recent work (Schneebeli et al., 2026) showed that disruptions in parent-toddler interactions caused by mobile devices elicited greater toddler self-regulation behaviors in comparison to a non-technology based disruption. By leveraging this modern variation of the SFP, the current study captures how toddlers regulate emotion in response to real-world interpersonal disruptions, offering insight into early regulatory patterns. Children’s ability to self-regulate during these technology-based disruptions may serve as an early indicator of adaptive regulatory capacity, helping to explain individual differences in later internalizing and externalizing behaviors.

1. Current study

Exploring the evolving context and predictors of toddlers' self-regulatory capabilities will advance our understanding of internalizing and externalizing problems during early childhood. Self-regulation may function as a promotive factor, with children exhibiting stronger regulatory abilities showing positive adjustment despite adverse environmental influences (Blair & Raver, 2012; Crespo et al., 2019). Prior studies have often focused on parental contributions to early childhood behavioral and emotional challenges, limiting our understanding of how child factors may shape developmental problems. Furthermore, less is known about how toddlers manage their emotions when parent-child interactions are disrupted by caregiver device use, even though such interruptions have become routine in daily life.

Here we aim to explore early self-regulation and maternal internalizing within a predominantly low-risk, normative sample to contribute to a better understanding of how children navigate common challenging interpersonal disruptions using early self-regulatory strategies. In this study, we examine whether toddler temperament, behavioral self-regulation, and maternal internalizing symptoms at 18 months predict internalizing and externalizing problems at 24 months. Extending prior research, we incorporated a developmentally relevant, observational measure of toddler regulatory behavior within a digitally common caregiving context. Specifically, toddler self-regulation was assessed in an ecologically valid context using a modified SFP, offering a novel methodological approach to examining these developmental processes. Based on prior research linking child self-regulation and maternal mental health to developmental outcomes, we hypothesized that higher levels of toddler temperamental (trait-level) and behavioral (during the still-face) self-regulation and lower maternal internalizing symptoms at 18 months, would be associated with fewer internalizing and externalizing problems at 24 months.

2. Method

2.1. Participants

Of an initial sample of 82 mother–toddler dyads who participated in a modified Still-Face Paradigm at 18 months, 52 mothers (M_{age} = 33.88 years, *SD* = 4.35) and their 18-month-old toddlers (29 female, 55.8%; M_{age} = 18.07 months, *SD* =.79) from communities surrounding State College, PA; Harrisburg, PA; and Newark, NJ, completed follow-up measures at 24 months. Of these 52 dyads, 44 had complete data on all study variables and constituted the analytic sample for the regression models; descriptive statistics and correlations are likewise based on this sample of 44 using listwise deletion. Attrition analyses (Table S1) showed that the two groups were similar on maternal depression and anxiety, the still-face regulatory behaviors, and early internalizing and externalizing problems, though the analytic sample was somewhat lower in negative affect and higher in parental education. A sensitivity power analysis confirming that the sample was adequate to detect the effects of interest is also reported in the Analytic Plan.

Participants' demographic information is presented in Table 1. Thirty-four (65.4%) parents reported their toddler's ethnicity as White, ten (19.2%) reported Hispanic, five (9.6%) reported multiracial, two (3.8%) reported as Asian, one (1.9%) reported African American. Thirty-four dyads were recruited from State College, PA, eight from Harrisburg, PA, and ten from Newark, NJ. All toddlers were born within two weeks of their due date, and mothers reported no major health complications for any child; no participants were excluded on these grounds. Dyads were part of a larger sample, but only a portion were able to complete in-person activities at 18 and 24 months due to COVID-related research restrictions (Vallorani et al., 2024).

2.2. Procedures and measures

As part of the Longitudinal Attention and Temperament Study (Pérez-Edgar et al., 2021), this study was approved by the institutional review board of the affiliated universities. After obtaining informed consent, we asked mothers to complete questionnaires on their own internalizing symptoms, their toddler's temperament, and demographic information. The mother-toddler dyads then participated in a video-recorded modified Still-Face Paradigm (SFP) lasting approximately 8 min. Each family received monetary compensation and a lab-branded T-shirt for their participation.

The modified SFP. The modified SFP with a mobile device (Myruski et al., 2018) consisted of three consecutive phases: freeplay (5 min), still face with mobile device (2 min), and reunion (1 min). The task was completed in an observation room equipped with audio/video recording equipment, a mobile device (iPod touch) placed on a table or cabinet, and a basket of toddler toys placed on the ground. Experimenters gave mothers instructions regarding each phase, information about the mobile device app they would use during the still face phase, and how they would signal to move on to the next phase (i.e., audible mobile device notification, knock on door). The task began when experimenters exited the observation room.

During the freeplay phase, mothers were instructed to play with their toddler as they typically would. To initiate the still face phase, experimenters sent a text to the mobile device in the observation room to generate an audible notification. The still face phase began when the mother picked up the mobile device. In this phase, mothers were instructed to complete a coloring activity via the *Happy*

Table 1
Demographic Information.

	%
Child age in months	*M* = 18.07 (*SD* =.79)
Child sex	
Girls	55.8% (n = 29)
Boys	44.2% (n = 23)
Child ethnicity	
White	65.4%
Hispanic	19.2%
Black or African American	1.9%
Asian	3.8%
Multiracial	9.6%
Mother age in years	*M* = 33.88 (*SD* = 4.35)
Mother education	2.0%
Grade school	3.9%
Some high school	9.8%
Trade, technical or some college	27.5%
College Graduate	23.5%
Graduate Training	33.3%
Graduate Degree	
Married or cohabiting parents	86.79%
Household income	
less than $31,000	10.5%
$31,000-$60,000	18.8%
over $60,000	70.8%

Note. Percentages are based on available data and may have different denominators because of missing demographic information.

Color app (X-FLOW LTD, https://happycolorapp.com), and asked to maintain their attention on the mobile device with a neutral expression throughout this period. The coloring activity consisted of filling an array of shapes with colors indicated by a corresponding number, and was selected due to its simple and engaging features. After 2 min, experimenters signaled via a knock that the parent should move on to the final phase. The reunion phase began immediately after the parent put down the mobile device. For the reunion phase, mothers were instructed to re-engage with their toddler and again interact as they typically would during play.

Toddler self-regulatory behavior. SFP videos were coded for toddler self-regulatory behavior following the coding scheme described in Myruski et al. (2018). Each phase was coded in 15 s epochs (i.e., 20 epochs for freeplay, 8 epochs for still face, 4 epochs for reunion) for the presence (1) or absence (0) of each target behavior. The behaviors of interest for the current study included object engagement, room exploration, and self-comforting, all examined during the still face phase only to capture toddler self-regulatory behavior throughout the interaction disruption. For attention- and motor-based regulatory strategies, object engagement consisted of playing with toys provided (e.g., balls, plushies) or other non-toy objects in the observation room setting (e.g., basket, curtains). To capture self-focused physiological and emotional regulation, room exploration was coded when toddlers moved around the room either by crawling or walking. Self-comforting behaviors included instances when the toddler used their body for self-stimulation either through oral (e.g., thumb sucking, object in mouth) or hand (e.g., clasping hands together, rubbing arms) behaviors. These behaviors were treated as non-mutually exclusive and dynamically co-occurring regulatory strategies (e.g., sucking thumb while moving around the room would be coded as presence of both self-comforting and room exploration). Videos were coded by six reliable coders (kappa $\geq$.70), with 20% of videos being double-coded for reliability (mean kappa =.83; range =.70 −.95; see Supplementary Materials for reliability summary).

For each of the three behaviors, we first computed a frequency score by summing the number of epochs in which the behavior was observed within each phase. To ensure sufficient variance for analysis, behaviors that were displayed at least once by at least 25% of toddlers were included in subsequent score computations. Next, to account for individual differences in overall activity level, we computed proportional scores for each behavior by dividing its frequency by the total behaviors observed for each toddler, including all behaviors (i.e., negative and positive affect, caregiver engagement, and bids for caregiver's attention) coded using the scheme described in Myruski et al. (2018). Thus, for example, a proportional score of.10 for self-comforting indicates that 10% of that child's behaviors during the still face phase were self-comforting. This approach was used to take each toddler's overall activity level into account, and isolate the proportion of behaviors that belonged to each subtype.

Questionnaires. Versions of each questionnaire were available in both English and Spanish and were administered based on the caregiver's first language (English: 91.4%; Spanish: 8.6%).

Maternal internalizing symptoms. Maternal internalizing symptoms were assessed at 18-months using the Beck Depression Inventory (BDI; Beck et al., 1961) and Beck Anxiety Inventory (BAI; Beck et al., 1988). Maternal depression was measured using the BDI, which consists of 21 items assessing symptom severity over the past week. For each item, mothers rated their symptoms on a four-point scale (0 = *symptoms absent* to 3 = *severe symptoms*). The BDI yields a total score between 0 and 63, with higher scores indicating greater depression severity. Internal consistency was good (α =.88). Anxiety symptoms were assessed using the BAI, a 21-item self-report questionnaire designed to evaluate the severity of anxiety in healthy and psychiatric populations. Mothers rated the severity of anxiety symptoms (e.g., fear of losing control) experienced in the past month using a four-point scale (0 = *not at all* to 3 = *severely*). Total scores range from 0 to 63, with higher scores reflecting greater anxiety severity. The BAI demonstrated strong internal consistency (α =.94). For both measures, when participants had missing item responses, we prorated the total score to the full 21-item scale, following standard practice.

Child temperament. Mothers reported their toddler's general behavioral patterns at 18 months using the Toddler Behavior Assessment Questionnaire (TBAQ; Goldsmith, 1996). In this study, we used the negative affect, activity, and inhibitory control dimensions. Parents rated their children's behavior over the past month across familiar situations using a 7-point Likert scale (1 = never, 7 = always). Ratings captured the frequency and intensity of negative affect displays, general motoric activity level, engagement in physical behaviors, and ability to suppress inappropriate responses. Internal consistency for each dimension demonstrated appropriate reliability: negative affect (α =.89), activity (α =.69), inhibitory control, (α =.89)

Child internalizing and externalizing problems. When children reached 24 months of age, mothers completed the Child Behavior Checklist (CBCL; Achenbach & Edelbrock, 1983) to assess behavioral and emotional difficulties in young children. Each item describes a behavior problem and mothers are asked to evaluate the extent to which each behavior has manifested as a concern over the previous six weeks. Each item describes a specific behavior problem, and mothers are asked to assess the extent to which the described behavior has been a concern over the past six weeks using a three-point scale (0 = *not true*, 1 = *somewhat or sometimes true*, 2 = *very or often true*).

The CBCL yields scores on two broad behavioral dimensions: Internalizing and Externalizing problems. The Internalizing dimension encompasses four distinct subscales that capture emotional and social difficulties: Emotional Reactivity, Anxiety/Depression, Somatic Complaints, and Social Withdrawal. The Externalizing dimension comprises two subscales focusing on behavioral regulation: Attention Problems and Aggressive Behavior. These scores are calculated by summing relevant items within each domain. When items were missing, scores were prorated to the full item set in accordance with the procedure recommended in the CBCL manual. Internal consistency for internalizing (α =.94) and externalizing (α =.91) dimensions were strong.

2.3. Analytic plan

Because of missing data on the 18-month maternal questionnaires, all regression, correlational, and descriptive analyses were conducted on participants with complete data on every study variable, using listwise deletion (n = 44). First, a sensitivity power

analysis in G*Power 3.1 (Faul et al., 2009; *F* test, linear multiple regression R^2 increase; α =.05, power =.80, $N = 44$, 3 tested predictors, 10 total predictors) indicated that the study had 80% power to detect an incremental effect of $f^2 = .28$ or larger, representing a medium-to-large effect (Cohen, 1988).

Second, we conducted hierarchical linear regression models in jamovi (Version 2.7.37.0; The jamovi project, 2026) to examine the longitudinal relations between toddler temperament, self-regulation, and maternal internalizing symptoms at 18 months, and toddler internalizing and externalizing problems at 24 months. We entered control variables of child age, sex, and data collection site on the first step. On the second step, we entered child temperament: activity, inhibitory control, negative affect.

The third step added maternal internalizing symptoms. Because maternal depression and anxiety at 18 months were highly correlated, we combined them into a single maternal internalizing composite, computed as the average of the standardized (z-scored) BDI and BAI totals, to avoid multicollinearity. As a robustness check, we also estimated separate models for anxiety and depression (see Supplementary Materials).

On the fourth step, we added children's self-regulation behaviors observed during the still face phase: object engagement, room exploration, and self-comforting. We checked the assumptions of linear regression before interpreting the models. Multicollinearity was assessed with variance inflation factors (VIFs), the normality of residuals was examined with Shapiro–Wilk tests and Q–Q plots, linearity and homoscedasticity were assessed through visual inspection of residual-versus-fitted-value plots, and potentially influential observations were evaluated using Cook's distance.

3. Results

3.1. Preliminary analyses

We checked the regression assumptions before interpreting the models, including multicollinearity, residual normality, linearity, homoscedasticity, and influential observations. All VIFs were low in both models (≤ 2.01), and the VIF for the maternal internalizing composite was 1.01 in the internalizing model and 1.05 in the externalizing model, so collinearity was not a concern. We examined the normality of residuals with Shapiro–Wilk tests and Q–Q plots. Residuals were approximately normal for the externalizing model, W = .98, p = .61. For the internalizing model, the Shapiro–Wilk test showed a minor departure from normality, W = .93, p = .01, but the Q–Q plot showed slight deviation in the tails. Across the final models, residual-versus-fitted-value plots did not indicate substantial violations of linearity or homoscedasticity. Cook's distance values were below the conventional cutoff of 1.0 in both final models, suggesting that no individual case exerted undue influence on the results.

3.2. Descriptive statistics

Descriptive statistics and correlations among study variables are presented in Table 2. We tested sex and site differences on all study variables. Girls and boys did not differ on any variable, including inhibitory control, $t(42) = -1.06$, $p = .29$; activity, $t(42) = -.35$, $p = .73$; negative affect, $t(42) = -.53$, $p = .60$; maternal internalizing symptoms, $t(42) = .29$, $p = .77$; object engagement, $t(42) = -.26$, $p = .80$; room exploration, $t(42) = 1.81$, $p = .08$; self-comforting, $t(42) = -1.75$, $p = .09$; internalizing problems at 24 months, $t(42) = 0.29$, $p = .78$; and externalizing problems at 24 months, $t(42) = .44$, $p = .66$. Site differences emerged for room exploration during the still-face phase, $F(2, 41) = 11.55$, $p < .001$, but no other variable differed by site: inhibitory control, $F(2, 41) = .82$, $p = .45$; activity, $F(2, 41) = 2.79$, $p = .07$; negative affect, $F(2, 41) = .57$, $p = .57$; maternal internalizing symptoms, $F(2, 41) = .28$, $p = .76$; object engagement, $F(2, 41) = .13$, $p = .88$; self-comforting, $F(2, 41) = 2.61$, $p = .09$; internalizing problems, $F(2, 41) = 1.63$, $p = .21$; and externalizing problems, $F(2, 41) = .01$, $p = .99$.

Toddler age was positively correlated with self-comforting during the still-face phase, $r = .39$, $p < .01$. At 18 months, toddler inhibitory control was negatively correlated with negative affect, $r = -.34$, $p < .05$, while activity was positively correlated with negative affect, $r = .39$, $p < .01$, as well as internalizing problems, $r = .45$, $p < .01$. In terms of self-regulation behaviors during the still face phase, toddler room exploration was negatively correlated with self-comforting $r = -.35$, $p < .05$.

Maternal internalizing symptoms demonstrated significant associations with later toddler outcomes. Maternal depressive symptoms at 18 months were positively related to their own anxiety symptoms, $r = .73$, $p < .001$, and to their toddlers' internalizing, $r = .40$, $p < .01$, and externalizing problems at 24 months, $r = .62$, $p < .001$. Additionally, maternal anxiety symptoms showed a positive association with their toddlers' externalizing problems, $r = .40$, $p < .01$. The maternal internalizing composite was positively associated with toddlers' internalizing, $r = .33$, $p < .05$, and externalizing problems at 24 months, $r = .55$, $p < .001$. Toddler internalizing problems and externalizing problems were also positively correlated with each other, $r = .57$, $p < .001$. Based on these findings, we included toddler sex, age, and data collection site as control variables in the analyses.

3.3. Longitudinal relations between maternal internalizing symptoms, toddler temperament, self-regulation and internalizing problems

In the regression analysis predicting toddler's internalizing problems at 24 months from child temperament, self-regulation, and maternal internalizing symptoms at 18 months, child activity and maternal internalizing symptoms were positive predictors, while child self-comforting negatively predicted outcome (Table 3). In Model 2, which included toddler temperament variables, the model explained 28% of the variance in internalizing problems. The addition of maternal internalizing symptoms in model 3 led to a significant improvement in the model, contributing an additional 10% of explained variance, $\Delta R^2 = .10$, $p < .05$, with the model now explaining 37% of the variance. In Model 4, adding toddler self-regulation during the still face phase (object engagement, room

Table 2
Means, Standard Deviations, Ranges, and Correlations of Study Variables.

Variable	*M*	*SD*	Min	Max	1	2	3	4	5	6	7	8	9	10	11
1. Toddler IC 18 M	3.42	0.95	1.85	6.42	-										
2. Toddler Act 18 M	4.39	0.81	2.70	6.62	−0.25	-									
3. Toddler NA 18 M	3.24	0.57	2.12	4.86	−0.34*	0.39**	-								
4. Mother Dep 18 M	4.87	5.37	0.00	23.10	−0.05	0.06	0.11	-							
5. Mother Anx 18 M	5.96	8.18	0.00	46.00	0.06	−0.03	−0.12	0.73***	-						
6. Mother Int 18 M	−0.00	0.93	−0.82	4.14	0.00	0.01	−0.00	0.93***	0.93***	-					
7. Toddler OE 18 M	0.08	0.10	0.00	0.40	−0.13	0.02	−0.02	−0.06	0.02	−0.02	-				
8. Toddler RE 18 M	0.19	0.13	0.00	0.44	−0.13	−0.09	−0.05	0.04	0.06	0.05	0.14	-			
9. Toddler SC 18 M	0.02	0.06	0.00	0.31	−0.03	0.01	0.13	0.15	0.08	0.12	−0.17	−0.35*	-		
10. Toddler Int 24 M	2.13	2.39	0.00	11.67	0.04	0.45**	0.07	0.40**	0.21	0.33*	−0.13	0.13	−0.21	-	
11. Toddler Ext 24 M	6.34	5.32	0.00	21.00	−0.30	0.27	0.08	0.62***	0.40**	0.55***	−0.04	0.21	−0.23	0.57***	-

Note. N = 44. All correlations are based on the same sample using listwise deletion. Mother Int = maternal internalizing composite (mean of standardized BDI and BAI totals); its *M, SD*, and range are on a standardized metric. IC = Inhibitory Control, Act = Activity, NA = Negative Affect, Dep = Depression, Anx = Anxiety, Int = Internalizing, OE = Object Engagement, RE = Room Exploration, SC = Self-Comforting, Ext = Externalizing.

* $p < .05$
** $p < .01$
*** $p < .001$.

Table 3
Hierarchical Regression Predicting Toddler Internalizing Problems at 24 Months.

Predictor	Step 1 *β*	Step 2 *β*	Step 3 *β*	Step 4 *β* [95% CI]
Child sex	−0.09	−0.12	−0.11	0.06 [−0.20, 0.32]
Data collect location	0.10	−0.07	−0.04	0.28 [−0.06, 0.61]
Child age	0.19	0.21	0.20	0.33* [0.07, 0.59]
Child inhibitory control		0.15	0.14	0.04 [−0.24, 0.31]
Child activity		0.54**	0.52**	0.40** [0.12, 0.68]
Child negative affect		−0.09	−0.09	−0.05 [−0.32, 0.22]
Maternal internalizing symptoms			0.31*	0.38** [0.14, 0.62]
Object engagement (Still Face)				−0.24 [−0.49, 0.01]
Room exploration (Still Face)				0.29 [−0.03, 0.61]
Self-comforting (Still Face)				−0.42** [−0.70, −0.13]
R^2	0.06	0.28	0.37	0.56
ΔR^2		0.22*	0.10*	0.19**
F for ΔR^2		3.72*	5.48*	4.68**
Overall F	0.82	2.36	3.05*	4.19***

Note. Values are standardized regression coefficients (β) at each step; 95% confidence intervals are reported for the final model (Step 4). Maternal internalizing = composite score computed as the average of standardized (z-scored) 18-month BDI and BAI totals. SF = still-face phase. All variance inflation factors were low (≤ 2.01; maternal internalizing composite = 1.01), indicating no multicollinearity. Residual normality was assessed with Shapiro–Wilk tests and Q–Q plots (W = 0.93, p = .01; Q–Q plots indicated only slight deviation in the tails)
* $p < .05$
** $p < .01$
*** $p < .001$.

exploration, and self-comforting) further improved the model, adding 19% additional variance explained, $\Delta R^2 = .19$, $p < .01$, and yielding a final model that explained 56% of the variance, $R^2 = .56$, $F(10, 33) = 4.19$, $p < .001$. Specifically, higher toddler activity levels, $\beta = .40$, $p < 0.01$, and maternal internalizing symptoms, $\beta = .38$, $p < 0.01$, at 18 months positively predicted internalizing problems at 24 months, while toddler self-comforting behavior at 18 months, $\beta = -.42$, $p < 0.01$, negatively predicted internalizing problems.

3.4. Longitudinal relations between maternal internalizing symptoms, toddler temperament, self-regulation and externalizing problems

For externalizing problems at 24 months, maternal internalizing symptoms positively predicted externalizing behaviors, while toddler self-comforting behavior and inhibitory control at 18 months negatively predicted externalizing outcomes (Table 4). In Model 2, toddler temperament variables explained 15% of the variance in externalizing problems. In Model 3, the addition of maternal internalizing symptoms significantly increased the explained variance, $\Delta R^2 = .29$, $p < .001$, with the model now explaining 43% of the variance. In Model 4, adding toddler self-regulation during the still face phase (i.e., object engagement, room exploration, and self-

Table 4
Hierarchical Regression Predicting Toddler Externalizing Problems at 24 Months.

Predictor	Step 1 *β*	Step 2 *β*	Step 3 *β*	Step 4 *β* [95% CI]
Child sex	−0.06	−0.03	−0.00	0.16 [−0.09, 0.41]
Data collect location	−0.01	−0.06	−0.01	0.29 [−0.03, 0.60]
Child age	−0.01	0.01	−0.00	0.12 [−0.12, 0.37]
Child Inhibitory control		−0.25	−0.27	−0.37** [−0.63, −0.11]
Child Activity		0.28	0.24	0.13 [−0.13, 0.40]
Child Negative affect		−0.11	−0.10	−0.06 [−0.32, 0.19]
Maternal internalizing symptoms			0.54***	0.61*** [0.38, 0.83]
Object engagement (Still Face)				−0.20 [−0.44, 0.03]
Room exploration (Still Face)				0.25 [−0.05, 0.55]
Self-comforting (Still Face)				−0.43** [−0.70, −0.16]
R^2	0.01	0.15	0.43	0.61
ΔR^2		0.14	0.29***	0.18**
F for ΔR^2		2.02	18.09***	4.94**
Overall F	0.07	1.05	3.90**	5.10***

Note. Values are standardized regression coefficients (β) at each step; 95% confidence intervals are reported for the final model (Step 4). Maternal internalizing = composite score computed as the average of standardized (z-scored) 18-month BDI and BAI totals. SF = still-face phase. All variance inflation factors were low (≤ 2.01; maternal internalizing composite = 1.05), indicating no multicollinearity. Residual normality was supported by Shapiro–Wilk tests and Q–Q plots (W = 0.98, p = .61)
* $p < .05$
** $p < .01$
*** $p < .001$.

comforting) contributed an additional 18% to the explained variance, $\Delta R^2 = .18$, $p < .01$, resulting in a final model accounting for 61% of the variance, $R^2 = .61$, F (10, 33) = 5.10, $p < .001$. Specifically, higher maternal internalizing symptoms at 18 months, $\beta = .61$, $p < .001$, positively predicted their children's externalizing problems at 24 months, while lower toddler self-comforting behavior, $\beta = -.43$, $p < 0.01$, and inhibitory control, $\beta = -.37$, $p < .01$, at 18 months predicted greater externalizing problems at 24 months.

4. Discussion

In the current study, we aimed to explore the longitudinal relations between toddler temperament, self-regulation, and maternal internalizing symptoms at 18 months, and toddler internalizing and externalizing problems at 24 months. Using a modified Still-Face Paradigm (SFP) to assess toddler self-regulation in a digitally relevant context, we examined toddler self-regulatory behaviors during parental mobile device use, extending previous research to a form of interactional disruption that has become routine in contemporary parent-child interactions. The modified SFP offers unique insights into how toddlers navigate disruptions that increasingly characterize modern parent-child interactions, providing ecological validity to our assessment of regulatory capacities. We found that while specific temperamental dimensions differentially predicted internalizing and externalizing problems, maternal internalizing symptoms and toddlers' self-regulatory behaviors demonstrated robust associations with both internalizing and externalizing problems at 24 months of age.

4.1. Internalizing problems

Toddlers with higher motor activity and whose mothers reported higher internalizing symptoms were more likely to display internalizing problems. Consistent with our results, toddler motor activity at 4 months predicted both internalizing and externalizing problems in middle childhood (Anaya et al., 2024; Morales et al., 2022). Findings on the relations between activity levels and internalizing problems in early childhood have been mixed. Prior studies suggest that toddlers with low activity levels, which may reflect behavioral inhibition, were at greater risk for later internalizing behaviors such as shyness, social withdrawal, and anxiety (Clauss & Blackford, 2012). In contrast, higher activity when paired with positive affect, often conceptualized as surgency, was linked to externalizing behaviors (Brown et al., 2022; Gartstein et al., 2012). Activity level may function more as an indicator of arousal rather than reflecting specific emotional states (Morales et al., 2022), suggesting that a toddler's activity patterns may initiate a complex developmental cascade. One possible pathway is that highly active toddlers experience more frequent or sustained arousal and have greater difficulty settling. When high activity occurs alongside fearfulness or limited regulatory control, toddlers may struggle to shift attention or soothe themselves and may need more caregiver support to regulate distress. If this pattern repeats over time, the accumulated difficulty managing arousal may contribute to later internalizing problems. In contrast, high activity paired with positive affect and approach may carry different implications for adjustment. Future longitudinal studies could explore how activity combines with behavioral inhibition, surgency, and caregiver co-regulation across development.

Our findings aligned with established research demonstrating that maternal internalizing symptoms predicted children's internalizing problems in early childhood (Norcross et al., 2017; Roubinov et al., 2022). Maternal internalizing symptoms have been linked to lower sensitivity and less consistent responsiveness (Norcross et al., 2020; Hoffman et al., 2006), which may compound children's emotional arousal and offer fewer opportunities to learn adaptive coping strategies. However, parenting behavior was outside the scope of the current study, and direct observation would be needed to test this pathway. In addition, the nuanced role of motor activity in toddlerhood and how maternal depression potentially amplifies risk for internalizing symptoms is noteworthy. Highly aroused toddlers place greater regulatory demands on caregivers, and mothers with internalizing symptoms may have greater difficulty consistently meeting these regulatory demands. Future research would benefit from longitudinal, multi-method designs that track how these transactional processes evolve.

Importantly, the significant negative association between self-comforting at 18 months and later internalizing problems at 24 months suggested that a toddler's emerging self-regulatory skills may have served as a promotive factor, even after accounting for their own temperament and maternal internalizing symptoms. This finding is consistent with previous studies demonstrating the contribution of child's self-regulation in the context of maternal internalizing symptoms (Eisenberg et al., 1998), indicating that toddlers who are able to self-sooth demonstrate an early capacity to reduce emotional arousal without relying exclusively on a caregiver. These early regulatory strategies lay the foundation for advanced emotion-regulation skills and coping styles (Kopp, 1989). In the process of engaging in these regulatory routines, they develop a more consistent autonomic profile and may experience lower stress reactivity (Calkins & Fox, 2002). In particular, toddlers who can soothe themselves during the still-face phase exhibit an emerging capacity to regulate emotions in the face of reduced parental responsiveness during technological distractions. The ability to self-regulate is particularly salient given that maternal internalizing symptoms may be associated with reduced emotional availability or responsiveness in real-life parent–child interactions. The development of early regulatory capacities in children emerges as especially meaningful, serving as an asset that predicts children's adjustment above and beyond the effects of maternal responsiveness.

4.2. Externalizing problems

Toddlers' lower inhibitory control and self-comforting behaviors at 18 months, as well as higher maternal internalizing symptoms, predicted higher levels of toddler externalizing problems at 24 months. While toddlers' motor activity predicted internalizing problems, our results suggest that early self-regulatory capacities, reflected in both temperamental traits and behavioral strategies, contribute to the emergence of externalizing problems. Consistent with prior studies (Buss et al., 2014; Utendale & Hastings, 2011), we

found that toddlers who struggle to regulate impulses and show early deficits in self-regulatory strategies are more likely to exhibit disruptive behaviors in early childhood. These early challenges in self-regulation likely reflect underlying vulnerabilities that may place children at risk for lasting difficulties in behavioral management and emotion regulation, suggesting fostering self-regulation skills from an early age could help redirect these developmental trajectories.

Maternal internalizing symptoms were a robust predictor of externalizing problems as well as internalizing problems, which indicates a potential pathway through which maternal mental health connects to child behavioral outcomes (Ivanova et al., 2022; Wagner & Valdez, 2020). As mentioned above, maternal internalizing symptoms may be accompanied by lower sensitivity and less consistent responsiveness during parent–child interactions (Gueron-Sela et al., 2018; Hoffman et al., 2006). For toddlers who are still developing inhibitory control, inconsistent co-regulatory support may make it harder to manage impulses and behavior. Parenting behavior was not assessed in the current study, however, so our findings suggest an association between maternal internalizing symptoms and toddlers' externalizing problems without identifying the parenting processes that may account for it. This pathway needs to be examined directly in future research. Our findings emphasize the need for family and social support systems for maternal mental health and their parenting resources. Accessible mental health services and parenting support programs may help mitigate these effects, potentially interrupting the transmission of risk from maternal internalizing symptoms to child behavioral difficulties.

While maternal internalizing symptoms increase environmental risk for children's psychological and behavioral difficulties, children's own self-regulatory behaviors may independently contribute to outcomes. As a component of early emotion regulation, toddlers who engage in effective self-soothing may be building pathways toward more adaptive emotion regulation as they grow, ultimately reducing their risk for both internalizing and externalizing problems. Our finding aligns with prior research highlighting the role of children's self-regulation abilities, which can develop even when mothers experience mental health challenges. Specifically, infants' self-comforting behaviors (e.g., thumb-sucking, self-soothing) at 3 months predicted advanced false belief understanding at preschool age, particularly among girls. Notably, maternal internalizing symptoms were not a significant predictor of this outcome (Nonnenmacher et al., 2021). These findings suggest that children's self-regulatory capacities may function as developmental resources, supporting their ability to navigate less optimal caregiving environments.

5. Limitations

Although the results from the current study confirm the findings that toddlers' behavioral regulation may serve as a promotive factor in early development, some limitations should be noted. First, our sample size was relatively small, primarily due to disruptions in data collection during the COVID−19 pandemic (Weiner et al., 2020). While the longitudinal design and rich observational data provide valuable insights, the limited sample size may constrain the generalizability of our findings. These findings should be considered preliminary and warrant replication in larger, more diverse samples. In addition, although a sensitivity power analysis confirmed that our sample was sufficiently powered to detect medium to large effect sizes, it is possible that we lacked the statistical sensitivity to reliably detect small effects. This is particularly relevant when interpreting null findings or marginal trends, which should be considered with caution. The restricted sample size also limited our ability to examine more nuanced developmental patterns or to conduct more complex analyses with multiple moderating variables. Attrition and missing data are another consideration. Of the 82 dyads we enrolled, 44 had complete data on every study variable and made up the analytic sample. We compared these 44 with the 38 who were excluded from the complete-case analyses because of attrition or missing data (Table S1). Maternal depression and anxiety, the still-face regulatory behaviors, and early internalizing and externalizing problems did not differ between the groups. Among the temperament measures, inhibitory control and activity were similar, but the analytic sample was lower in negative affect than the excluded dyads. And the analytic sample showed higher levels of education, and the groups differed on child age, site, and race or ethnicity. Our results therefore may not extend to families from more diverse socioeconomic backgrounds or to toddlers higher in negative reactivity. Future research with larger and more diverse samples will be essential to replicate and extend these findings, as well as to explore potentially subtle associations that may not have been detectable in the current study.

Another limitation is that mothers reported both child behavioral problems and their own internalizing symptoms, which raises the possibility of reporter bias due to shared method variance. This bias may have artificially inflated the observed associations, as maternal mental health can influence perceptions of child behavior. However, the inclusion of observed self-regulation behaviors in the present study helps mitigate this limitation by incorporating an independent, objective behavioral measure. Additionally, recent work suggests that caregivers can provide unbiased reports distinct from their own socioemotional profiles (Olino et al., 2021). To further strengthen the validity of future research, it will be important to incorporate additional informants or observational methods that can provide a more nuanced and objective picture of both child and parental mental health.

A related limitation is that our sample showed generally low levels of maternal depression and anxiety. Given this restricted variability, our findings should be interpreted with some caution. The associations we found may not generalize to mothers experiencing higher, clinically significant levels of depression and anxiety, where links with toddler outcomes could differ in size or form. Our conclusions therefore apply primarily to relatively mild, largely subclinical symptoms rather than to maternal internalizing problems more broadly. Future work including mothers across a broader range of symptom severity would help clarify whether these associations extend to clinical populations.

Finally, although the technoference induced by the modified still face reflects a common type of disruption encountered in modern life, the controlled nature of the paradigm required parents to refrain from multitasking (e.g., periodically engage with their child during device use). Recent research indicates that toddlers recognize that digital devices interfere with adults' attention and goal-directed behavior when multitasking (Cao et al., 2025), yet open questions remain regarding maternal (e.g., internalizing symptoms) and toddler (e.g., self-regulation) characteristics that may make these disruptions especially difficult to navigate. Future research

should investigate individual differences in the ability to maintain a connected interaction while distracted by technology and how this relates to child social-emotional outcomes.

6. Conclusion

Despite these limitations, this study contributes preliminary evidence supporting previously observed associations between early self-regulation, maternal internalizing symptoms, and child behavioral challenges, extending prior research by using a developmentally relevant, observational measure of toddler regulatory behavior within a digitally relevant context. Our findings highlight that toddlers' observed self-regulatory behaviors are meaningfully related to later emotional and behavioral outcomes, even after accounting for temperament and maternal mental health. Importantly, these findings should be interpreted in light of the relatively low levels of maternal depression and anxiety observed in our sample. This study emphasizes the importance of early prevention and intervention efforts by highlighting the link between maternal internalizing symptoms, children's early self-regulation, and their emotional and behavioral outcomes, even at relatively mild symptom levels. Enhancing supportive parenting practices and promoting children's early regulatory skills can potentially mitigate the risk of developing psychopathology and promote healthier developmental trajectories.

CRediT authorship contribution statement

Eunkyung Shin: Writing – original draft, Visualization, Methodology, Formal analysis, Conceptualization. **Sarah Myruski:** Writing – review & editing, Validation, Resources, Project administration, Methodology, Data curation. **Tracy A. Dennis-Tiwary:** Writing – review & editing, Resources, Investigation, Data curation. **Vanessa LoBue:** Writing – review & editing, Resources, Funding acquisition. **Kristin A. Buss:** Writing – review & editing, Resources, Funding acquisition. **Koraly Pérez-Edgar:** Writing – review & editing, Supervision, Resources, Funding acquisition.

Author notes

Data collection for this study was supported by grants from National Institutes of Mental Health awarded to Perez-Edgar, Buss, and LoBue (R01MH109692). Drs. Buss and Pérez-Edgar's Psychology Professorships are supported by the Social Science Research Institute of The Pennsylvania State University, and endowments through the Tracy Winfree and Ted H. McCourtney Professorship in Children, Work, and Families (Buss) and the McCourtney Professorship of Child Studies (Pérez-Edgar). The authors declare they have no conflicts of interest.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.infbeh.2026.102230.

Data Availability

The data that support the findings of this study are not publicly available due to privacy and ethical restrictions involving minor participants and sensitive maternal mental health information. Requests for data access may be directed to the corresponding author.

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