International Journal of Psychophysiology 177 (2022) 111–121

Contents lists available at ScienceDirect

International Journal of Psychophysiology

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

Observed parental spontaneous scaffolding predicts neurocognitive signatures of child emotion regulation

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ARTICLE INFO

Keywords:
Emotion regulation
Late positive potential
Parental scaffolding

ABSTRACT

Emotion regulation (ER), a key predictor of positive adjustment throughout the lifespan, is forged in development with profound contributions from parents. In particular, parent scaffolding of child cognition and emotion serves to bolster child regulatory abilities beyond what they could achieve alone. Through habitual parent-child interactions, scaffolded ER likely becomes internalized and drives foundations of neurocognitive regulatory circuitry. Yet, biobehavioral research is needed to establish predictive links between parent scaffolding behaviors and neurocognitive signatures of adaptive child ER. The present study examined observed parental spontaneous scaffolding of child performance during emotionally and cognitively challenging behavioral tasks to predict a neurocognitive signature of adaptive ER: the late positive potential (LPP). The LPP is an event-related potential (ERP) that is modulated by reappraisal, a widely-studied ER strategy defined as interpreting a stimulus in a more positive light. Reduced magnitude of the LPP via reappraisal is a signature of adaptive ER because it predicts both reduced emotional arousal and increased use of adaptive ER strategies. Ninety-seven (49 females; $M_{age} = 6.96$, $SD = 1.15$) 5 to 9 year olds were recruited along with one parent each. Parents and children then completed a cognitively challenging blocks task and a frustrating waiting task, which were subsequently coded to quantify scaffolding quality. Participants completed a Directed Reappraisal Task (DRT) in which unpleasant pictures were paired with either reappraisal or negative interpretations while EEG was recorded. Results showed that greater parental use of high-quality scaffolding predicted greater reduction of the LPP via reappraisal. These findings suggest that habitual parent scaffolding supports adaptive ER measured at the neurocognitive level in childhood. Further, results highlight the importance of examining parent-child interactions when evaluating biological processes underlying ER in childhood.

1. Introduction

Decades of developmental research has shown that emotion regulation (ER), the processes underlying the monitoring and modulation of emotional experience and expression, is a fundamental correlate of psychological adjustment (Berking and Wupperman, 2012; Zeman et al., 2006). In particular, the ability to flexibly downregulate negative emotions, for instance by viewing an unpleasant stimulus or event through a positive lens (i.e., reappraisal), has been consistently associated with fewer symptoms of psychopathology throughout the lifespan (e.g., Aldao et al., 2010; Dryman and Heimberg, 2018; Eftekhari et al., 2009; Hu et al., 2014; John and Gross, 2004). Given the key developmental role of ER in mental health and well-being, it is crucial to clarify how social factors relate to biobehavioral ER in childhood (e.g., Perry and Calkins, 2018).

The impact of parenting on biological bases of child ER is of particular interest. Child ER is shaped by habitual interactions with parents during emotional and cognitive challenges (e.g., Morris et al., 2017; Morris et al., 2007; Zeman et al., 2006), when parents serve as demonstrative regulatory guides and also directly instruct child self-regulation. Yet, few studies have connected specific aspects of those interactions with targeted biological indices of child ER.

ER ability can be indexed by an event-related potential called the late positive potential (LPP), which has been shown to predict adaptive observed ER behaviors in school-aged children (Babkirk et al., 2015; Myruski and Dennis-Tiwary, 2021). However, little is known about the

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https://doi.org/10.1016/j.ijpsycho.2022.05.004
Received 24 September 2021; Received in revised form 3 May 2022; Accepted 7 May 2022

associations between parent-child interactions during challenges and the specific biological indices of adaptive ER like the LPP. The current study will explore this gap by examining whether spontaneously generated parental support during cognitive and emotional challenges predicts LPP indices of child ER.

1.1. Parental scaffolding

Through scaffolding, parents can increase their children's cognitive and social-emotional functioning (e.g., Bibok et al., 2009; Wood et al., 1976). Effective scaffolding practices are characterized by lifting the child into their zone of proximal development, the level of ability just above what the child could achieve alone. This process fosters manageable but challenging learning experiences by giving children a balance between support and autonomy (Mermelshtine, 2017; Vygotsky, 1978; Wood et al., 1976).

Parental scaffolding has been examined in a large body of research focused on cognitive performance among preschool- and school-aged children (Gottman et al., 1996; Hammond et al., 2012; McNaughton and Leyland, 1990; Mermelshtine, 2017; Neitzel and Stright, 2003; Pino-Pasternak and Whitebread, 2010; Pratt et al., 1992). For example, Gottman et al. (1996) measured parents' level of scaffolding of their 5-to-8-year-old children during collaborative cognitive-based behavioral tasks. High-quality scaffolding, defined as giving developmentally appropriate information about the goals and restrictions of the tasks, and letting the child take the lead but intervening when needed, was related to greater child academic achievement. Pratt et al. (1992) highlighted another crucial aspect of effective scaffolding, showing that learning among school-aged children is bolstered when parents withdraw or lower the intensity of support when children gain proficiency and confidence in the task. In addition, Neitzel and Stright (2003) showed that maternal scaffolding characterized by providing emotional support during problem-solving was related to increased child persistence during a challenging cognitive task and was longitudinally related to greater self-regulation one year later.

While cognitive scaffolding entails a degree of sensitivity to the child's emotional state in the service of completing a cognitive-based task (e.g., Neitzel and Stright, 2003), parents can also scaffold with the primary goal of aiding ER during an emotional challenge. Emotional scaffolding requires parents to be sensitive to the child's emotional state and help them modulate that state or expression if needed (Dix, 1991). In particular, features of adaptive scaffolding include emotion coaching, the practice of placing emphasis and value on a child's emotional experience, and using direct instruction to assist children in their attempts to manage and express emotions (e.g., Fabes et al., 2001; Morris et al., 2007).

Aspects of emotional scaffolding have been associated with child psychological adjustment. Greater self-reported parental acceptance of child emotions has been linked to greater reported child ER (Ramsden and Hubbard, 2002). Further, when parents discuss stressful events with their children using explanatory and emotional language, their children show fewer behavioral problems (Sales and Fivush, 2005), while in the opposite association has been shown when parents are dismissive or disparaging of their child's emotional expression (Lunkenheimer et al., 2007). Parental emotional scaffolding is also associated with improved comprehension of internal states of others (e.g., Clarke-Stewart and Beck, 1999), better parent and teacher reported social skills (Baker et al., 2007), and fewer externalizing and internalizing symptoms (Sales and Fivush, 2005). These findings suggest that measurement of parental scaffolding of child ER is essential to accurately understanding child regulatory abilities and emotional adjustment.

Spontaneously generated emotional scaffolding in parent-child dyads has also been observed in emotionally challenging behavioral laboratory tasks (e.g., Hoffman et al., 2006; Morris et al., 2011). Specifically, one study (Morris et al., 2011) with 4 to 9 year olds found that when mothers scaffold the use of relatively adaptive ER approaches like reappraisal, children show fewer negative emotions during a disappointing behavioral task. Another study found that greater observed parent emotional scaffolding was longitudinally related to less emotional dysregulation among 3 to 4 year olds across a range of emotional challenges (Hoffman et al., 2006), suggesting that high quality scaffolding in childhood lays the foundation for future emotional competence. Further, Perry et al. (2012) showed that parents' self-reported non-supportive responses to their 4-year old child's negative emotions predicted less adaptive observed child ER, and that poor ER indexed via physiological regulation (i.e., vagal suppression) moderated this association, highlighting the importance of examining biological individual differences underlying ER. However, little is known about how scaffolding relates to ER measured on a neural level, thus the current study builds on this prior work by testing the link between spontaneous parent scaffolding and neurocognitive indices of child ER.

1.2. Neurocognitive indices of child ER via the LPP

Event-related potentials are highly sensitive measures of the flexible modulation of emotion. Previous research indicates that a scalp-recorded event-related potential (ERP) called the late positive potential (LPP) is sensitive to the use of reappraisal in children and adults (Hajcak and Dennis, 2009; Hajcak and Nieuwenhuis, 2006; Kennedy and Montreuil, 2020; Schupp et al., 2000). The LPP is a positive deflection that emerges at approximately 200 to 300 ms post-stimulus-onset and is sustained throughout and following stimulus presentation (Hajcak and Olvet, 2008). LPP amplitudes are maximal at posterior and occipital recording sites in children (Hajcak and Dennis, 2009). LPP amplitudes are positively correlated with subjective affective arousal (Cuthbert et al., 2000; Hajcak and Nieuwenhuis, 2006; Schupp et al., 2000) and are elevated to emotional versus neutral visual stimuli (Foti and Hajcak, 2008). Thus, the LPP is thought to indicate enhanced attention to and selective processing of motivationally-salient emotional stimuli.

Importantly, when individuals are asked to modulate their emotional responses to stimuli, LPP amplitudes reflect these changes. For example, when participants are asked to engage in cognitive reappraisal by re-interpreting the meaning of an unpleasant image in a more positive way, LPP amplitudes are reduced (Foti and Hajcak, 2008; Hajcak et al., 2010; MacNamara et al., 2011). In addition, reductions in the LPP are associated with decreased subjective arousal and greater self-reported ER in adults (Hajcak and Nieuwenhuis, 2006; Moser et al., 2009). Together these findings indicate that the LPP can index ER ability by capturing the degree to which amplitudes are down-shifted during a decrease versus a maintain emotion condition.

Reappraisal-induced reductions of the LPP have also been demonstrated in studies of school-aged children (e.g., Dennis and Hajcak, 2009; Kennedy and Montreuil, 2020, review; Leventon and Bauer, 2016; Liu et al., 2019). A greater degree of LPP modulation was associated with reduced child anxiety symptoms measured by parent-report (DeCicco et al., 2014; Dennis and Hajcak, 2009), as well as predicted adaptive observed child ER concurrently in 5 to 7 year olds and longitudinally two years later (Babkirk et al., 2015). Further, in a previous study using data from the current sample (Myruski et al., 2019; Myruski and Dennis-Tiwary, 2021), we demonstrated that the LPP is sensitive to experimentally-manipulated parenting context. That is, school-aged children showed greater reappraisal-induced reduction of the LPP when parents were physically present or actively scaffolded child ER by reading reappraisal scripts before unpleasant picture stimuli, in comparison to when children attempted reappraisal alone. These results indicate that when parents are given the tools (i.e., pre-written scripts) to scaffold their child's ER, neurocognitive indices of ER are bolstered accordingly. The current study builds on this finding by examining how spontaneously-generated parent scaffolding is related to child ER capture via the LPP.

1.3. The current study

Data for this study was derived from larger study (Myruski et al., 2019; Myruski and Dennis-Tiwary, 2021) investigating biological signatures of ER in children, with an emphasis on the role of parent-child social context. The goal of the current study was to capture spontaneous parent scaffolding during behavioral observations, reflecting habitual scaffolding in daily life, and a major environmental contribution to how the neural foundations of ER circuitry is formed. We also address a gap in the existing scaffolding literature by focusing on links between biological signatures of ER and observed ER. School-aged children from ages of 5 to 9 years old were the target sample, since this developmental period is characterized by unstable frontal control over highly active limbic areas, brain regions related to emotional reactivity and regulation (Tottenham, 2017). Thus, during this school-age period, we can capture a range of both individual differences in ER ability (e.g., DeCicco et al., 2012) and the potential impact of parent scaffolding on bolstering of ER (Gee et al., 2014; Tottenham, 2015).

We also sought to measure parent scaffolding of both cognitive and emotional functioning in children by quantifying scaffolding behavior in a cognitively-challenging block task as well as a frustrating waiting task. By contrasting a task that is an explicit emotional challenge with one that is cognitively focused, but implicitly emotionally demanding, will allow us to test the context specificity of these effects of parent scaffolding. We predicted that children whose parents provide high quality scaffolding during these behavioral challenges, indicating adaptive habitual social support during parent-child interactions, will show more adaptive ER during a reappraisal task as indexed by the LPP. We also explored interactions between habitual scaffolding captured in behavioral challenges and experimentally-manipulated scaffolding during a computerized directed reappraisal task.

2. Method

2.1. Participants

Ninety-seven children [49 (50.5%) females, 48 (49.5%) males] were recruited from New York City and the surrounding communities to participate along with one parent for each child [91 (93.8%) mothers, 6 (6.2%) fathers]. Ninety children provided usable EEG data,[1] and 94 children had usable video recordings for behavioral tasks.[2]

Children ranged in age from 5.09 to 9.05 years old ($M = 6.96$, $SD = 1.15$). Child race/ethnicity was reported by parents as follows: 39 (40.2%) White, 20 (20.6%) Black/African-American, 9 (9.3%) Hispanic/Latinx, 9 (9.3%) Asian, 3 (3.1%) Black and another category, 1 (1.0%) Hispanic and another category, 2 (2.1%) reported other, and 14 (14.4%) opted not to report race/ethnicity. Parents' highest level of education ranged from High School (9th Grade) to Doctorate level (Median = Bachelor's Degree), and annual household income ranged from less than $10,000 to $150,000 and up (Median = $70,000 to $90,000).

2.2. Materials and procedure

Measures for the current study were part of a larger study with a procedure that lasted approximately 3 h with breaks included. Following informed consent and assent (10 min), parents and children completed questionnaires (20 min), EEG equipment was applied (30 min) and participants completed a baseline EEG task (8 min; not included in the current study) followed by the Directed Reappraisal Task (DRT; 45 min). After EEG removal and clean-up (15 min), participants completed behavioral tasks in counterbalanced order (30 min) and were then debriefed (10 min).[3]

2.2.1. Electroencephalography (EEG) application

Children were fitted with an elasticized nylon EEG cap and electrodes were applied according to the international 10/20 system. EEG was recorded during the DRT using Biosemi 64 Ag/AgCl active scalp electrodes sampled at 512 Hz. Eye movements were measured by electro-oculogram (EOG) recorded from electrodes placed 1 cm above and below the left eye (for vertical movements), and 1 cm from the outer edge of each eye (for horizontal movements). EEG signal pre-amplification was applied at each electrode during recording to improve signal-to-noise ratio. The voltage from each electrode was referenced online with respect to the common mode sense active electrode, which produces a monopolar (nondifferential) channel.

2.2.2. Directed Reappraisal Task (DRT)

Children were randomly assigned to one of three versions (parent-absent, parent-present, parent-scaffolding) of a computerized Directed Reappraisal Task (DRT; adapted from DeCicco et al., 2012; Myruski et al., 2019; Myruski and Dennis-Tiwary, 2021), during which EEG was recorded. In the DRT, children viewed a total of 30 unpleasant and 15 neutral IAPS pictures[4] presented in three conditions (reappraisal, negative, neutral; 10 min each), counterbalanced across participants. Children were instructed to think about each picture so that it matched the preceding story. Unpleasant pictures (e.g., snake) were paired with either a negative (“This poisonous snake is very dangerous.”) or reappraising story (“This snake is harmless; it doesn't have teeth.”). Neutral pictures were paired with neutral stories. The parameters of the DRT were the same in the current study as in prior studies, except for the addition of the parent presence and scaffolding manipulations described below.

In the parent-absent group ($n = 31$; 16 males, 15 females), children completed the DRT alone with parents in another room. In the parent-present group ($n = 34$; 16 males, 18 females), the parent was seated in the EEG recording booth during the entire task but did not interact with the child or participate during the DRT. In the parent-scaffolding group ($n = 32$; 16 males, 16 females), parents sat in the recording booth with their child *and* participated actively in the task. In this version only, parents read aloud a scaffolding script that appeared on the computer screen during each trial (e.g., Parent reads: “Next, we will see a picture of a snake. Most snakes are harmless, and they don't come close to people.”), followed by the same audio story used in the non-scaffolding versions of the DRT (e.g., “This is a snake that is

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[1] EEG data loss occurred in seven cases caused by unusable recordings due to equipment malfunction or user error ($n = 3$), low trial counts ($n = 2$; see EEG data processing section), or EEG refusal ($n = 2$).

[2] Observed behavior data loss occurred in three cases caused by video equipment malfunction.

[3] The protocol was initially designed to counterbalance the order of the behavioral tasks and the EEG task so that assignment to the various social contexts during the DRT would not influence subsequent parenting behavior. While some ($n = 11$) children were run in this reverse order (behavioral tasks first, then EEG tasks later in the visit), we noted higher than expected levels of fatigue caused by the demands of enduring EEG recording after several hours in the lab. For this reason, the remainder of the sample all completed the EEG task during the first half of the visit. We statistically confirmed that there was no significant effect of order on parenting scaffolding behavior ($ps > .28$).

[4] IAPS stimuli used were the same as reported in DeCicco et al. (2012). While children in the current study were no asked to provide subjective ratings of the stimuli, ratings from the IAPS manual (Lang and Bradley, 2007) are as follows. Unpleasant stimuli (1050, 1120, 1201, 1300, 1321, 1930, 2120, 2130, 2688, 2780, 2810, 2900, 3022, 3230, 3280, 5970, 6190, 6300, 6370, 7380, 9050, 9250, 9421, 9470, 9480, 9490, 9582, 9594, 9600, and 9611) had a mean valence of 3.31 (SD = 0.73) and arousal of 5.78 (SD = 0.70). The neutral stimuli (5740, 5820, 7000, 7002, 7004, 7009, 7010, 7041, 7090, 7100, 7140, 7150, 7224, 7595, and 7950) had a mean valence of 5.12 (SD = 0.68) and arousal of 2.81 (SD = 0.71).

completely harmless; it doesn't even have teeth."), followed by the picture stimulus.

The parent-absent, parent-present, and parent-scaffolding groups did not significantly differ in terms of child gender, child ethnicity, parent highest level of education, or household income ($ps > .10$).

Following the DRT, the EEG cap was removed, and participants cleaned up briefly, and then took a 5–10-minute snack break.

2.2.3. Behavioral tasks

2.2.3.1. Waiting task (WT). During the WT (Cole et al., 2003), children are asked to wait to open a gift placed in front of them on a small table. Parents were seated next to their child but were busy completing paperwork. At the start of the task, a researcher gave the child a boring toy (a plastic fish), and parents read the following instructions to their child: "This is a surprise for you, but you must wait until I finish my work to open it." Parents were free to interact with their children as they chose, which allowed for variability parental scaffolding of children's ER attempt, similar to what may occur in daily life. This task lasted 10 min and was video recorded for subsequent coding.

2.2.3.2. Block task (BT). In the BT (adapted from Carr and Pike, 2012; Meins, 1997; Wood et al., 1978), children were instructed to complete five predetermined block designs which sequentially increased in complexity. Prior to the start of the task, the researcher placed a set of multicolored blocks on the table in front of the child and handed the design cards to the parent. Parents were instructed that "Your child should build the designs, but assist him/her as needed, like you normally do when you play together". This task lasted 15 min, or until the child completed all five designs. Interactions were video recorded for subsequent coding.

2.2.4. EEG data processing

Brain Vision Analyzer (Version 2.2, GmbH, Munich, DE) was used to prepare the EEG data. All data were re-referenced offline to the mastoids and filtered with a low cutoff frequency of 0.1 Hz and a high cut-off frequency of 30 Hz. Stimulus-locked data were segmented into epochs for each trial ranging from 400 ms before picture onset to 2000 ms after (length of stimulus presentation), with a 400 ms baseline correction. Ocular correction was performed to identify and correct blinks and horizontal eye movements (Gratton et al., 1983). Artifacts were identified using the following criteria and removed from analyses: data with voltage steps greater than 75 μV, changes within a given segment greater than 200 μV, amplitude differences greater than 120 μV in a segment, and activity lower than 0.2 μV per 100 milliseconds. In addition to this semi-automatic identification of artifacts, trials were also visually inspected for further artifacts, which were removed on a trial-by-trial basis.[5] All EEG parameters used were consistent with other studies with children in this age range (Babkirk et al., 2015; DeCicco et al., 2014; DeCicco et al., 2012; Kennedy and Montreuil, 2020).

The LPP was quantified as the mean amplitude at electrode sites where maximal amplitudes were observed: PO3, PO4, PO7, PO8, POz, O1, Oz, O2, and Iz for each stimulus type (negative, reappraisal, neutral) within the DRT (Fig. 1). The early window (250 ms to 800 ms post stimulus onset) was targeted for analyses, since previous studies (Babkirk et al., 2015) have shown that this segment of the LPP predicts ER strategy use in children. These electrodes and this time window are the same as used in prior studies of the LPP in this age group (Babkirk et al., 2015; Kujawa et al., 2012). We also examined the late window (800 ms to 2000 ms) at the same electrode sites to explore whether differential patterns emerged regarding sustained reappraisal-induced reduction of the LPP.

ER was quantified via the LPP by computing between-condition change scores (separately for the early and late windows). There has been recent debate regarding use of subtraction difference scores versus residual change scores to capture contrast between conditions (Clayson et al., 2021; Meyer et al., 2017; Weinberg et al., 2015). Residual scores are less vulnerable to intercorrelations between conditions, and thus less biased by baseline, in this case negative interpretation condition. We found significant correlations between LPPs to negative and parent scaffolding behaviors (see Table 1), suggesting that emotional reactivity to negatively interpreted unpleasant stimuli may relate to parenting behaviors independently of reappraisal ability. Thus, we conducted analyses using both approaches to computing outcome variables, with subtraction difference scores maintaining variance for the negative interpretation condition, and residual scores isolating this variance. Residual scores were computed with LPPs to negative predicting LPPs to the reappraisal condition, with greater negative residual scores indicating a greater impact of directed reappraisal on the LPP. Subtraction difference scores were computed as LPPs to reappraisal minus LPPs to negative, again with more negative scores indicating greater reappraisal.[6]

2.2.5. Behavioral coding

2.2.5.1. Parental scaffolding during the waiting task. The WT was coded for parent scaffolding using the Maternal Scaffolding Coding System (Maslin-Cole and Spieker, 1990). Inter-rater reliability was established among 4 independent coders, with approximately 30% of the videos double-coded ($ICC = 0.94$). Motivational and emotional scaffolding was rated globally for the entire 10-minute task on a Likert-type scale of 1 (low quality) to 5 (high quality). For motivational scaffolding, high scores indicated that throughout the task, the parent successfully helped the child maintain understanding of the rules of the task, and persistence toward the goal of waiting to open the present. For emotional scaffolding, high scores indicated that throughout the task, parents placed value on child's attempts to express and regulate their own emotions, sharing of positive emotions, high maternal sensitivity, and an emphasis on child efficacy in ER. Details of the WT coding scheme are presented in Appendix A. We examined differences between motivational and emotional scaffolding scores and found that 11 out of 97 (11.34% of cases) parents showed greater than 2 points difference between these scores. For all of these cases, motivational scaffolding was greater than emotional scaffolding. A scatterplot depicting the association between motivational and emotional scaffolding scores is included in Appendix A. Emotional and motivational scaffolding scores were significantly correlated ($r = 0.46, p < .001$), therefore a sum score was also computed to quantify overall parental scaffolding during the WT.

2.2.5.2. Parental scaffolding during the block task. The BT was coded for parent scaffolding of child's ability to correctly complete the block designs using a coding scheme adapted from Carr and Pike (2012). Inter-rater reliability was established among 4 independent coders, with approximately 20% of the videos double-coded ($ICC = 0.83$). Parental scaffolding interventions were coded on a scale from 0 (simple feedback; e.g., "Good.") to 6 (Taking control; e.g. "Let me do it", parent builds

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[5] Average trial counts out of a total possible 30 trials for each condition are as follows: Negative (M = 27.13; SD = 4.48); Reappraisal (M = 27.38; SD = 4.15); Neutral (M = 26.87; SD = 3.31). If fewer than eight artifact-free trials per condition were for a participant, EEG data was imputed. This eight-trial benchmark was selected following Moran, Jendrusina & Moser (2013) who demonstrated that the LPP becomes reliable with eight or more trials.

[6] Subtraction scores may be computed such that the lesser emotion-eliciting condition is subtracted from the greater condition. In this case we selected the opposite approach to maintain directionality between residual and subtraction scores to aid interpretation. We confirmed that patterns and levels of significance of results for models using subtraction scores did not differ based on how the score was computed.

Fig. 1. LPP waveform and topographic map depicts the grand average across DRT groups, with waveforms separated by condition (adapted from Myruski et al., 2021) in the early (250 ms to 800 ms) and late (800 ms to 2000 ms) windows.

alone). Following each parent intervention, subsequent child actions were coded as either (0) no action, (1) incorrect block placement, or (2) correct block placement. Parent scaffolding scores were then computed based on the contingency rule (Carr and Pike, 2012; Meins, 1997; Wood et al., 1978) or how well the parent adjusted his/her interventions based on the child's success or failure. Contingent shifting was defined as the parent either increasing their level of intervention following an incorrect or absent block placement by the child or maintaining/decreasing their level of intervention following a correct block placement by the child. Fixed failure feedback was defined as the parent either maintaining or decreasing their level of intervention following an incorrect or absent block placement by the child. Finally, over-intervention referred to when parents increased their level of intervention despite the child correctly placing blocks. Each time one of these patterns of behavior occurred, the parent was assigned a point for the relevant scaffolding variable. Details of the BT coding scheme are presented in Appendix B. To control for individual differences in overall quantity of intervention instances, ratio scores were computed by dividing the number of intervention instances for each category (i.e., contingent shifting, fixed failure feedback, over-intervention) by the total number of interventions performed throughout the entire task. Pearson correlations revealed that ratio scores for contingent shifting were significantly negatively correlated with fixed failure feedback ($r = -0.84$, $p < .001$) and over-intervention ($r = -0.43$, $p < .001$). To avoid multicollinearity issues in regression analyses, a scaffolding composite score was computed by taking the mean of the contingent shifting score and reversed scores for fixed failure feedback and over-intervention. Higher composite scores indicated greater contingent shifting, less fixed failure feedback, and less over-intervention, thus capturing a parent's ability to attune to their child's scaffolding needs.

3. Results

3.1. Analytic plan

Little's missing completely at random (MCAR) test was conducted and indicated that data was indeed MCAR [χ^2 (31) = 31.92, $p = .420$]. Missing data was handled via multiple imputation using the missForest R package (Stekhoven, 2011), an appropriate approach for imputing MCAR data which yields low imputation error for mixed data types (Waljee et al., 2013). This approach was selected since the current data included both ordinal (i.e., Likert-type scale for behavioral coding) and ratio (e.g., LPP) variables with missing data. The significance level (i.e., $p < .05$) of effects reported in results did not differ when analyses were conducted with and without imputed data.

Prior to main analyses, we examined whether age or sex were related to the main study variables (parent scaffolding behavior in the BT and WT, LPP indices of child ER), to inform inclusion of covariates in main analyses.

To test our hypothesis, parent scaffolding behaviors during the BT and WT were then investigated as predictors of LPP indices of child ER. Hierarchical multiple regressions were planned with age and/or sex entered in the 1st step as covariates, DRT group (parent-absent, parent-present, parent-scaffolding) in the 2nd step, BT or WT parental scaffolding score in the 3rd step, the interaction between DRT group and parental scaffolding score in the 4th step, and LPP change scores (subtraction differences scores and residual scores) as the dependent variables. To test the hypothesis, eight regressions were conducted, with separate regressions for the BT (composite scaffolding ratio score) and WT (composite of motivational and emotional scaffolding global scores), and the LPP at early and late windows examined as the dependent variables separately. We also conducted additional regressions with the same structure except with the PP and PS DRT groups combined, since prior studies (Myruski and Dennis-Tiwary, 2021; Myruski et al., 2019) demonstrated that these groups did not significantly differ in terms of reappraisal-induced reduction of the LPP. For significant models without a significant f-change detected at step 4, that is when no significant interaction emerged between scaffolding score and DRT group predictors, models reported below include the first three steps described above.

3.2. Descriptive statistics and covariates

Descriptive statistics of imputed data and correlations between the LPP and observed scaffolding behaviors are presented in Table 1. Pearson correlations were conducted between age in months and LPP indices of child ER and parental scaffolding behaviors, including LPP condition-level amplitudes (negative, neutral, reappraisal), LPP change scores, parent scaffolding intervention frequencies (contingent-shifting, fixed failure feedback, over-intervention, and total number of interventions), ratio scores, and composite scores for the BT, and motivational, emotional, and overall scaffolding global ratings for the WT. Age was significantly negatively correlated with LPP amplitudes in the negative condition ($r = -0.20$, $p = .045$), with older children exhibiting lower amplitudes to negative interpretations of unpleasant pictures. Child age was also significantly negatively correlated with the raw frequency of parental contingent-shifting ($r = -0.28$, $p = .006$), fixed failure feedback ($r = -0.24$, $p = .016$), and total number of interventions ($r = -0.30$, $p = .003$) during the BT, such that parents used these interventions less frequently for older children.

Independent-samples t-tests were conducted to examine differences between males and females for LPP indices of child ER and parental

Table 1
Descriptive statistics and correlations.

Variable	Min	Max	M (SD)	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
LPP (early)																			
1. Negative	1.91	66.76	30.41 (13.24)	0.58***	0.74***	−0.58***	0.00	0.80***	0.48***	0.56***	−0.43***	0.19	−0.17	−0.06	0.17	0.28**	0.00	−0.08	−0.06
2. Neutral	0.31	44.63	20.15 (9.58)	–	0.50***	−0.25*	0.11	0.33**	0.67***	0.35***	−0.08	0.21*	−0.14	−0.10	0.00	0.13	−0.08	−0.10	−0.10
3. Reappraisal	−5.08	52.57	27.20 (10.84)		–	0.12	0.68***	0.51***	0.29**	0.74***	0.04	0.56***	−0.08	−0.03	−0.05	−0.03	−0.06	−0.21*	−0.17
4. Subtraction score	−30.24	26.11	−3.21 (9.03)			–	0.81***	−0.56***	−0.35***	0.07	0.68***	0.40***	0.15	0.04	−0.31**	−0.45***	−0.07	−0.14	−0.12
5. Residual score	−22.76	20.75	0.00 (7.34)				–	−0.12	−0.09	0.48***	0.53***	0.62***	0.07	0.01	−0.26**	−0.36***	−0.09	−0.23*	−0.19
LPP (late)																			
6. Negative	−15.76	74.56	20.91 (14.60)					–	0.41***	0.49***	−0.70***	0.00	−0.13	−0.06	0.26*	0.32**	0.08	−0.03	0.01
7. Neutral	−9.87	44.56	12.77 (10.13)						–	0.17	−0.32**	−0.04	−0.09	−0.17	0.14	0.24*	−0.14	−0.19	−0.19
8. Reappraisal	−17.03	56.91	19.95 (10.77)							–	0.27**	0.87***	0.01	0.02	0.06	−0.04	0.00	−0.03	−0.02
9. Subtraction score	−51.84	45.85	−0.96 (13.18)								–	0.71***	0.16	0.08	−0.23*	−0.39***	−0.09	0.02	−0.03
10. Residual score	−35.15	23.52	0.00 (9.36)									–	0.09	0.05	−0.07	−0.23*	−0.05	−0.01	−0.03
Block task																			
11. FFF	0.00	34.00	6.60 (6.69)										–	0.34**	0.35**	−0.54***	0.19	0.03	0.12
12. OI	0.00	14.00	4.43 (3.17)											–	0.42***	−0.31**	0.08	0.09	0.11
13. CS	1.00	78.00	21.83 (14.55)												–	0.25*	0.14	0.22*	0.23*
14. BT composite	−0.21	0.33	0.11 (0.12)													–	−0.07	−0.01	−0.04
Waiting task																			
15. Motivational	1.00	5.00	4.11 (1.10)														–	0.46***	0.79***
16. Emotional	1.00	5.00	3.57 (1.55)															–	0.90***
17. WT sum	2.00	10.00	7.69 (2.26)																–

Note. FFF = fixed failure feedback, OI = over-intervention, CS = contingent shifting.
* $p \leq .05$.
** $p \leq .01$.
*** $p \leq .001$.

scaffolding behaviors. Parents used contingent-shifting during the BT significantly more frequently for female ($n = 49$; $M = 25.61$, $SD = 16.80$) versus male ($n = 48$; $M = 17.98$, $SD = 10.69$) children, $t(81.66) = -2.67$, $p = .009$.[7] Further, parents engaged in significantly more interventions overall during the BT for female ($n = 49$; $M = 37.29$, $SD = 20.58$) versus male ($n = 48$; $M = 28.33$, $SD = 17.78$) children, $t(95) = -2.29$, $p = .024$.

No other age or sex associations with main study variables reached significance. Since age and sex were both related to parent scaffolding behaviors in the BT, and age was also related to the LPP, age in months and sex were entered as covariates in subsequent analyses.

To evaluate differences in LPP amplitudes across conditions in the sample as a whole, we conducted a 3 (Condition: negative, neutral, reappraisal) × 2 (Window: early, late) × 3 (DRT Group: parent-absent, parent-present, parent-scaffolding) repeated-measures ANCOVA, with age in months and sex as covariates. Results showed a significant main effect of Condition [F (2, 91) = 5.40, $p = .006$] such that LPP amplitudes were significantly lower in neutral ($M = 16.48$, $SD = 0.93$) compared to both negative [($M = 25.62$, $SD = 1.32$), $p < .001$] and reappraisal [($M = 23.63$, $SD = 1.00$), $p < .001$] conditions, demonstrating the expected effect of emotional content on the LPP. Further, LPP amplitudes to the reappraisal condition were marginally lower than the negative condition ($p = .052$).

3.3. *Main analyses*

First, parental scaffolding of child cognitive performance during the BT was tested as a predictor of child ER indexed via LPP during the DRT. We first present findings using LPP residual scores as the outcome measure. For the LPP early window, the model was significant [$R^2 = 0.19$, F (4, 92) = 5.23, $p = .001$; Table 2a], with a significant F-change detected when parental scaffolding score was included [$\Delta R^2 = 0.12$, ΔF (1, 92) = 13.86, $p < .001$]. Higher quality parental scaffolding of child cognitive performance during the BT, characterized by high levels of contingent-shifting and low levels of fixed failure feedback and over-intervention, significantly predicted greater ER, indexed as larger magnitude reappraisal-induced reduction of the LPP (β = −0.35, $p < .001$; Fig. 2, top left). The same pattern was detected in the LPP late window [$R^2 = 0.13$, F (4, 92) = 3.36, $p = .013$; F-change: $\Delta R^2 = 0.05$, ΔF (1, 92) = 4.97, $p = .028$; Table 2b], again with higher quality scaffolding significantly predicting greater reappraisal via the LPP (β = −0.22, $p = .028$; Fig. 2, top right).

When LPP subtraction scores were used as the outcome variable, the pattern of results for the BT was consistent with the findings with the residual scores. The models with both the LPP early window and late window were significant [early: $R^2 = 0.22$, F (4, 92) = 9.19, $p < .001$, Table 2c; late: $R^2 = 0.17$, F (4, 92) = 4.79, $p = .001$, Table 2d], with a significant F-change detected when parental scaffolding score was included [early: $\Delta R^2 = 0.15$, ΔF (1, 92) = 26.57, $p < .001$; late: $\Delta R^2 = 0.15$, ΔF (1, 92) = 16.73, $p < .001$]. Higher quality scaffolding predicted greater reappraisal via the LPP in both windows (early: β = −0.46, $p < .001$; late: β = −0.39, $p < .001$).

Next, parental scaffolding of child emotion and motivation during the WT was tested as a predictor of LPP indices of child ER during the DRT. For the LPP early window, the model was significant [$R^2 = 0.10$, F (4, 92) = 2.59, $p = .042$; Table 3a], with a significant F-change detected when parental scaffolding score was included [$\Delta R^2 = 0.04$, ΔF (1, 92) = 3.97, $p = .049$]. Higher quality parental scaffolding during the WT, characterized by parents emphasizing child ER efficacy, sharing positive emotions, high maternal sensitivity, and maintaining understanding of task rules and persistence toward the waiting goal, significantly predicted greater ER via the LPP [β = −0.20, $p = .049$; Fig. 2, bottom left]. The model with the LPP late window was not significant for WT

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[7] Levene's test for equality of variances was significant ($F = 7.87$, $p = .006$), so adjustments for equal variances not assumed were used for this t-test.

Table 2

Parent scaffolding in the block task predicting child ER indexed via the LPP.

A. Dependent variable: LPP early window residual score

Step	Predictors	R^2	ΔF	β	t	p
1		0.030	1.45			
	Age in months			0.011	0.104	.918
	Gender			−0.172	−1.682	.096
2		0.063	3.23			
	Age in months			−0.003	−0.030	.976
	Gender			−0.171	−1.694	.094
	DRT group			0.181	1.796	.076
3		0.185	13.86			
	Age in months			0.017	0.176	.861
	Gender			−0.167	−1.768	.080
	DRT group			0.168	1.775	.079
	BT scaffolding composite			−0.351	−3.722	<.001***

B. Dependent variable: LPP late window residual score

Step	Predictors	R^2	ΔF	β	t	p
1		0.080	4.09			
	Age in months			−0.278	−2.794	.006**
	Gender			−0.090	−0.904	.368
2		0.080	0.20			
	Age in months			−0.279	−2.783	.007**
	Gender			−0.090	−0.899	.371
	DRT group			0.014	0.143	.887
3		0.127	4.97			
	Age in months			−0.267	−2.713	.008**
	Gender			−0.088	−0.895	.373
	DRT group			0.006	0.062	.951
	BT scaffolding composite			−0.217	−2.228	.028*

C. Dependent variable: LPP early window subtraction score

Step	Predictors	R^2	ΔF	β	t	p
1		0.046	2.28			
	Age in months			0.125	1.237	.219
	Gender			−0.162	−1.600	.113
2		0.079	3.32			
	Age in months			0.112	1.112	.269
	Gender			−0.161	−1.611	.111
	DRT group			−0.182	−1.823	.071
3		0.285	25.57			
	Age in months			0.137	1.542	.127
	Gender			−0.156	−1.765	.081
	DRT group			−0.165	−1.863	.066
	BT scaffolding composite			−0.455	−5.155	<.001***

D. Dependent variable: LPP late window subtraction score

Step	Predictors	R^2	ΔF	β	t	p
1		0.019	0.91			
	Age in months			−0.035	−0.342	.733
	Gender			−0.137	−1.334	.185
2		0.022	0.003			
	Age in months			−0.039	−0.380	.705
	Gender			−0.137	−1.326	.188
	DRT group			−0.055	−0.536	.593
3		0.172	16.73			
	Age in months			−0.017	−0.182	.856
	Gender			−0.133	−1.392	.167
	DRT group			−0.040	−0.425	.672
	BT scaffolding composite			−0.389	−4.090	<.001***

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

scaffolding ($p = .10$; Table 3b).

When LPP subtraction scores were used as the outcome variable, the models with both the LPP early window and late window were non-significant [early: $R^2 = 0.10$, F (4, 92) = 2.41, $p = .055$, Table 2c; late: $R^2 = 0.15$, F (4, 92) = 0.54, $p = .707$, Table 2d]. Moreover, there was no significant effect for WT scaffolding behavior predicting the LPP subtraction score in either time window ($ps > .10$).[8]

4. Discussion

Results showed that high-quality parent scaffolding predicted greater child ER indexed via the LPP, and this pattern was consistent across two challenging behavioral tasks: a cognitively demanding block task and an emotionally evocative waiting task. The generalization of this finding across two parenting contexts, including one designed to be primarily cognitively demanding, suggests that scaffolding may support child self-regulation broadly in ways that have direct downstream effects on ER capacity. Findings also suggest that the way parents approach supporting their child's problem-solving may reflect similar approaches used in emotionally demanding contexts, namely sensitivity toward the child's emotional state and need for support.

There were also differences across the BT and WT regarding significant effects. For the BT, higher quality scaffolding predicted ER measured via the LPP in both the early and late window, while this pattern was only significant in the early window of the LPP when WT scaffolding was the predictor. These differences across tasks may be due to the nature of the coding schemes in terms of level of detail. Specifically, since parent scaffolding in the BT was coded based on parents' level of intervention in the context of the child's moment-to-moment successes and failures, the parenting behaviors captured may have greater ecological validity, particularly regarding variation across children in terms of scaffolding needs. In contrast, global codes were used to quantify parent scaffolding across the entire 10 min of the WT, which were limited in terms of detecting more nuanced variation. For example, parents of children exhibiting low levels of need for support may have been assigned a relatively low score if they missed a single opportunity for intervention, in comparison to a parent whose child presented many opportunities for them to provide support, and proportionally fewer of these were missed by the parent. Another possibility is that the scaffolding behavior elicited by the BT, which was more cognitively oriented and interactive compared to the WT, better captures aspects of parenting behavior that may influence neurocognitive development through habitual interactions.

Results for the WT also differed based on whether LPP subtraction scores or LPP residual scores were used as the outcome measure. Parent scaffolding behavior in the WT only significantly predicted reappraisal via the LPP when variance due to activity in the negative interpretation condition was controlled (i.e., residual score outcome). This difference could be due to the coding schemes described above, but also may be due to what aspects of ER are emphasized by these different score computation approaches. Importantly, the interpretation stories in the negative condition were designed to elicit a negative emotional response that may be greater than what a child may experience by simply viewing the picture. Thus, between-child variability in the LPP to negative condition may reflect differences in emotional reactivity, ability to up-regulate negative emotions, or both. In contrast, the reappraisal condition LPP responses uniquely reflect the degree of down-regulation.

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[8] When PP and PS groups were collapsed into a single group, the pattern and significance levels of results did not change, except with this approach, DRT Group significantly predicted LPP residual and subtraction scores such that reappraisal-induced reduction of the LPP in the early window was significantly greater when parents were present or scaffolded during the DRT ($ps < 0.05$), consistent with prior findings with this data (Myruski and Dennis-Tiwary, 2021; Myruski et al., 2019).

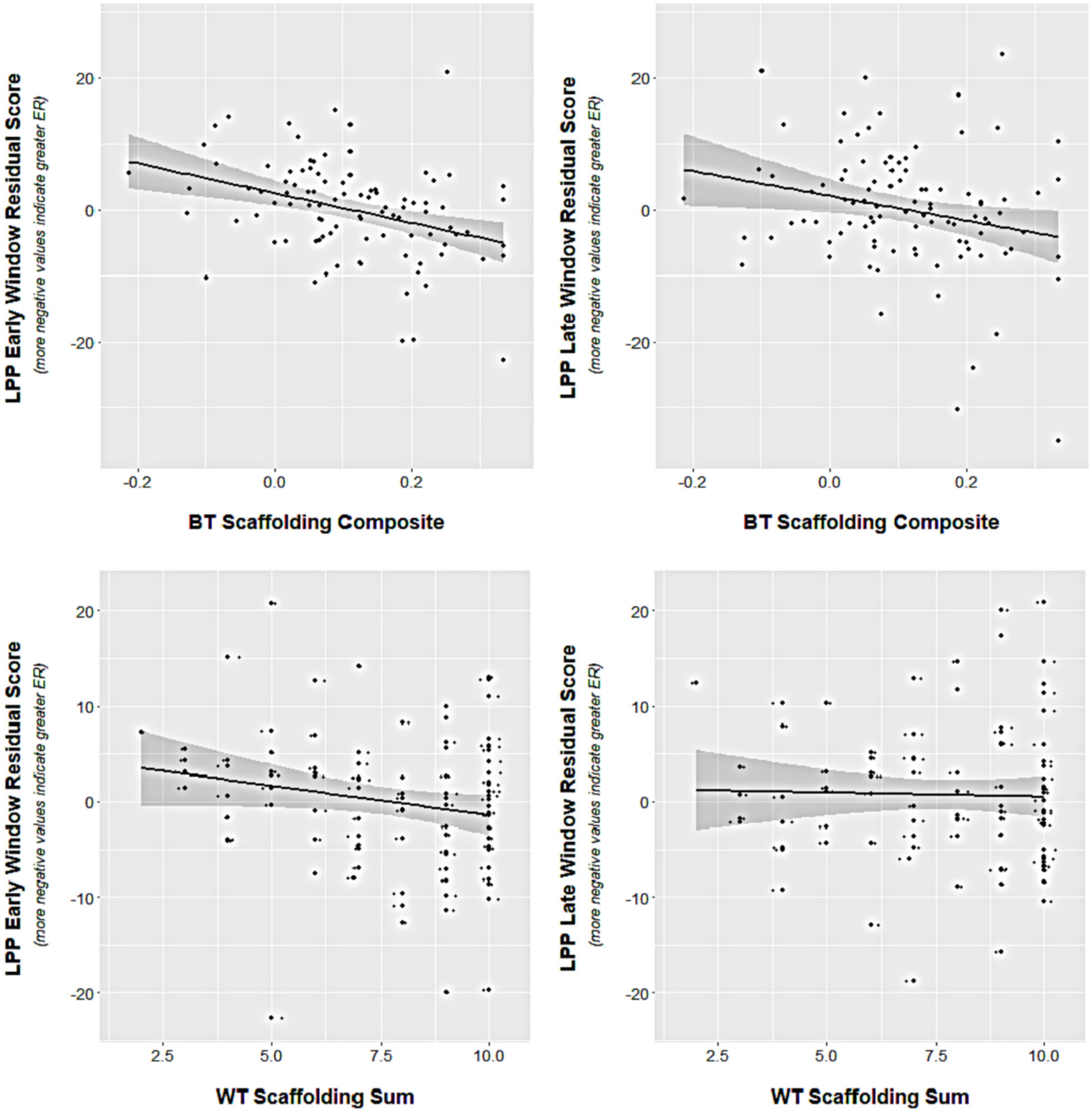

Fig. 2. Parent scaffolding in the BT (top) significantly predicted child ER measured via the LPP early window (top left) and late window (top right). Parent scaffolding in the WT (bottom, points jittered to visualize overlapping points) significantly predicted the LPP in the early window (bottom left), but not the late window (bottom right). Shaded bands represent 95% CI.

While residual scores may emphasize neural responses during reappraisal that are distinct from negative reactivity, subtraction scores may better encompass between-subject variability of negative reactivity, or bidirectional modulation. Since correlations between WT scaffolding and the LPP to negative on its own were not statistically significant, this lends support to the interpretation that the link between parent scaffolding and ER measured via the LPP is not an artifact of reactivity only. In sum, residual and subtraction scores may emphasize different aspects of ER when it comes to negative and reappraisal interpretations. The nature of that potential distinction should be investigated as a target hypothesis in a larger sample, including a passive view with no modulation instruction condition.

The link between parental scaffolding during behavioral challenges and child ER did not depend on the experimentally-manipulated parenting context during which the LPP was recorded. Only when DRT group was collapsed across the two contexts involving the parent (parent-present and parent-scaffolding) did group predict ER via the LPP. In our previous studies (Myruski and Dennis-Tiwary, 2021; Myruski et al., 2019), we demonstrated that the LPP was significantly reduced via reappraisal versus negative story interpretations, but only when parents scaffolded or were present during the DRT. Further, we found that this pattern generalized across cultures (US and Japan; Myruski et al., 2019). In the current study, we handled missing data using multiple imputation to maximize study power and included age and sex as covariates in our models due to significant effects with these variables regarding parent scaffolding behaviors targeted in the current study. The greater complexity of the models in the current study may have overshadowed the significant effect of DRT group on the LPP. Nevertheless, the current findings build upon the findings of previous publications using this sample, by showing that spontaneous parental

Table 3
Parent scaffolding in the waiting task predicting child ER indexed via the LPP.

A. Dependent variable: LPP early window residual score

Step	Predictors	R^2	ΔF	β	t	p
1		0.030	1.45			
	Age in months			0.011	0.104	.918
	Gender			−0.172	−1.682	.096
2		0.063	3.23			
	Age in months			−0.003	−0.030	.976
	Gender			−0.171	−1.694	.094
	DRT group			0.181	1.796	.076
3		0.101	3.97			
	Age in months			−0.005	−0.048	.962
	Gender			−0.176	−1.772	.080
	DRT group			0.183	1.845	.068
	WT scaffolding sum			−0.197	−1.992	.049*

B. Dependent variable: LPP late window residual score

Step	Predictors	R^2	ΔF	β	t	p
1		0.080	4.09			
	Age in months			−0.278	−2.794	.006**
	Gender			−0.090	−0.904	.368
2		0.080	0.02			
	Age in months			−0.279	−2.783	.007**
	Gender			−0.090	−0.899	.371
	DRT group			0.014	0.143	.887
3		0.081	0.10			
	Age in months			−0.279	−2.772	.007**
	Gender			−0.091	−0.902	.369
	DRT group			0.015	0.146	.885
	WT scaffolding sum			−0.031	−0.308	.759

C. Dependent variable: LPP early window subtraction score

Step	Predictors	R^2	ΔF	β	t	p
1		0.046	2.28			
	Age in months			0.125	1.237	.219
	Gender			−0.162	−1.600	.113
2		0.079	3.32			
	Age in months			0.112	1.112	.269
	Gender			−0.161	−1.611	.111
	DRT group			−0.182	−1.823	.071
3		0.095	1.59			
	Age in months			0.111	1.105	.272
	Gender			−0.165	−1.650	.102
	DRT group			−0.183	−1.841	.069
	WT scaffolding sum			−0.125	−1.263	.210

D. Dependent variable: LPP late window subtraction score

Step	Predictors	R^2	ΔF	β	t	p
1		0.019	0.91			
	Age in months			−0.035	−0.342	.733
	Gender			−0.137	−1.334	.185
2		0.022	0.29			
	Age in months			−0.039	−0.380	.705
	Gender			−0.137	−1.326	.188
	DRT group			−0.055	−0.536	.593
3		0.023	0.83			
	Age in months			−0.040	−0.380	.705
	Gender			−0.138	−1.327	.188
	DRT group			−0.055	−0.536	.593
	WT scaffolding sum			−0.030	−0.288	.774

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

cognitive and emotional scaffolding predicted greater child ER regardless of whether or not parents were present or participated in the DRT. Our prior research (Babkirk et al., 2015) showed that LPP downregulation via directed reappraisal predicts observed ER during laboratory tasks longitudinally, lending support to the notion that the LPP during this task reflects individual differences in ER ability that can subsequently be detected at a behavioral level. This suggests that habitual high-quality parent scaffolding may provide children with regulatory tools that become internalized and in turn bolstered reappraisal ability even when they were alone, and when active scaffolding was absent during the DRT.

Several limitations should be considered. First, the current sample included a wide age range considering the development of cognitive and emotional functioning in the early school-aged period. We intentionally selected this age range since prior studies showed a high degree of variation in ER captured by the LPP (i.e., DeCicco et al., 2012; Babkirk et al., 2015) which could be compared to individual differences in observed ER. However, since our design was cross-sectional, and sample sizes for each age were small, we were not able to examine age-related changes as a primary research question. Future research should focus on smaller age ranges within this period followed longitudinally to clarify the developmental time course of neurocognitive and behavioral ER in relation to parental scaffolding.

Next, as described earlier, the coding schemes differed between the BT and WT. These coding approaches were appropriate given the differences in the goals of the task. That is, only the BT included frequent opportunities for correct and incorrect behaviors, and thus discrete moments during which parents could intervene. Future research could develop a comparable emotionally-challenging task or coding scheme to provide confirmatory evidence of the generalization of links with the LPP across scaffolding modalities. In addition, downregulation of the LPP during the DRT has not yet been linked to child ER or parenting behaviors measured outside the lab. While laboratory-based behavioral tasks provide a snapshot of habitual parent-child interactions, and we can assume to some extent that observations in the laboratory capture core elements of child ER and parenting that extend to daily life, future research should more directly test the ecological validity of the DRT by incorporating at-home observations.

Finally, the current sample consisted of typically-developing children at a single timepoint. Future research should examine links between parent scaffolding and neurocognitive indices of ER longitudinally to capture trajectories of how and when these associations emerge or change throughout development. For instance, the impact of parenting on neurocognitive indices of child ER may decrease in adolescence as peers become increasingly important sources of social-emotional support (Morris et al., 2007; Watson, 2017). In addition, future work should target children with elevated symptoms of psychopathology or those at risk for future mental health challenges, as well as index individual differences in parental psychological adjustment, including parents' own ER indexed via the LPP, as predictors of parent scaffolding and child ER. Additionally, future studies could develop targeted interventions designed to enhance parent scaffolding frequency and quality with the overarching goal to support child ER development and psychological adjustment.

In sum, the current findings add to the growing evidence for the social context sensitivity of the LPP and highlight the adaptive value of parenting behaviors that titrate the level of intervention to the child's fluctuating cognitive and emotional needs.

Acknowledgements

This research was made possible by grant SC1MH104907 awarded to T.D.T from the National Institute of General Medical Sciences, and grant R56MH111700 awarded to T.D.T from the National Institute of Mental Health, both of the National Institutes of Health. This research was also made possible by grant 69391-00-47 awarded to S.M and T.D.T by the Professional Staff Congress of The City University of New York.

Appendix A. Parental scaffolding during the waiting task (adapted from Maslin-Cole and Spieker, 1990)

Score	Description
1	Parent exhibits characteristic **ineffectiveness** in scaffolding in a particular domain (i.e., motivational or emotional scaffolding)
2	Parent exhibits **some** scaffolding effectiveness but many more missed opportunities for scaffolding.
3	Parent partially meets the child's needs for scaffolding, **about half of the time**.
4	Parent meets the child's scaffolding needs **most of the time**, but with a couple of noticeable missed opportunities.
5	Parent meets the child's scaffolding needs **almost the entire time**; there may be a rare instance in which the parent misses a minor opportunity for scaffolding.

Appendix B. Parental scaffolding during the block task (adapted from Carr and Pike, 2012)

Parental scaffolding intervention	Description
Simple feedback (0)	The parent gives short, simple feedback on a child's action indicating correct or incorrect block placement, for example include "Good." "No." "Ok."
Orienting (1)	The parent offers strategies, general rules, and comments regarding the design to focus the child on the task or increase their level of engagement. Examples include questions which bring the child's attention to the design in general without giving the answer (e.g., "How many blocks do you need?"; "This one looks tricky.").
Suggestions (2)	The parent makes suggestions about specific blocks, colors, locations, or actions but not combinations of the three. Examples include drawing focus to an aspect of the design, like a certain side or series of blocks, or statements like "You need a blue one".
Solutions (3)	The parent gives information about more than one of the following: block colors, order, locations, orientations. This behavior is always verbal and in the form of a statement aimed at focusing the child's attention at a specific and complex aspect of the design. For example: "The blue one goes next to the red one"; "You need to move those three green blocks on the end closer together"
Physical help (4)	The parent engages in physical intervention that aids the child in completing a section of the task. This can include pointing at blocks, selecting the correct block for the child and handing it to him/her, adjusting blocks, but not actually placing a block in the design herself. For example: "This bit needs a blue block, here you go" and gives block to child.
Demonstration (5)	The parent performs the task herself while the child observes. This can include placement of a single block, or several blocks in a row while she is providing verbal explanation and/or attempting to re-engage the child in the task. Although the parent is taking the lead, he/she is not excluding the child, and encouraging his/her participation. For example: A parent says, "Here let me show you this part" and builds a section.
Complete control (6)	The parent has taken over the building completely, with little or no verbal explanation of what she is doing. This can include overt exclusion of child from building, or more passive ignoring of the child's participation while the parent takes control. The parent is displaying signs of disinterest in working together with the child and does not let the child take the lead.

Block task parental scaffolding scoring

Score category	Description
Contingent shift	The parent adjusts her level of intervention based on the child's needs. This can occur by increasing the level of intervention following an incorrect (or no) block placement, or by maintaining or decreasing the level of intervention following correct block placement.
Fixed failure feedback	The parent either keeps intervening at the same level, or decreasing level of intervention, following the child's incorrect or lack of block placement.
Over-intervention	The parent increases her level of intervention following the child's correct block placement.

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