

Neural signatures of child cognitive emotion regulation are bolstered by parental social regulation in two cultures

Sarah Myruski,¹ Samantha Birk,² Mayumi Karasawa,³ Aya Kamikubo,³ Midori Kazama,³ Hidemi Hirabayashi,³ and Tracy Dennis-Tiwary¹

¹Hunter College of the City University of New York, Psychology Department, New York, NY, 10065, USA

²Temple University, Psychology Department, Philadelphia, PA, 19122, USA ³Tokyo Woman's Christian University, Psychology Department, Sugunami City, Tokyo, 167-8585, Japan

Correspondence should be addressed to Sarah Myruski: Tracy Dennis-Tiwary; E-mail: tracy.dennis@hunter.cuny.edu; Psychology Department, Hunter College, CUNY, 695 Park Avenue, New York, NY 10065

Abstract

Caregiver impact on the efficacy of cognitive emotion regulation (ER; i.e. reappraisal) during childhood is poorly understood, particularly across cultures. We tested the hypothesis that in children from Japan and the USA, a neurocognitive signature of effective reappraisal, the late positive potential (LPP), will be bolstered by cognitive scaffolding by parents, and explored whether the two cultures differed in whether mere physical proximity of parents provides similar benefit.

Five-to-seven-year-olds ($N = 116$; $n_{\text{Japan}} = 58$; $n_{\text{USA}} = 58$) completed a directed reappraisal task (EEG-recorded) in one of three contexts: (i) parent-scaffolding, (ii) parent-present and (iii) parent-absent. Across cultures, those in the parent-scaffolding group and parent-present group showed effective reappraisal via the LPP relative to those in the parent-absent group. Results suggest that scaffolding is an effective method through which parents in these two cultures buttress child ER, and even parental passive proximity appears to have a meaningful effect on child ER across cultures.

Key words: emotion regulation; social context; cultural context; late positive potential; social-emotional development

Although interest in the parental socialization of emotion and emotion regulation (ER) has grown (Baker *et al.*, 2007; Bariola *et al.*, 2011; Cole *et al.*, 2004), little is known about the impact of parenting across cultures on cognitive ER strategies such as reappraisal (Keller *et al.*, 2004a). In the current study, we draw on theoretical models of cross-cultural socialization and the social regulation of emotion to address this gap in the research. In a group of children from Japan and the USA, we test the hypothesis that the efficacy of reappraisal will be bolstered by direct maternal scaffolding of child ER. We further predict, given research on the impact of social proximity on ER (e.g. Coan *et al.*, 2006; Coan, 2011), that physical proximity of mothers will also boost

effective reappraisal but that these effects may vary between cultures given culture-specific socialization practices. We utilize an event-related potential (ERP), the late positive potential (LPP), as a neural signature of effective reappraisal because it is sensitive to cognitive ER in children (DeCicco *et al.*, 2012; Babkirk *et al.*, 2015; Mehmood & Lee, 2016; Van Cauwenberge *et al.*, 2017) and to cultural differences in ER (Murata *et al.*, 2013).

ER in children

ER is the ability to monitor and modify the experience and expression of emotions to meet goals and manage arousal (Gross

Received: 15 October 2018; Revised: 29 July 2019; Accepted: 19 August 2019

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& Thompson, 2007). ER is a key component of emotional well-being and predicts positive mental health outcomes throughout the lifespan (Gross & Muñoz, 1995; Stifter *et al.*, 1999; Bonanno, 2005; Mennin *et al.*, 2005; Zeman *et al.*, 2006; Graziano *et al.*, 2007). Poor child ER has been related to internalizing and externalizing problems both concurrently (Rydell *et al.*, 2003) and longitudinally (Mullin & Hinshaw, 2007), and clinically anxious children showed greater self-reported difficulties managing their emotions, and greater parent-reported problems regulating negative emotions (Suveg & Zeman, 2004). Further, when children face an emotionally challenging task, such as one requiring separation from their parent, the presence of a stranger or having to wait for a desired reward, greater distress is observed among those children who use fewer ER strategies including social engagement, self-distraction or self-soothing (e.g. Weinberg & Tronick, 1994; Grolnick *et al.*, 1996; Diener & Mangelsdorf, 1999).

Cognitive ER strategies are a widely studied subtype of ER that serve to alter how we attend to and interpret emotional stimuli and events. Reappraisal, the cognitive ER strategy of reinterpreting an unpleasant stimulus or event in a more pleasant or neutral light (Gross & John, 2003; Gross & Thompson, 2007; Dennis & Hajcak, 2009), has been extensively examined in adults, with greater use of reappraisal associated with more frequent expression of positive relative to negative emotions, greater satisfaction with interpersonal relationships, fewer depressive symptoms and greater life satisfaction (Gross & John, 2003; Dennis, 2007; Eftekhari *et al.*, 2009). In adolescents, greater use of cognitive ER strategies like reappraisal during childhood is associated with lower depression and fearfulness/worry (Garnefski *et al.*, 2007). However, relatively little is known about the use and consequences of reappraisal in typically developing children (Zeman *et al.*, 2006; Babkirk *et al.*, 2015).

The LPP as a neural signature of reappraisal

The majority of extant research on cognitive ER relies on self-report measures, which not only are an indirect measure of cognitive ER strategies like reappraisal but also may significantly challenge children's developing language and introspection abilities. This mismatch between methods and developmental level likely in part underlie previous findings that reappraisal is less common (John & Gross, 2004) and less effective (DeCicco *et al.*, 2012; DeCicco *et al.*, 2014) in childhood, which may represent an underestimation of children's ER ability. Indeed, developmental studies of reappraisal have suggested that self-report of ER is not reliable until around age 9 (Gullone *et al.*, 2010), and little is known about the emergent abilities likely predating the capacity to explicitly report ER use. The use of neurophysiological measures, such as scalp-recorded ERPs, has the benefit of minimizing or removing these language- and cognitive-based methodological limitations.

The LPP is a slow, positive-going ERP that emerges around 200 to 300 ms after a visual stimulus is presented and is sensitive to the use of reappraisal (Schupp *et al.*, 2000; Hajcak & Nieuwenhuis, 2006; Hajcak & Dennis, 2009). LPP amplitudes are larger in response to affectively positive and negative stimuli as compared to neutral stimuli (Foti & Hajcak, 2008), and larger LPP amplitudes are correlated with increased affective arousal (Hajcak & Nieuwenhuis, 2006). Thus, the LPP is thought to reflect increased attention to and perceptual processing of emotional material. The LPP is correlated with activity in the lateral occipital, inferotemporal and parietal visual areas, providing converging evidence that it reflects increased perceptual and/or attentional processes engaged by emotional material (Sabatinelli

et al., 2006). In several studies with adults, participants were instructed to reappraise an unpleasant image in more neutral or positive ways. LPP amplitudes were reduced, suggesting that the LPP is sensitive to the effortful downregulation of emotional processing (e.g. Foti & Hajcak, 2008; MacNamara *et al.* 2011).

Several studies have examined the LPP as a neural signature of cognitive ER in children, but with mixed findings (Hajcak & Dennis, 2009; DeCicco *et al.*, 2012; Babkirk *et al.*, 2015). For example, in one study in 5- to 7-year-olds, LPP amplitudes were generated to unpleasant pictures from the International Affective Picture System (IAPS; Lang *et al.*, 2008) preceded by either reappraisal negative story interpretations. Children failed to show reduced LPPs via reappraisal vs the negative condition, the target neural pattern indicating cognitive ER (DeCicco *et al.*, 2012). However, this same group of children showed the expected reappraisal-induced reductions in the LPP by 8 to 9 years of age (DeCicco *et al.*, 2014). Another study (Van Cauwenberge *et al.* 2017) using the same within-subject experimental design approach, found that only children 12 years and older showed the effect of reappraisal on the LPP. Importantly, while these studies suggest developmental maturation of the LPP response to reappraisal in young children, another study (Babkirk *et al.*, 2015) documented reappraisal-induced reductions in the LPP in children as young as 5 years of age. Children who showed effective reappraisal-induced reduction of the LPP also showed greater use of adaptive ER strategies observed 2 years later. These findings suggest that the LPP may be a sensitive measure of individual differences in reappraisal capacity, at least for some school-aged children.

However, given that young children rely upon caregivers to support their early attempts at more cognitively sophisticated ER strategies like reappraisal, lack of consideration of social context may be another source of underestimation of a child's cognitive ER capacity (Eisenberg, 2000; Cole *et al.*, 2004; Morris *et al.*, 2011). This motivated the method of the current study, to directly examine child LPP indices of reappraisal at two related levels of social context: culture and parenting practices. Few studies have examined the LPP in cross-cultural samples. In one such study, Murata *et al.* (2013) examined how culture impacts the LPP during emotional suppression, an ER strategy involving masking physical expressions of emotions, and which is used more frequently among Asians compared to European Americans. While both Asian and European American participants showed an equally elevated LPP following unpleasant images, only Asian participants showed a significant decrease in the LPP when prompted to suppress compared to maintain emotional responses. These findings highlight the important role of cultural expectations or experiences on ER. Just as culturally specific habits surrounding the use of suppression in Asian cultures are reflected via the LPP, so may other socio-cultural practices impact neurocognitive processes corresponding to ER. In early childhood, cultural differences in parenting and the socialization of ER may exert a powerful influence on these processes.

Cross-cultural parenting and child ER

Prominent cross-cultural theories of child socialization highlight how culturally shaped parenting practices guide development of self and emotion regulatory processes throughout early childhood development (Chan *et al.*, 2009; Keller *et al.*, 2004b). A distal parenting style, characterized by frequent face-to-face verbal interactions and object-based play (Keller *et al.*, 1999; Keller & Greenfield, 2000), is associated with greater self-recognition at an earlier age in infancy. In contrast, infants whose parents evidence a more proximal parenting style, characterized by

emphasis on body contact and stimulation (Keller, 2003), reach self-regulation milestones (including self-inhibition and rule compliance) earlier in the first 2 years of life. Distal parenting is common in relatively individualistic cultures, such as the USA, in which socialization goals center around individual enhancement and achievement (Keller, 2007). Proximal parenting, in contrast, is common in relatively collectivist cultures, such as Japan, in which interpersonal relatedness and compliance are prioritized (Kağitçibaşı, 1996; Keller et al., 2005; Keller et al., 2004a; Keller et al., 2004b). Parents from individualistic or collectivist cultures may have distinct expectations and methods for bolstering children's ER efforts. For example, two observational studies showed that when pre-school-aged children faced emotional challenges, mothers from the USA promoted child autonomous and independent expression of emotion, whereas mothers from Japan promoted more physical contact and discussion of shared experiences (Dennis et al., 2002; Dennis et al., 2007).

Indeed, theories such as the Social Baseline Theory (SBT; Beckes & Coan, 2011; Coan, 2011) suggest that Child ER may be directly bolstered through such implicit parenting practices. According to SBT, neural circuits corresponding to regulatory functions have evolved and developed in social contexts, and thus the proximity of others can mediate ER effectiveness. For instance, several studies including adults from the USA document that hand-holding and social proximity, particularly when relationship satisfaction is high, reduces threat-related neural responses (Coan et al., 2005; Coan et al., 2006; Coan & Maresh, 2014). Importantly, such social dynamics around proximity are likely shaped by cultural norms (Coan, 2011). In childhood, broad cultural influences, and more specific parent-child socialization experiences such as distal and proximal parenting practices, shape expectations about social resources available during ER. For example, the presence of a caregiver may have a distinct impact on child ER depending on whether the child has developed culture-specific expectations around parent presence based on experiences with distal parenting (verbal interactions predominate) vs proximal parenting (use of direct physical contact predominates). Specifically, children reared with distal parenting may be more accustomed to functioning somewhat independently of the parent even when they are present physically. In contrast, children reared with proximal parenting, in which use of direct contact predominates, may expect parents to engage in immersive and physical interaction when they are present. Importantly, when expectations for parent-child interactions are violated, ER resources may be depleted.

Parental scaffolding of child ER

Research on parental scaffolding of emotion further examines the role that parents play in bolstering children's ER ability. Scaffolding is a technique through which parents can increase their children's functioning to a level that is greater than what their child could achieve alone but below the full ability of the parent (the zone of proximal development; Bibok et al., 2009; Vygotsky, 1980), such as by providing developmentally appropriate information about the task (Pratt et al., 1992; Pino-Pasternak & Whitebread, 2010; Mermelshstine, 2017). Similar to the scaffolding of child cognitive skills, parents scaffold their child's ER by sensitively detecting a child's emotional state and supporting the use of specific strategies to modulate emotions (Dix, 1991). In early to middle childhood, children's understanding of their own and other's emotions grows, and improving social skills correspond to more complex coregulation of emotion (e.g. Eisenberg

et al., 2004; Zeman et al. 2006 for review). When parents scaffold child ER, they enhance child ER in the moment and support the development of more sophisticated self-generated ER. For example, Morris et al. (2011) showed that when parents from the USA scaffolded the use of reappraisal during a disappointing behavioral task, children showed less negative emotions, such as anger and sadness, compared to when parents used physical comfort and attention refocusing. Further, habitual parental emotional scaffolding relates to less child emotion dysregulation (Hoffman et al., 2006), indicating that scaffolding represents an advantageous approach to emotion socialization. Scaffolding has been shown to be advantageous during child emotional challenges across cultures (Cole et al., 2004; Cole & Tan, 2007), but it is unknown whether its positive impact can be detected at the neural level.

The current study

Given the crucial role of caregiver support in children's regulation of their own emotions, ER may be most accurately measured via context-sensitive biological signatures measured in developmentally appropriate and ecologically valid social contexts (Cole et al., 2004). To this end, the goal of the study was to examine whether the LPP, as a neural signature of ER, was sensitive to two levels of social context—parenting practices and culture of origin. The current study included 5- to 7-year-old children from Japan and the USA and their parents. Children completed a directed reappraisal task (DRT) in one of three between-subject parenting contexts: parent-absent, parent-present and parent-scaffolding. The LPP was generated for each of three within-subject conditions: reappraisal, negative and neutral.

We tested two hypotheses. First, we predicted that children who complete reappraisals while parents provide scaffolding, vs alone or with parent merely present, will show more effective ER via the LPP. This prediction was based on the rationale that parent scaffolding of child ER represents an ecologically valid social context during early-to-middle childhood. Second, given the potential regulatory impact of social proximity of significant others (Coan, 2011), we tested the exploratory hypothesis that children who complete reappraisals with parents present but passive (i.e. unresponsive) will show intermediate levels of LPP reductions via reappraisal, but that this effect may be dampened in Japanese relative to US children given potential violation of cultural expectations regarding proximal parenting (e.g. physical touch and responsiveness). This prediction was based on the rationale that, consistent with Murata et al.'s (2013) findings, culturally based expectations will shape neurophysiological responding to emotional and contextual demands. That is, parent presence without interaction may be a greater violation of expectation for children reared in a culture which emphasizes proximal parenting (i.e. Japan), more so than for children reared via distal parenting (i.e. USA).

Method

Participants

Participants included 116 children (53 females) ages 5.00 to 7.69 years ($M=6.01$, $SD=0.74$) and one parent per child [110 (94.8%) were mothers, 6 (5.2%) were fathers]. Fifty-eight parent-child dyads lived in the USA¹, and 58 parent-child dyads lived

1 The US participants consisted of a subsample from a larger study (Myruski & Dennis-Tiwary, under review). This subsample was desig-

in Japan. In the US subsample, child ethnicity was reported as follows: 25 (43.1%) White, 10 (17.2%) Black/African-American, 6 (10.3%) Hispanic/Latino, 7 (12.1%) Asian, 2 (3.4%) Black and another category, 1 (1.7%) Hispanic and another category and 7 (12.1%) chose not to report ethnicity. The highest levels of education for participating parents of US children were as follows: 1 (1.7%) less than high school, 9 (15.5%) high school diploma, 8 (13.8%) vocational or associates degree, 17 (29.3%) bachelor's degree, 21 (36.2%) graduate degree and 2 (3.4%) reported other. In the Japan subsample, all 58 (100%) children were ethnically Asian. The highest levels of education for participating parents of Japanese children were as follows: 6 (10.3%) high school diploma, 18 (31.0%) vocational or associates degree, 30 (51.7%) bachelor's degree, 3 (5.2%) graduate degree and 1 (1.7%) reported other. Participants were randomly assigned to complete a DRT in one of the three conditions: parent-scaffolding ($n = 40$, 34.5%), parent-present ($n = 39$, 33.6%) or parent-absent ($n = 37$, 31.9%).

Materials

Questionnaires

Parents reported child positive adjustment via questionnaires. Exploratory associations between these measures and other study variables are presented in the Supplement.

Emotion Regulation Checklist (ERCL). Parents completed the ERCL (Shields & Cicchetti, 1997), a 24-item measure of child ER. The ERCL yields two subscales: ER (e.g. emotional self-awareness, empathy and emotion modulation abilities) and negativity/lability (e.g. dysregulation of negative affect, emotional inflexibility and mood lability).

Child Behavioral Checklist (CBCL). Parents also completed the CBCL (Achenbach, Dumenci, & Rescorla, 2001). Five-year-olds were assessed using the CBCL for ages 1.5 to 5, and children older than 6 years old were assessed using the CBCL for ages 6 and up. The CBCL was used to assess total problems (e.g. anxiety, depression, aggressive behavioral problems), which was examined as a T-score.

DRT

There were three conditions of the DRT (reappraisal, negative and neutral), which each participant completed. Each condition lasted ~10 min with breaks offered between conditions. In the DRT, children viewed a total of 30 unpleasant² and 15 neutral³ IAPS pictures. Children were instructed to think about each picture so that it matched the preceding story. Each condition included 15 trials (IAPS pictures and associated interpretation stories) which were repeated twice for a total of 30 trials per condition (presented in random order). Unpleasant pictures were randomly chosen to either appear in the negative or reappraisal condition, which varied between participants. 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. Each story was followed by a 500 ms delay prior to picture stimulus onset. Pictures were then presented for 2000 ms with a 1500 ms inter-trial interval between each picture and the next story. The order of conditions was counterbalanced across participants, and the order of story presentation within each condition block was randomized.

Based on random assignment, one-third of the sample was placed in the parent-absent group and completed the DRT without parent assistance. In this version of the task, picture stimuli were preceded by auditory stories that were played twice in a row to ensure comprehension. Another third of the sample was placed in the parent-present group. This version of the task is identical to the other non-scaffolding version, except that the parent was present in the booth during the DRT. Parents were instructed to sit comfortably on a stool behind the child and complete a questionnaire while their child completed the computer task. They were told to refrain from interacting with their child, except to redirect their attention back to the computer should the child attempt to talk to them. The purpose of including this condition in the experimental design is to examine the impact of the mere presence of the parent on children's neurocognitive responses to the DRT. Finally, the remaining third of the sample was placed in the parent-scaffolding group during which parents scaffolded their child's reappraisal. The parameters of this DRT are the same as the one used for the other groups, except parents sat in the recording booth with their child and participated in the task. During each trial, parents read a scaffolding script aloud (e.g. Mom read: 'Next we will see a picture of a big snake. Where we live, snakes are shy and like to keep away from people.'). followed by the same audio story used in the non-scaffolding versions of the DRT (e.g. 'This is a snake that is completely harmless; it doesn't even have teeth.'). followed by the picture stimulus. Scaffolding scripts were designed to orient the child to the upcoming stimulus and frame the interpretation story to be personally relatable. To allow for differences in reading speed, the parent clicked the mouse to manually advance to the next part of the trial after they read each scaffolding script. Parents received instructions for how to complete the task earlier during the EEG application period, so that they had time to prepare. Parents were instructed to read the scaffolding scripts in a neutral but natural tone and to refrain from elaborating on the story in any way except what is prompted on the screen.

Electroencephalography (EEG) parameters and data reduction. EEG was recorded during the DRT using either BioSemi 32 (Japanese subsample) or 64 (USA subsample) Ag/AgCl active scalp electrodes sampled at 512 Hz. Eye movements were measured by electrooculogram (EOG) signals from electrodes placed around each eye. To monitor vertical eye movements, electrodes were positioned 1 cm above and below the left eye, and to monitor horizontal eye movements, electrodes were positioned 1 cm from the outer edge of each eye. Pre-amplification of the EEG signal was applied at each electrode during recording to improve the 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 (non-differential) channel.

BrainVision 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 1 Hz and a high cutoff 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

nated from the larger sample by selecting only children aged within 9 months of the oldest child in the Japanese sample.

- 2 Unpleasant IAPS: 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.
- 3 Neutral IAPS: 5740, 5820, 7000, 7002, 7004, 7009, 7010, 7041, 7090, 7100, 7140, 7150, 7224, 7595 and 7950.

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 μ V, changes within a given segment greater than 200 μ V, amplitude differences greater than 120 μ V in a segment and activity lower than 2 μ V 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.⁴ All EEG parameters used were consistent with other studies with children in this age range (DeCicco et al., 2012; Babkirk et al., 2015).

Electrode sites and the time window of the LPP were selected based on prior developmental studies examining emotional processes in children (e.g. Babkirk et al., 2015; Kujawa et al. 2012). Specifically, the early window was targeted since previous research documents that individual differences in the magnitude of the LPP are linked to emotional vulnerabilities (e.g. Kujawa et al., 2012), and predict ER behavior (e.g. Babkirk et al., 2015) in school-aged children. Since there is variability in the electrodes and time windows selected across these prior studies, we finalized our selections by choosing the maximal region from the grand average waveform collapsed across all conditions (as opposed to selecting only where waveforms diverged across conditions), as recommended by Luck & Gaspelin (2017). Inspection of a portion of our individual participants (~20%) confirmed that this time window consistently encompassed the maximal amplitude. Thus, the LPP was quantified as the mean amplitude from 250 to 800 ms post-stimulus onset at posterior and occipital electrode sites (PO3, PO4, O1, Oz, O2)⁵ for each stimulus type (negative, reappraisal, neutral) within the DRT (Figure 1). We also examined the later window (800 to 2000 ms), and these results are presented in Supplementary Table S1.

We conducted a manipulation check to confirm whether LPP amplitudes were significantly reduced in the reappraisal vs negative conditions indicating the target expected effect of reappraisal on the LPP for the sample as a whole. To do so, we conducted a repeated-measures ANOVA with Condition (negative, reappraisal, neutral) as the within-subjects variable and LPP amplitudes as the dependent variable. There was a main effect of Condition [$F(2, 230)=60.23, P < .001$] such that LPP amplitudes were significantly greater in both negative [$M=35.70, SD=12.33, t(115)=9.26, P < .001$] and reappraisal [$M=33.05, SD=10.90, t(115)=8.68, P < .001$] conditions compared to the neutral ($M=24.80, SD=11.70$) condition. Further, LPP amplitudes were significantly reduced in the reappraisal vs negative condition, $t(115)=2.75, P = .007$.

To quantify the magnitude of LPP modulation in the reappraisal vs negative condition, residual scores were computed via a linear regression model. Residuals offer advantages over subtraction scores such that (i) residuals better account for inter-correlations between baseline and relative responses (Weinberg et al., 2015) and (ii) residuals better reflect individual differences in variability of measurement. LPP amplitudes to negative were entered as the predictor and LPP amplitudes to reappraisal as

the outcome. More negative residual scores indicated a greater impact of directed reappraisal on reduction of the LPP, the targeted neural signature of ER.

Procedure

Following informed consent and assent, children were fitted with an elasticized nylon EEG cap and electrodes were applied according to the international 10/20 system. The child then completed the DRT in one of three social contexts (parent-absent, parent-present, parent-scaffolding). Following EEG clean-up, parents and children completed tasks relevant to the larger study. Parents completed questionnaires during EEG application, during the EEG task (for parent-absent or parent-present group), and after all study tasks were complete if additional time was needed. Finally, participants were debriefed, parents were compensated \$50 and children received a small gift.

Results

Descriptive statistics

Descriptive statistics for LPP amplitudes are presented in Table 1. Gender and age were examined in relation to LPP amplitudes in the sample as a whole, and in each subsample (USA and Japan). Independent samples t-tests revealed that there were no significant gender differences in LPP amplitudes in any condition, both within each subsample (USA and Japan) and in the sample as a whole ($P > .10$). Further, age was not significantly correlated with LPP amplitudes in either subsample ($P > .10$), nor in the sample as a whole ($P > .10$). However, since mean age was significantly greater among child participants from USA ($M = 76.75, SD = 9.25$) vs Japan [$M = 69.78, SD = 7.01; t(106.28) = 4.57, P < .001$], age in months was entered as a covariate in subsequent analyses.

Further, to examine possible cross-cultural differences in general reactivity to complex visual stimuli, we tested for a difference in LPP amplitudes in the neutral condition across the US and Japanese subsamples. An independent samples t-test revealed that LPP amplitudes in the neutral condition were significantly greater among Japanese ($M = 28.07, SD = 11.19$) vs US [$M = 21.52, SD = 11.36; t(114) = -3.13, P = .002$] children. To account for this, LPP amplitudes in the neutral condition were entered as a covariate in subsequent analyses.

Parent and cultural context effects on the LPP in two cultures

To examine the influences of parent-child social context and culture on the magnitude of reappraisal-induced reduction of the LPP compared to the negative condition, we conducted a 2(Culture: USA, Japan) \times 3(Social Context Group: parent-scaffolding, parent-present, parent-absent) ANCOVA, with age in months and LPP amplitudes to the neutral condition as covariates, and LPP residual scores as the dependent variable. More negative residual scores indicated a greater impact of directed reappraisal on reduction of the LPP. Bonferroni's correction was used to account for multiple comparisons (adjusted Ps reported where appropriate).

There was a significant main effect of Culture on LPP residual scores [$F(1, 108) = 4.29, P = .041, \eta_p^2 = .04$], such that the magnitude of reappraisal-induced reduction of the LPP was significantly greater in US ($M = -0.18, SE = 0.12$) vs Japanese ($M = 0.19, SE = 0.12, d = .41, P = .04$) children, regardless of the Social Context Group.

4 Average trial counts out of total possible 30 trials for each condition are as follows: negative ($M = 27.19; SD = 4.60$), reappraisal ($M = 27.59; SD = 3.78$) and neutral ($M = 27.05; SD = 3.05$).

5 The cluster selected represents the same area of the scalp captured by the two systems (32- and 64-channels in Japan and USA, respectively), including only those electrodes which are present in both systems. Results remain consistent if the non-overlapping electrodes (PO7, PO8, POz, Iz) are included in analyses for USA.

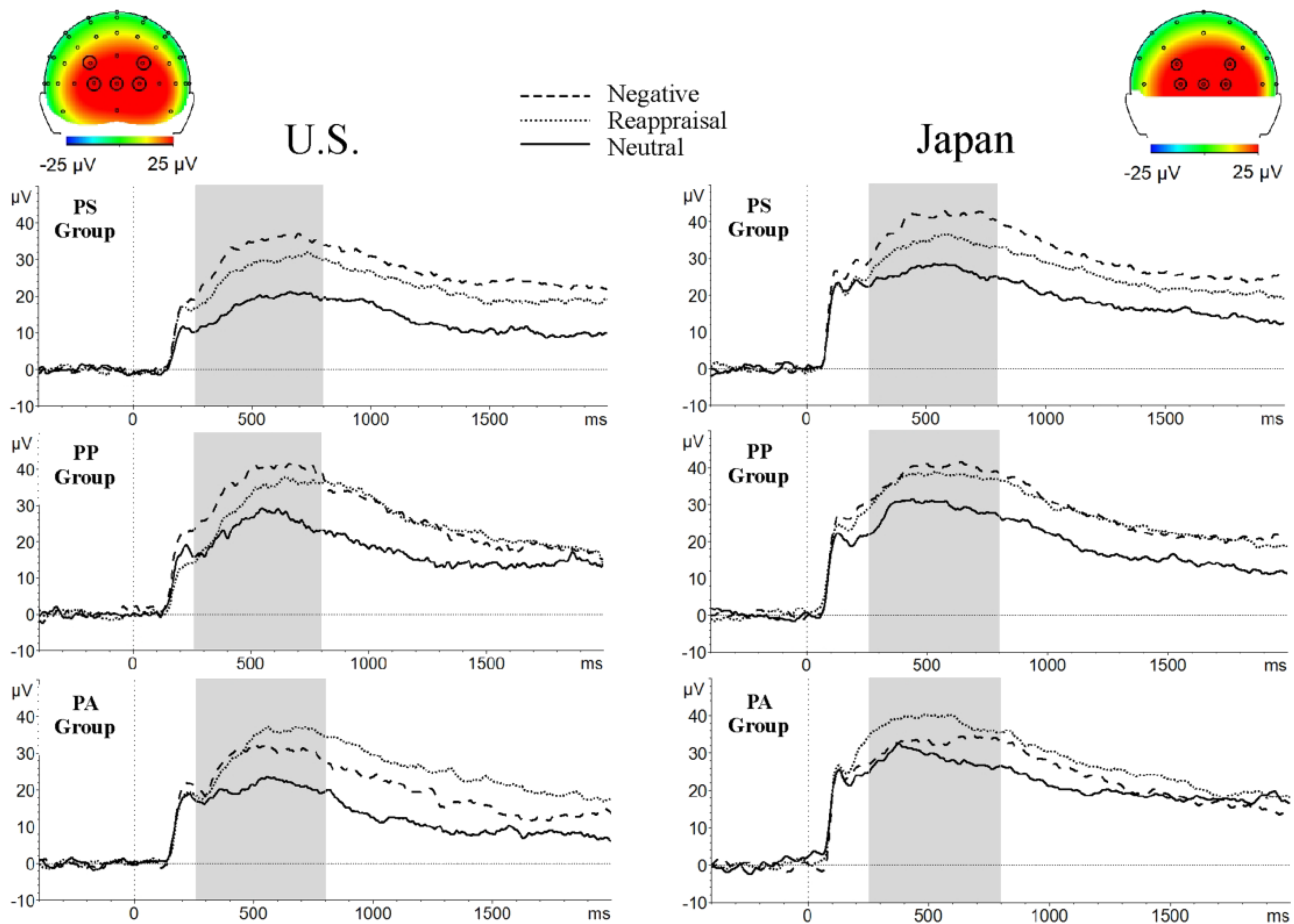


Fig.1. Waveforms depict the LPP separately for each Culture (USA, Japan), Social Context Group (PS, PP, PA) and Condition (negative, reappraisal, neutral). Electrode sites used to quantify the LPP are indicated in the scalp distributions.

Table 1. Descriptive statistics for LPP amplitudes during the DRT [M (SD)]

LPP amplitude (μV)	Full sample	Parent-absent	DRT condition	
			Parent-present	Parent-scaffolding
Neutral condition	24.80 (11.70)	25.30 (12.57)	23.70 (13.25)	25.40 (9.20)
Negative condition	35.70 (12.33)	31.57 (11.72)	36.26 (12.65)	38.97 (11.76)
Reappraisal condition	33.05 (10.90)	34.85 (11.45)	32.21 (11.87)	32.18 (9.33)
LPP standardized residual	0.00 (1.00)	0.46 (1.00)	-0.13 (0.93)	-0.30(0.91)

Note. Standardized residual represents the extent to which LPP amplitudes were decreased via reappraisal vs the negative condition. More negative residual scores indicate greater reduction of the LPP via reappraisal.

There was also a significant main effect of Social Context Group [$F(2, 108) = 6.84, P = .002, \eta_p^2 = .11$], such that the magnitude of reappraisal-induced reduction of the LPP was significantly greater in the parent-scaffolding ($M = -0.31, SE = 0.14, d = .84, P = .001$) and parent-present ($M = -0.08, SE = 0.14, d = .58, P = .047$) groups, in comparison to the parent-absent group ($M = 0.41, SE = 0.14$), regardless of Culture. However, LPP residual scores did not significantly differ between the parent-scaffolding and parent-present groups ($P = .720, d = .26$)⁶. Further, there was no significant Culture \times Social Context Group interaction ($P = .620$).

6 Adjusted means are reported. Effects sizes were computed for all ANCOVA follow-up comparisons using adjusted means.

Discussion

The current study addressed the substantial research gap in our understanding of how caregivers impact cognitive ER in childhood and how these patterns might vary across cultures. Using a temporally and functionally sensitive neural signature of ER, we tested the hypothesis that effective reappraisal would be bolstered by the direct cognitive scaffolding of mothers. Further, we explored potential cultural differences in whether the distal presence of the caregiver provided a similar positive impact of ER. We found that, as predicted, children from both Japan and USA showed more effective reappraisal when mothers provided cognitive scaffolding, compared to when children were alone (Condition \times Social Context Group interaction). These findings suggest that scaffolding may be an effective method through

which parents in these two cultures buttress child cognitive ER. In addition, we found that children showed more effective reappraisal when mothers were present in the room compared to when the children were alone, and this finding also generalized across both cultures. This suggests that the proximity of parents can bolster child ER effectiveness.

This study was largely motivated by the observation that current methods for evaluating child cognitive ER suggest that early school-aged children show immature patterns of neural responses during tasks designed to prompt and measure neural signatures of cognitive ER (DeCicco et al., 2012). However, these methods, being directly exported from the adult literature, ignore the developmental role that caregivers have in supporting child ER. That is, during early childhood, it is developmentally normative—and adaptive—for children to achieve successful ER in part through the social regulation of emotion by caregivers and gradually developing the expertise to shift towards relatively greater reliance on internal ER capacities during later childhood and adolescence. The present study directly addressed this by comparing effects when children were completing the ER task alone vs two distinct types of parenting contexts.

Results showed that the magnitude of reappraisal-induced reduction of the LPP was enhanced in both cultures when parents actively scaffolded child ER during reappraisal by reading scripts which oriented the child to the upcoming unpleasant pictures and framed the accompanying stories to be personally relatable. This is consistent with a range of theories and bodies of empirical evidence emphasizing the social regulation of emotion, including social baseline theory (Beckes & Coan, 2011; Coan, 2011), and research documenting maternal buffering of stress in animals (Sullivan & Perry, 2015) and humans (Gee et al., 2014; Tottenham, 2015). We also found that both children in Japan and USA showed a robust reappraisal effect while their parent was present but not scaffolding ER compared to when they were alone. This pattern is consistent with the notion that social proximity may serve to distribute the burden of processing and managing emotions (Coan, 2011), thus allowing for more effective ER in the mere presence of a source of social support. Taken together, these results suggest that social context must be considered when studying child ER so as not to potentially underestimate child ER. For example, previous findings suggesting that reappraisal is less common (John & Gross, 2004) and less effective (DeCicco et al., 2012; DeCicco et al., 2014) in childhood and the mixed literature resulting from studies examining the LPP as a neural signature of cognitive ER in children (Hajcak & Dennis, 2009; DeCicco et al., 2012; Babkirk et al., 2015) may be related to the lack of the consideration of social context. Given that young children rely upon their caregivers to support their use of cognitive ER strategies, like reappraisal, inclusion of an ecologically valid parent-child social context is a key to the accurate estimation of child ER abilities.

Despite the enhancement of child ER in the parent scaffolding and parent-present conditions compared to the child alone condition across both cultures, the US children showed greater reappraisal via the LPP compared to Japanese children overall. This could be because more participants in the US sample compared to the Japanese subsample benefited from the parents' mere presence, reflecting a greater magnitude reappraisal effect on the LPP in the US subsample mean. However, since there was no significant culture by social context group interaction, the current study was not able to probe this question. Another possible explanation for this cross-cultural difference is that, in

the Japanese subsample, LPP amplitudes in the parent-absent condition showed a high magnitude and consistent inversion of the predicted pattern such that greater mean LPP amplitudes were observed in the reappraisal vs negative conditions, driving a lesser magnitude reappraisal effect on the targeted early window of the LPP in the Japanese subsample mean. This reversal of the predicted pattern when children in the Japanese subsample were alone may be explained by a violation of the expectation of parent support, such that greater neural resources were required when children were alone and they heard an unknown adult's voice (the experimental recording of the reappraisal story) offering a reappraisal interpretation. US children the parent-absent group also showed this reversed pattern of LPP divergence, but later in the waveform. Future studies should investigate potential cross-cultural similarities and differences regarding violation of expectation of parent presence during ER due to culture-specific childrearing practices.

Several limitations should be noted. First, due to the complexity of the study design, which included two between-subject variables (i.e. Culture, Social Context), sample sizes for each subset were relatively small. This may have prevented the Culture \times Social Context Group interaction in significantly predicting LPP residual scores. Further, mean age significantly differed across samples, but age was entered as a covariate in main analyses to account for this difference. Future studies should examine age-related changes in the benefit of parental scaffolding on child ER. Also, parents in the current study included mostly (94.8%) mothers, and thus findings may not represent patterns of scaffolding of child ER from fathers. Future research should examine the potential moderating role of parent gender regarding parent-child context effects on the LPP. Importantly, while broad cultural differences in parenting style have been demonstrated, there is also evidence for considerable variability within a larger culture based on sociodemographic variability including income, education and ethnicity (Keller et al., 2009). Future research should examine differential patterns of social bolstering of ER via the LPP in large samples of heterogeneous cultures. Furthermore, in the current study, the parental scaffolding condition involved the parent reading additional information aloud to assist the child with reappraisal. In order to clarify whether differences in reappraisal are due to parental presence and involvement or the presentation of additional examples of reappraisal, future research should include additional comparison conditions, such as a reappraisal condition in which the examples are read by the audio recording rather than the parent. In addition, the current study examined the early window of the LPP, given previous research that has demonstrated effects of ER in this period (e.g. Babkirk et al., 2015). Future research could examine the later time window of the LPP to examine the longer time course of the LPP across cultural and social contexts. Finally, while the current study targeted the LPP as a neural signature of effective reappraisal, future studies should examine how other indexes of neural, physiological or behavioral regulation are influenced by socio-cultural factors.

Taken together, results highlight the importance of examining social-emotional competencies in ecologically valid social contexts and that the failure to do so may yield underestimations of ER capacities, particularly in childhood when parent-child interactions lay the foundation for ER throughout the lifespan. Thus, findings emphasize the need for culturally sensitive and developmentally informed methods for studying the social regulation of child cognitive ER and its neural correlates.

Research highlights

- Caregiver impact on the efficacy of cognitive ER, such as reappraisal, during childhood is poorly understood, particularly across cultures.
- We used a neurocognitive index of ER, the LPP, to examine whether parent presence or scaffolding bolstered child ER in Japanese and US samples.
- Across cultures, children showed effective reappraisal via the LPP when parents actively scaffolded child ER and when parents were merely present.
- Results suggest that scaffolding and passive proximity are effective methods through which parents in these two cultures buttress child ER.

Supplementary data

Supplementary data are available at SCAN online.

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