Social Cognitive and Affective Neuroscience, 2018, 535–545

doi: 10.1093/scan/nsy031
Advance Access Publication Date: 28 April 2018
Original article

Behavioral and neural correlates of parenting self-evaluation in mothers of young children

Laura K. Noll,[1,3] Nicole R. Giuliani,[2,3] Kathryn G. Beauchamp,[1,3] and Philip A. Fisher[1,3]

[1]Department of Psychology, [2]Department of Special Education and Clinical Sciences, and [3]Center for Translational Neuroscience, University of Oregon, Eugene, OR 97403, USA

Correspondence should be addressed to Laura K. Noll, Department of Psychology, University of Oregon, 1227 University of Oregon, Eugene, OR 97403-1227, USA. E-mail: lkn@uoregon.edu

Abstract

In this study, we utilized a novel fMRI paradigm to examine the behavioral and neural correlates of parenting self-evaluation in a sample of mothers with at least one child under the age of 4 ($N = 37$). Prior self-report, behavioral and observational research document the implications of parenting self-evaluations for parent well-being and caregiving behavior; however, relatively little is known about the neural circuitry underlying these self-referential processes and to what extent they are influenced by caregiving experience. Although neuroimaging paradigms indexing other aspects of parental function exist, this is the first to use functional neuroimaging to study parenting self-evaluation in a controlled laboratory setting. We found parenting self-evaluations elicited significantly greater activity across most cortical midline structures, including the medial prefrontal cortex compared to control evaluations; these findings converge with previous work on the neural underpinning of general trait self-evaluation. Notable differences by parity were observed in exploratory analyses: specifically, primiparous mothers endorsed a higher number of developmentally supportive traits, exhibited faster reaction times, and showed a greater difference in mPFC activity when making self-evaluations of developmentally supportive traits than of developmentally unsupportive traits, compared to multiparous mothers. Implications of these findings and study limitations are discussed.

Key words: parenting self-evaluation; parental self-efficacy; parity; medial prefrontal cortex; functional magnetic resonance imaging

Introduction

For many individuals, the period spent parenting a young child represents a time of rapid, complex identity development. Within this context, parents' implicit and explicit judgments of themselves as caregivers (i.e. parenting self-evaluations) across such dimensions as competence, consistency, stress and warmth represent important variables of interest, as these may have a significant impact on parental well-being and caregiving behavior. However, apart from self-report questionnaires, few measures examine parenting self-evaluation in controlled laboratory settings. In this paper, we present a novel experimental task designed to fill this gap in the literature, and initial behavioral and neuroimaging data documenting the correlates of parenting self-evaluation in mothers of young children.

A neuroscience-based approach to parenting self-evaluation

Despite the robust behavioral literature documenting links between parenting self-evaluations and parental function (Coleman and Karraker, 1997; Jones and Prinz, 2005), relatively

Received: 26 July 2017; **Revised:** 8 April 2018; **Accepted:** 23 April 2018

little is known about the neural circuitry underlying these processes. Historically, there has been an extensive focus on parental self-efficacy as a domain of parenting self-evaluation in parenting studies; however, there is a paucity of parenting self-evaluation research using paradigms that assess global/categorical judgments parents make about themselves across self-evaluation domains or across multiple levels of analysis. Neuroimaging is a promising methodology to deepen our understanding of parenting self-evaluation, as it allows for explication of mechanisms underlying links between parents' self-referential processing and the neural correlates of parental function. Notably, although extensive neuroimaging research documents the neural correlates of general self-evaluation and self-reflection, no functional magnetic resonance imaging (fMRI) work has investigated the specific neural correlates of parenting self-evaluation.

Reviews and meta-analyses identify robust correlations between self-referential processes (including those with important implications for parenting, such as mentalizing) and activation in cortical midline structures (CMS). Particularly strong associations have been found within the medial prefrontal cortex (mPFC) and adjacent regions of the anterior cingulate cortex (Northoff *et al.*, 2006; Qin and Northoff, 2011; Denny *et al.*, 2012; Wagner *et al.*, 2012). It remains unknown, however, to what extent parenting self-evaluations, specifically, recruit these same circuits.

Links between parenting self-evaluations and parental function

With respect to parenting self-evaluations of ability, consistency, and warmth, a large body of empirical work using self-report questionnaires suggests that differences in parental self-efficacy (i.e. the extent to which a parent evaluates themselves as competent in their parenting role) are associated with aspects of parent well-being, parenting behavior and child development (for reviews see Coleman and Karraker, 1997; Jones and Prinz, 2005). For example, parents with low parenting self-efficacy are more likely to be depressed (Kohlhoff and Barnett, 2013; Michl *et al.*, 2015) and less likely to report satisfaction with parenting (Coleman and Karraker, 2000). In contrast, robust associations have been reported between endorsements of high parenting self-efficacy and developmentally supportive parenting behavior (Bohlin and Hagekull, 1987; Teti and Gelfand, 1991). Recent longitudinal work suggests that poor parenting self-efficacy may represent a risk factor for negative dyadic transactions across early childhood (Verhage *et al.*, 2013) and both direct and indirect effects have been observed between parental self-efficacy and children's academic and social competence (Bogenschneider *et al.*, 1997; Ardelt and Eccles, 2001; Junttila *et al.*, 2007). Taken together, these findings suggest parents' evaluations of their self-efficacy, including developmentally supportive and unsupportive qualities, represent important factors in the family system that may have a significant impact on child development.

Parity as a predictor of parental function

Growing evidence from human and non-human animal studies suggests that significant, long-lasting changes in maternal circuitry occur with caregiving experience, and may underlie observed enhancements in maternal responsiveness (Pereira and Ferreira, 2016) and other aspects of parental function, such as neural responses to infant cues (Maupin *et al.*, 2018). However, no research has examined the impact of parity on parenting self-evaluation *in vivo*. Since positive parenting thoughts increase across the perinatal period in healthy individuals (Kim *et al.*, 2013), previous caregiving experience may impact parenting self-evaluation.

To understand the underlying mechanisms of such changes, new multimodal experimental paradigms characterizing the neural correlates of parenting self-evaluations, alongside other salient factors (e.g. parents' history of childhood adversity, demographic risk, parity) are needed. Additional research is needed to examine the relationship between domain-specific components of parenting self-evaluation (e.g. parental self-efficacy, parenting stress) and the neural underpinnings of global parenting self-evaluations; such investigations may represent a precursor to further elucidating self-other processing (as with parental mentalization and reflective function).

The current study

The goal of this study was to examine the behavioral and neural correlates of parenting self-evaluation via a new experimental paradigm. This study builds on Pfeifer *et al.*'s research on self-referential processing across the lifespan, and self- and malleability-evaluations among emerging adults (Pfeifer *et al.*'s, 2007, 2009, 2013; Jankowski *et al.*, 2014). To the best of our knowledge, this is the first study to examine the behavioral and neural correlates of self-evaluation in the context of one's own parenting. However, consistent with meta-analyses documenting robust CMS activity during self-referential processes (Denny *et al.*, 2012; Wagner *et al.*, 2012), we hypothesized that self-evaluation of parenting qualities would engage these structures. We further hypothesized that the mPFC would be specifically sensitive to individual differences in these evaluations due to its known role in personal evaluation, self-referential processing and social evaluative judgments (Mitchell *et al.*, 2006; Denny *et al.*, 2012; Nicolle *et al.*, 2012). Furthermore, the mPFC is central to the neural circuit involved in affective processing and responding, and thus may be particularly sensitive to individual differences in stress and affect (Callaghan and Tottenham, 2016).

We also hypothesized that behavioral and neural correlates of parenting self-evaluation would relate to both self-reported parenting stress and self-efficacy, as seen in previous theoretical and empirical work (Jones and Prinz, 2005). Given the documented associations between early childhood adversity and adult outcomes including reduced parental self-efficacy (e.g. Michl *et al.*, 2015; Kunseler *et al.*, 2016), we posited that individual differences in mothers' history of early childhood adversity would be negatively associated with parenting self-evaluation and related neural activity. Finally, we explored differences in brain activity and its associations with self-reported parental self-efficacy and history of childhood adversity in first-time mothers (primiparous) compared to those who have more than one child (multiparous). Notably, the small sample size made these parity examinations preliminary in nature.

Given documented associations between negative affect and clinical disorders characterized by poor self-evaluation (Lonigan *et al.*, 2003; Crawford and Henry, 2004), it is possible that state affect could confound the hypothesized associations between parenting self-evaluation and brain activity. As such, we included negative and positive state affect, alongside key demographics (income, maternal age) as covariates in our analyses.

Materials and methods

Participants

Thirty-seven mothers aged 20–43 (M = 31.16 years, s.d. = 5.78 years) with at least one child under the age of 4 were recruited via fliers and targeted advertising on social media as part of a larger study investigating the impact of a video-coaching program for caregivers of young children. The ethnic composition of participants was representative of the region: 86.5% Caucasian, 8.1% Hispanic and 5.4% Asian/Pacific Islander. Maternal education ranged from GED to doctoral diploma, and family gross income ranged from $0 to $200 000 per year (M = $56 610, s.d. = $40 653). Of the 37 mothers, 16 were primiparous (number of children: range = 1–6, M = 1.89, s.d. = 1.20). Interested participants were screened by phone for eligibility (i.e. right-handedness, absence of neurological disorders and MRI contraindications) and scheduled for an initial MRI session at the University of Oregon Robert and Beverly Lewis Center for Neuroimaging (LCNI).

Procedure

All procedures used in this study were approved and monitored by the university's Office for the Protection of Human Subjects and written informed consent was obtained from all participants at the beginning of their first study visit.

Measures

Self-report measures. Parenting stress was measured using the Parenting Stress Index, Third Edition Short Form (PSI-3-SF; Abidin, 1995), which contains subscales assessing parental distress, parent–child dysfunctional interaction, and difficult child. Parental self-efficacy was measured using a modified version of the Parenting Sense of Competence Scale (PSOC; Johnston and Mash, 1989). State affect was measured using the Positive and Negative Affect Schedule (PANAS; Watson *et al.*, 1988). Participants' history of childhood adversity was measured using an abbreviated version of the Adverse Childhood Experiences Scale (ACES; Felitti *et al.*, 1998). Basic demographic information was collected via a questionnaire created by the researchers, and all surveys were administered after the experimental task.

The parenting self-evaluation task (PSET). The PSET is an adaptation of an experimental task described in Jankowski *et al.* (2014), which we modified to focus on qualities associated with parenting. Participants are presented with positively and negatively valenced terms that are widely regarded to correspond to developmentally supportive ("DS") or developmentally unsupportive ("DU") caregiving behavior, respectively (Table 1). Blocks vary by instruction, asking participants to evaluate whether these words described them as a parent (Self) or whether they believe these qualities can change for parents in general (Change). In contrast to low-level control conditions used in previous studies of positive and negative trait evaluations (e.g. counting vowels, capital letters or syllables) and consistent with Jankowski *et al.* (2014) paradigm, the latter malleability-evaluation was selected as a high-level control condition with similar semantic and evaluative demands as self-evaluation. Indeed, it could be argued that some self-evaluation may be involved in the control (Change) condition, rendering this a very conservative contrast. Mothers with more than one child were instructed to think of parenting their youngest child (study child age for full sample ranged 7 weeks–4 years, M = 1.72 years, s.d. = 1.35).

The PSET paradigm is a mixed block/event-related design, consisting of two block types representing evaluation perspective and two event types representing trait valence (Figure 1). This produces four conditions, with 26 trials per condition. For each trial, participants answer the prompt via a left or right button press indicating a 'yes' or 'no' response. Behavioral performance is calculated as percent of qualities endorsed in each condition and the corresponding average reaction time.

fMRI data collection and analysis. Data were acquired using a 3.0-T Siemens Skyra scanner at the LCNI. Blood oxygen-level dependent echo planar images (BOLD-EPI) were acquired with a T2*-weighted gradient echo sequence (TR = 2000 ms, TE = 25 ms, flip angle = 90°, matrix size = 104×104, 72 contiguous axial slices with interleaved acquisition, field of view = 200 mm, slice thickness = 2 mm; total time = 5 min 50 s per run × 2 runs). For each participant, a high-resolution structural T1-weighted 3D MPRAGE pulse sequence (TR = 2300 ms, TE = 2.1 ms, matrix size = 192 × 192, 160 contiguous axial slices, voxel size = 1 mm, slice thickness = 1 mm; total time = 5 min 59 s) was acquired coplanar with the functional images, as well as a pair of opposite phase encoded images (SE-EPI) to be used to account for inhomogeneities in the magnetic field within the functional images (TR = 6390 ms, TE = 47.8 ms, flip angle = 90°, matrix size = 104×104, 72 slices, field of view = 200 mm, slice thickness = 2 mm, total time = 1 min 8 s per run×2 runs). Additional functional runs that assessed inhibitory motor control and attentional control were collected that are not reported here, and run order was counterbalanced across subject. Therefore, we do not expect that the addition of these tasks to the PSET significantly affected either PSET behavior or associated brain activity.

Before preprocessing, all DICOM images were converted to NIfTI format via MRI-Convert (http://lcni.uoregon.edu/~jolinda/MRIConvert/), and non-brain tissue was removed from MPRAGE images using robust skull stripping with the Brain Extraction Tool in FMRIB's Software Library (FSL; http://www.fmrib.ox.ac.uk/fsl/). All further analyses were conducted using SPM12 (Wellcome Department of Cognitive Neurology, London, UK; http://www.fil.ion.ucl.ac.uk/spm/). Briefly, MPRAGE images were coregistered to the MNI template and segmented into gray matter, white matter and cerebrospinal fluid, and combined to create a study-specific template using the DARTEL toolbox for SPM12. Field inhomogeneities were corrected by using a fieldmap to unwarp functional images. Images were motion-corrected using realignment, and the mean of all functional images was co-registered to each subject's own structural MPRAGE using a six-parameter rigid body transformation model. All images were then spatially normalized into MNI template space using the study-specific template, and smoothed using a 4-mm^3 full-width at half-maximum Gaussian kernel.

Statistical analyses were conducted in SPM12. For each subject, event-related condition effects were estimated according to the general linear model, using a canonical hemodynamic response function, high-pass filtering (128 s) and a first-order autoregressive error structure. At the subject level, BOLD signal was modeled in a fixed effects analysis with separate regressors modeling each condition of interest (Self DS, Self DU, Change DS, Change DU) for the 4 s after the time of onset. No subject moved more than one voxel in any direction over the course of each run. To control for the effect of the motion that did occur, five-parameter motion regressors were calculated as deviations from the origin (Euclidean translation, Euclidean rotation, derivative of Euclidean translation, derivative of Euclidean rotation, and trash), and entered into single-subject models as

Table 1. Neuroimaging task stimuli by quality valence

PSET stimuli			
Positive/developmentally supportive (DS) qualities		Negative/developmentally unsupportive (DU) qualities	
At ease	Helpful	At my wit's end	Irritable
Attentive	Interested	Bad parent	Lazy
Aware	Nurturing	Burdened	Lonely
Calm	Patient	Cannot handle it	Nervous
Capable	Present	Distracted	Overwhelmed
Comforting	Relaxed	Exhausted	Stressed
Committed	Reliable	Frustrated	Tense
Competent	Responsive	Inadequate	Too busy
Consistent	Sensitive	Inattentive	Unpredictable
Effective	Skilled	Incapable	Unsatisfied
Encouraging	Supportive	Incompetent	Unsure of myself
Flexible	Understanding	Inconsistent	Whined at
Good parent	Warm	Ineffective	Worried

Note. Candidate PSET stimuli were first extracted from commonly used parenting self-report questionnaires and observational scales, then evaluated for inclusion by a panel of experienced clinicians with expertise in early childhood development. Words or phrases with high demand characteristics (e.g. "abusive," "neglecting") were eliminated. The most highly rated 26 words from each valence category were selected for inclusion in the PSET task.

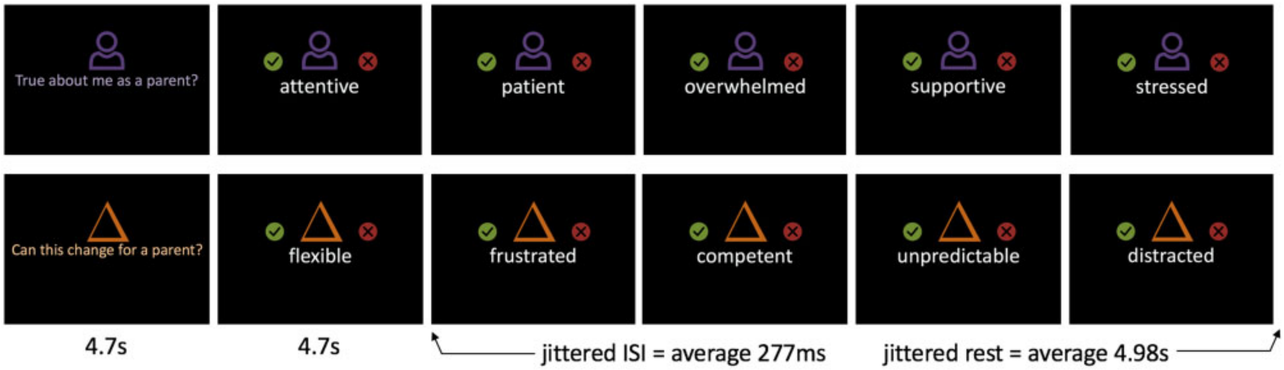

Fig. 1. Example Self (top) and Change (bottom) blocks from the PSET. The task included two runs, with 10 blocks per run. Each block began with a 4.7-s cue instructing participants how to respond to the following trials, followed by five to six trials of 4.7 s each separated by a jittered inter-stimulus-interval (ISI) averaging 277 ms. Blocks were separated by a jittered rest period averaging 4.98 s. A total of 26 trials were conducted in each of 4 conditions: instruction block (self, change) by trial type (developmentally supportive, developmentally unsupportive). Each trial (see Table 1 for stimuli) was seen under each instruction, and traits were mixed within blocks. General code can be found at gitlab.com/dsnlab/svc.

covariates of non-interest. Button press (left/right index finger) and reaction time were also included as covariates of non-interest in the single-subject models. Linear contrasts were created for each condition *vs* implicit resting baseline (i.e., DS Self > Rest, DU Self > Rest, DS Change > Rest, DU Change > Rest) for each participant, which were then imported to group-level analyses. A 2 (instruction block: Self *vs* Change) × 2 (trial type: DS *vs* DU) whole-brain, repeated measures ANOVA was conducted to examine the main effect of instruction block, the main effect of trial type and their interaction [(DS self > DS change) > (DU self > DU change)].

Since the brain regions previously identified in self-evaluation encompass several large CMS, we investigated the neural correlates of parenting self-evaluation using whole-brain analyses. For these analyses, we applied a combined voxel height and cluster-extent correction for multiple comparisons to guard against Type I error derived from AFNI's 3dClustSim software with the –acf (spatial autocorrelation function) option (Cox, 1996). 3dClustSim takes into account the size of the search space and the estimated smoothness of the data (calculated using individual subject residuals derived from the group-level model) to generate probability estimates (using Monte-Carlo simulations) of a random field of noise producing a cluster of voxels of a given size for a set of voxels passing a given voxel-wise P-value threshold. In our data, these simulations determined that a voxel-wise threshold of $P < 0.001$ combined with a spatial extent threshold of 46 voxels corresponded to a family-wise error (FWE) corrected false-positive probability of $P < 0.05$ across the whole brain.

Because several of our hypotheses were specific to mPFC activity associated with self-evaluation, we built an anatomical region of interest (ROI) based on the WFU Pickatlas anterior cingulate volume (Maldjian *et al.*, 2003), which overlaps with clusters found in previous investigations of self-evaluation (see Jankowski *et al.*, 2014). The use of an anatomical ROI is naturally more conservative than a cluster-based ROI, as it is independent from the hypotheses, and is naturally biased toward the null hypothesis by virtue of containing more voxels than would be in a cluster-based ROI (see Poldrack and Mumford, 2009). Parameter estimates of individual subjects' activity in this ROI were extracted using MarsBar (MRC Cognition and Brain Sciences Unit, Cambridge, UK; marsbar.sourceforge.net/) for the

Table 2. Means and standard deviations among major study variables across full sample and by parity

	Parity					
	Full sample ($N = 37$)		Primiparous ($n = 16$)		Multiparous ($n = 21$)	
	M	s.d.	*M*	s.d.	*M*	s.d.
Age	31.16	5.78	30.63	6.93	31.57	4.87
Income	56.61	40.65	56.57[a]	45.38	55.62	34.14
PSET DS %-S	90.65	11.68	95.08	6.00	87.28	13.95
PSET DU %-S	22.38	14.49	15.01	9.59	28.00	15.24
PSET DS %-C	84.94	19.99	81.60	21.70	87.48	18.72
PSET DU %-C	81.39	17.85	81.00	17.81	81.83	18.31
PSET DS RT-S	1.18	0.22	1.08	0.14	1.27	0.24
PSET DU RT-S	1.55	0.30	1.37	0.20	1.68	0.28
PSET DS RT-C	1.46	0.35	1.41	0.30	1.50	0.38
PSET DU RT-C	1.63	0.35	1.55	0.30	1.70	0.39
mPFC ME instruction	0.315	0.263	0.328	0.298	0.306	0.241
mPFC ME trait	−0.084	0.169	−0.103	0.193	−0.071	0.152
mPFC interaction	−0.16	0.391	0.015	0.345	−0.294	0.378
PSI – TOT	74.43	15.74	70.31	12.58	77.57	17.42
– PD	28.08	7.55	25.63	6.60	29.95	7.84
– PCDI	20.09	5.51	19.50	4.49	20.53	6.25
– DC	26.31	5.53	25.19	4.55	27.16	6.14
PSOC	52.43	5.59	54.94	5.88	50.52	4.63
PA	36.14	7.58	38.06	8.27	34.67	6.84
NA	20.05	6.75	18.25	6.22	21.43	6.96
ACES	2.97	2.85	2.81	2.71	3.10	3.02

Note. Age = Maternal age (years); Income = annual household gross income (thousands of dollars/year); PSET = Parenting Self-Evaluation Task; DS = developmentally supportive; DU = developmentally unsupportive; PSET DS %—S = percentage of developmentally supportive parenting qualities endorsed during the PSET in the 'Self' condition; PSET DU %—S = percentage of developmentally unsupportive parenting qualities endorsed during the PSET in the 'Self' condition; PSET DS %—C = percentage of developmentally supportive parenting qualities endorsed during the PSET in the 'Change' condition; PSET DU %—C = percentage of developmentally unsupportive parenting qualities endorsed during the PSET in the 'Change' condition; mPFC ME instruction = neural activity in the mPFC ROI for the main effect of instruction (Self > Change, arbitrary units); mPFC ME trait = neural activity in the mPFC ROI for the main effect of trait (DS > DU; arbitrary units); mPFC interaction = neural activity in the mPFC ROI for the interaction of instruction (self, change)×trait (DS, DU; arbitrary units); PSI–TOT = Parenting Stress Index Total Score (possible range 36–180); PD = Parental Distress Subscale (possible range 12–60); PCDI = Parent-Child Dysfunctional Interaction Subscale (possible range 12–60); DC = Difficult Child Subscale (possible range 12–60); PSOC = Parenting Sense of Competence Total Score (possible range 18–72); PA = Positive Affect Subscale Score from the PANAS (possible range 10–50); NA = Negative Affect Subscale Score from the PANAS (possible range 10–50); ACES = Adverse Childhood Experiences Survey Total Score (possible range 0–10).

[a] One participant chose not to report their income.

three contrasts of interest (the main effect of instruction type, the main effect of trial type, and the interaction).

Analytic approach

Individual averages of BOLD signal in the mPFC ROI for all the three contrasts of interest were exported to SPSS (version 24.0, IBM) for further analyses. We computed descriptive statistics (Table 2) and correlations (Tables 3 and 4) for PSET performance (percent endorsed, reaction time) across all qualities and by quality valence, as well as self-reported childhood adversity, parenting stress, parental self-efficacy and positive and negative state affect. We further interrogated significant effects among these variables using multiple regressions. For all variables, outliers were winsorized at three standard deviations from the mean, and checked for normality. Gross income and number of ACES were transformed (square root) to improve the distribution.

Results

Here, we present main effects and associations with other variables of interest for both the behavioral and neuroimaging analyses. We end with a consideration of the effects of parity on these findings.

Behavioral

Descriptive statistics for study variables are shown in Table 2. Across all participants, an average of 90.65% of DS qualities (range = 54–100%, s.d. = 11.68%) and 22.38% of DU qualities (range 0–67%, s.d. = 14.49%) were endorsed as self-descriptive. Average reaction time for these conditions was 1.18 s (range 0.82–1.82 s, s.d. = .22) and 1.55 s (range 1.08–2.42 s, s.d. = 0.30), respectively. For the change condition, an average of 84.94% (range 25–100%, s.d. = 19.99%) of the DS and 81.39% (range 35–100%, s.d. = 17.85%) of the DU qualities were endorsed as malleable, with average reaction times of 1.46 s (range 0.92–2.37 s, s.d. = 0.35) and 1.63 s (range 1–2.59 s, s.d. = 0.35), respectively.

Total self-reported parenting stress on the PSI averaged 74.43 (range 50–124, s.d. = 15.74), and self-efficacy as reported on the PSOC averaged 52.43 (range 42–67, s.d. = 5.59). State positive affect averaged 36.14 (range 21–50, s.d. = 7.58) and negative affect averaged 20.05 (range 10–39, s.d. = 6.75). Number of self-reported Adverse Childhood Experiences (ACEs) averaged 2.97 (range 0–9, s.d. = 2.85).

Table 3. Intercorrelations for variables of interest in the full sample ($n = 37$)

Variables	1	2	3	4	5	6	7	8	9	10	11	12
1. Age	–											
2. Income^{a}	0.386*	–										
3. PSET DS %	−0.035	0.051	–									
4. PSET DU %	0.007	−0.204	−0.486**	–								
5. mPFC ME instruction	−0.384*	−0.093	0.073	−0.058	–							
6. mPFC ME trait	−0.136	−0.063	−0.014	−0.106	0.177	–						
7. mPFC interaction	0.165	0.053	0.156	−0.008	−0.142	0.045	–					
8. PSI	−0.058	−0.284	−0.447**	0.709***	0.167	−0.043	−0.087	–				
9. PSOC	−0.089	0.090	0.500**	−0.636***	−0.156	−0.085	0.238	−0.741***	–			
10. PA	−0.069	0.142	0.482**	−0.493**	−0.196	−0.029	0.142	−0.600***	0.718***	–		
11. NA	0.049	−0.275	−0.519**	0.661***	−0.075	−0.001	−0.125	0.753***	−0.697***	−0.670***	–	
12. ACES^{a}	−0.309^{+}	−0.282	−0.275	.304^{+}	.258	−0.189	.194	.360*	−0.093	−0.042	.261	–

Note. Age = Maternal age (years); Income = annual household income; PSET = Parenting Self-Evaluation Task; DS = developmentally supportive; DU = developmentally unsupportive; PSET DS % = percentage of developmentally supportive parenting qualities endorsed during the PSET in the 'Self' condition; PSET DU % = percentage of developmentally unsupportive parenting qualities endorsed during the PSET in the 'Self' condition; mPFC ME instruction = neural activity in the mPFC ROI for the main effect of instruction (Self > Change, arbitrary units); mPFC ME trait = neural activity in the mPFC ROI for the main effect of trait (DS > DU; arbitrary units); mPFC interaction = neural activity in the mPFC ROI for the interaction of instruction (self, change) × trait (DS, DU; arbitrary units); PSI = Parenting Stress Index Total Score; PSOC = Parenting Sense of Competence Total Score; PA = Positive Affect Subscale Score from the PANAS; NA = Negative Affect Subscale Score from the PANAS; ACES = Adverse Childhood Experiences Survey Total Score.

$^{+}P = 0.05$–0.07.

$^{*}P < 0.05$.

$^{**}P < 0.01$.

$^{***}P < 0.001$.

^{a}Square root transformation to improve normality.

Table 4. Intercorrelations for variables of interest as a function of parity

Variables	1	2	3	4	5	6	7	8	9	10	11	12
1. Age	–	0.451	−0.306	−0.195	−0.507*	−0.132	0.288	0.073	−0.022	0.016	0.084	−0.276
2. Income^{a}	0.294	–	−0.240	−0.089	−0.141	0.217	0.231	−0.138	0.076	0.080	−0.135	−0.436
3. PSET DS %	0.118	0.228	–	−0.393	−0.018	−0.030	−0.099	−0.570*	0.623*	0.551*	−0.492^{+}	−0.033
4. PSET DU %	0.071	−0.407^{+}	−0.405^{+}	–	0.427	−0.418	0.284	.742**	−0.625*	−0.567*	0.446	0.560*
5. mPFC ME instruction	−0.219	−0.023	0.105	−0.322	–	0.119	−0.099	0.410	−0.287	−0.404	0.112	0.457
6. mPFC ME trait	−0.163	−0.333	0.042	−0.032	0.257	–	0.063	−0.140	0.052	−0.120	−0.066	−0.269
7. mPFC interaction	.158	−0.076	0.062	0.181	−0.238	0.118	–	0.214	0.100	0.020	−0.001	0.119
8. PSI	−0.204	−0.474*	−0.379	0.682**	0.040	−0.022	−0.097	–	−0.853***	−0.825***	0.811***	0.283
9. PSOC	−0.116	0.178	0.431^{+}	−0.569**	−0.070	−0.177	0.093	−0.687**	–	0.836***	−0.732**	−0.156
10. PA	−0.140	0.258	0.478*	−0.420^{+}	0.006	0.122	0.091	−0.447*	0.550*	–	−0.756**	−0.053
11. NA	−0.019	−0.476*	−0.511*	0.733***	−0.217	0.011	−0.056	0.709***	−0.648**	−0.580**	–	0.054
12. ACES^{a}	−0.360	−0.159	−0.377	0.252	0.103	−0.130	0.269	0.412^{+}	−0.055	−0.035	0.393	–

Note. Intercorrelations for primiparous mothers ($n = 16$) are presented above the diagonal and intercorrelations for multiparous mothers ($n = 21$) are presented below the diagonal. Age = Maternal age (years); Income = annual household income; PSET = Parenting Self-Evaluation Task; DS = developmentally supportive; DU = developmentally unsupportive; PSET DS % = percentage of developmentally supportive parenting qualities endorsed during the PSET in the 'Self' condition; PSET DU % = percentage of developmentally unsupportive parenting qualities endorsed during the PSET in the 'Self' condition; mPFC ME instruction = neural activity in the mPFC ROI for the main effect of instruction (Self > Change, arbitrary units); mPFC ME trait = neural activity in the mPFC ROI for the main effect of trait (DS > DU; arbitrary units); mPFC interaction = neural activity in the mPFC ROI for the interaction of instruction (self, change) × trait (DS, DU; arbitrary units); PSI = Parenting Stress Index Total Score; PSOC = Parenting Sense of Competence Total Score; PA = Positive Affect Subscale Score from the PANAS; NA = Negative Affect Subscale Score from the PANAS; ACES = Adverse Childhood Experiences Survey Total Score.

$^{+}P = 0.05$–0.07.

$^{*}P < 0.05$.

$^{**}P < 0.01$.

$^{***}P < 0.001$.

^{a}Square root transformation to improve normality.

Associations. Bivariate correlations for self-evaluations in the full sample are listed in Table 3. As shown, total parenting stress negatively correlated with percent of self-endorsed DS ($r = -0.447$, $P = 0.006$) and positively correlated with DU ($r = 0.709$, $P < 0.001$) qualities. All of the PSI subscales were in the same directions and significant. Parental self-efficacy positively correlated with percent of self-endorsed DS ($r = 0.5$, $P = 0.002$) and negatively correlated with DU ($r = -0.636$, $P < 0.001$) qualities. State positive affect (PA) positively correlated with percent of self-endorsed DS ($r = 0.482$, $P = 0.003$) and negatively correlated with DU ($r = -0.493$, $P = 0.002$) qualities, and state negative affect (NA) negatively correlated with percent of self-endorsed DS ($r = -0.519$, $P = 0.001$) and positively correlated with DU ($r = 0.661$, $P < 0.001$) qualities. Due to the interrelations between many of these items, we interrogated the

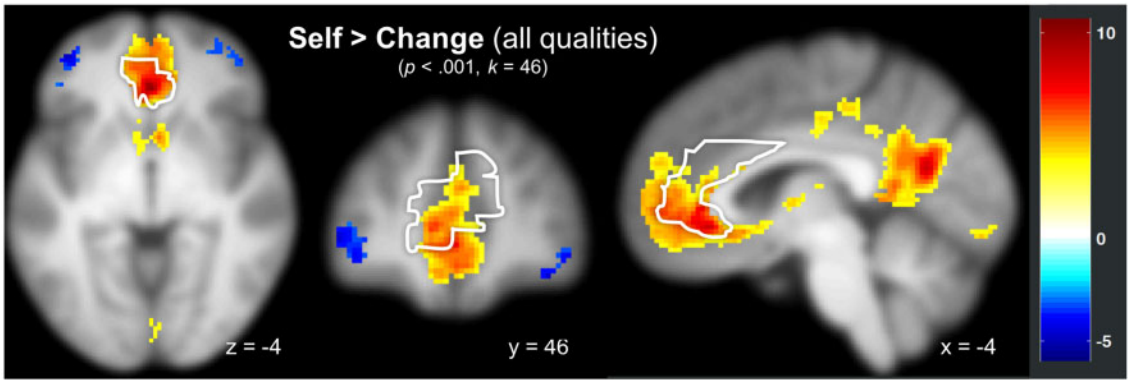

Fig. 2. Main effect of parenting self-evaluation *vs* malleability evaluation. Across all 37 subjects, the contrast of Self > Change was calculated across both types of parenting qualities (voxel-wise threshold of $P < 0.001$ combined with a spatial threshold $k = 46$ corresponds to an FWE-corrected false-probability of $P < 0.05$ across the whole brain). Illustrated here are the network of CMS involved in self-evaluation. The mPFC ROI is outlined in white.

unique effects of total PSI, PSOC, PA, and NA on percent of self-endorsed DS and DU qualities using multiple regression. Considered together, none of these individually significantly predicted percent of self-endorsed DS qualities ($Ps > 0.26$), but total PSI remained a trend-level predictor of percent of self-endorsed DU qualities ($t = 1.98$, $P = 0.056$).

Age of mother and income did not significantly relate to task performance. Considered alone, mothers' number of ACEs showed a trend-level positive association with the percent of DU qualities endorsed ($r = 0.304$, $P = 0.067$), but this did not remain significant in a multiple regression model with other variables significantly correlated with task performance (PSI, PSOC, PA, NA).

With regard to reaction time, self-reported parental self-efficacy significantly negatively correlated with DS self RT ($r = -0.393$, $P = 0.016$) and negatively correlated with DU self RT at the trend level ($r = -0.309$, $P = 0.063$). Similarly, PA significantly negatively correlated with DS self RT ($r = -0.418$, $P = 0.01$) and negatively correlated with DU self RT at the trend level ($r = -0.302$, $P = 0.069$). Reaction time for the change conditions did not significantly correlate with any of the self-reported measures. Neither of these associations remained significant when considered together in a multiple regression model predicting RT.

Neuroimaging

As shown in Figure 2, the main effect of instruction (i.e. Self *vs* Change) across both types of stimuli (thresholded at $P < 0.001$ $k = 46$) produced a large cluster of voxels encompassing most CMS, including the mPFC and orbitofrontal cortex, and anterior and posterior cingulate cortex. Other clusters with significant main effects for this contrast included the thalamus, left angular gyrus, cerebellum, and right superior frontal gyrus (Table 5). For the main effect of trait (i.e. DS *vs* DU) across both instructions (thresholded at $P < 0.001$ $k = 46$), clusters of voxels emerged in the left anterior premotor cortex, right primary visual cortex, and right intraparietal sulcus (Table 5). For the interaction of instruction and trait at the same threshold, no significant clusters survived.

Associations. Individual participants' activity within the anatomical mPFC ROI was calculated for the main effects of instruction (Self > Change) and trait (DS > DU), and their interaction. Activity in the mPFC ROI for the main effect of instruction significantly negatively correlated with mother's age ($r = -0.384$, $P = 0.019$), as shown in Table 3. In other words, younger mothers showed a greater difference in mPFC activity when performing self *vs* malleability evaluations compared to older mothers. This remained significant in a multiple regression model controlling for individual differences in PSI, PSOC, PA and NA ($t = -2.49$, $P = 0.018$). None of the other individual difference variables included in our hypotheses (income, ACES, PSI, PSOC, PA, NA) related to brain activity in the mPFC for our three contrasts of interest.

Parity

To explore differences in results with regard to parity, we looked at behavior and brain differences in primiparous *vs* multiparous mothers, as well as correlations within each group (Table 4).

Compared to multiparous mothers ($n = 21$), primiparous mothers ($n = 16$) showed a higher percentage of self-endorsed DS qualities ($F_{(1,\ 35)} = 4.428$, $P = 0.043$), a lower percentage of self-endorsed DU qualities ($F_{(1,\ 35)} = 8.9$, $P = 0.005$), and overall faster reaction times for both DS ($F_{(1,\ 35)} = 7.596$, $P = 0.009$) and DU ($F_{(1,\ 35)} = 14.79$, $P < 0.001$) qualities. Furthermore, there was a significant difference between multiparous and primiparous mothers in mPFC ROI activity for the interaction of instruction and trait ($F_{(1,\ 35)} = 6.586$, $P = 0.015$), such that primiparous mothers showed a greater difference in mPFC activity when making self-evaluations of DS traits than for DU traits compared to multiparous mothers. This did not survive multiple-comparison correction when modeled in a 2×2×2 (parity×instruction×trait) RMANOVA across the whole brain. Lastly, primiparous mothers reported a higher sense of parental self-efficacy via the PSOC compared to multiparous mothers ($F_{(1,\ 35)} = 6.53$, $P = 0.015$). There was no difference between the groups of mothers with regard to age, income, ACES, parenting stress, or state affect ($Ps > 0.15$).

After investigating self-report and behavioral differences in parental self-efficacy by parity, we examined parity group effects on the associations among brain activity, task performance, and self-report measures. In terms of brain–behavior associations by group, there was a significant effect of group on the association between Self > Change activity in the mPFC ROI and percent of self-endorsed DU qualities ($F_{(1,\ 33)} = 5.54$,

Table 5. Peak voxel and maximum Z-values for PSET main effect results

Region	Cluster size	F	Z-score	Side	MNI coordinates		
					x	y	z
Main effect of instruction (Self > Change)							
Mid Orbital Gyrus	2620	111.44	>10	Midline	0	34	−6
		52.91	6.60	Left	−4	34	2
		50.86	6.48	Midline	0	50	0
L Parahippocampal gyrus	1655	83.73	>10	Left	−10	−62	18
		43.78	6.06	Right	4	−62	26
		42.73	5.99	Right	6	−52	26
L Angular gyrus	430	34.36	5.42	Left	−46	−56	50
		22.92	4.46	Left	−42	−54	42
		21.16	4.28	Left	−34	−68	52
R Superior frontal gyrus	89	29.05	5.00	Right	42	14	46
Anterior cingulate	98	28.49	4.96	Midline	0	−16	40
Thalamus	86	28.07	4.92	Midline	0	−6	6
		18.74	4.03	Left	−2	−18	10
L Orbital frontal cortex	73	24.86	4.64	Left	−44	48	2
Posterior cingulate	50	20.05	4.17	Left	−8	−28	50
Cerebellum	74	19.33	4.09	Right	34	−46	−28
		15.39	3.64	Right	22	−50	−26
R Orbital frontal cortex	49	18.40	3.99	Right	34	54	0
R Orbital frontal cortex	107	17.34	3.87	Right	46	−60	48
		14.93	3.59	Right	46	−52	40
Main effect of trait (DS > DU)							
Left anterior premotor cortex	242		4.56	Left	−42	0	34
			4.23	Left	−46	6	26
			4.13	Left	−52	12	28
Right primary visual cortex	123		4.17	Right	14	−76	10
			4.12	Right	10	−90	4
Intraparietal sulcus	80		4.17	Left	−28	−56	48
			3.79	Left	−28	−60	58
Interaction of instruction and trait							
No significant clusters							

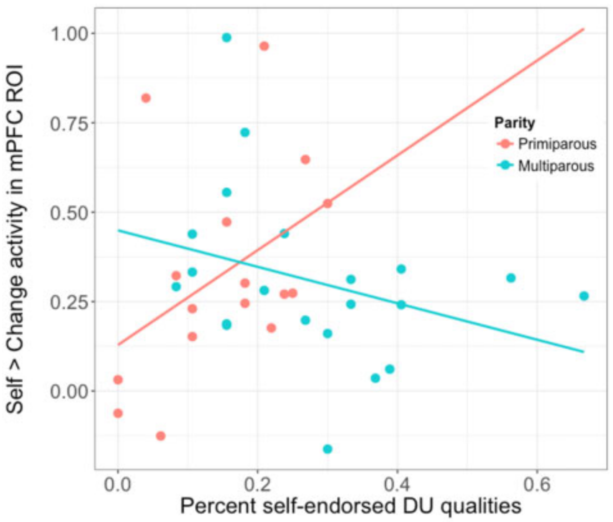

Fig. 3. Illustration of the significant effect of parity group on the relationship between percent of self-endorsed DU qualities and Self > Change activity in the mPFC ROI ($F_{(1,\,33)} = 5.54$, $P = 0.024$).

$P = 0.024$; Figure 3) such that primiparous mothers showed a non-significant positive association between percent DU qualities endorsed and mPFC activity ($r = 0.427$, $P = 0.099$) while multiparous mothers had a non-significant negative association ($r = -0.322$, $P = 0.155$). There were no significant differences in the associations between self-report measures and brain activity in the mPFC ROI by parity group.

Discussion

The purpose of this study was to examine the behavioral and neural correlates of parenting self-evaluation. Given the paucity of experimental paradigms for evaluating parenting self-evaluation *in vivo*, we created and employed a new task that represents an integration of behavioral research on parental self-experience and neuroimaging work documenting the neural underpinning of general self-evaluation. We focused on mothers of young children because early childhood is characterized by dramatic developmental change and represents a potential inflection point where parenting self-evaluations likely exert maximal influence on downstream outcomes.

Behavioral correlates of parenting self-evaluation

While completing the PSET in the MRI scanner, mothers endorsed significantly more positive (developmentally supportive) qualities than negative (developmentally unsupportive) qualities in the self-evaluation trials than during the malleability trials, indicating they believed negative qualities could change more than they self-identified with those same qualities. These initial results suggest the presence of a positivity bias in self-evaluation of parenting qualities similar to that typically seen in other forms of self-evaluation (Cunningham and Turk, 2017). The absence of differences between positive and negative qualities in the change condition suggests that malleability evaluations represent an adequate high-level control condition for parenting self-evaluations. Mothers were quicker to endorse positive qualities than negative qualities for both self-evaluation and change; and quicker to make self-evaluations than malleability evaluations—possibly indicating mothers gave comparatively greater consideration to the latter.

As expected, positive parenting self-evaluations were associated with greater self-reported parental self-efficacy, lower levels of caregiving-related stress and higher levels of positive state affect. Conversely, negative parenting self-evaluations were associated with poorer parental self-efficacy, higher levels of caregiving-related stress, more adverse childhood experiences and higher levels of negative state affect. These bivariate associations provide preliminary evidence that the PSET may serve as a useful index of parenting self-evaluation with convergent validity with respect to self-report measures that index overlapping but conceptually distinct constructs. Additionally, negative parenting self-evaluations may represent a risk factor for developmentally unsupportive caregiving, as previous work indicates non-abusive mothers report higher parental self-efficacy than abusive mothers (e.g. Mash *et al.*, 1983). This risk factor may be particularly salient for parents who have experienced maltreatment in childhood, especially in the context of challenging child behavior (e.g. Michl *et al.*, 2015; Kunseler *et al.*, 2016). Conversely, positive parenting self-evaluations may represent an important intervention target and protective factor that buffers parents from the cumulative impact of environmental adversity (Peterson *et al.*, 2003; Fisher *et al.*, 2016) and difficulties that emerge during the transition to parenthood (Mihelic *et al.*, 2016).

In this study, parenting stress independently predicted negative parenting self-evaluation in regression analyses at the trend level. This finding suggests the link between caregiving stress and global parenting self-evaluation may be more salient than the rest of the bivariate associations. It also highlights the importance of differentiating between general state affect and more specific self-referential trait endorsement in future work with greater statistical power.

Neural correlates of parenting self-evaluation

As in previous neuroimaging work examining other types of self-evaluation in other populations (Denny *et al.*, 2012; Wagner *et al.*, 2012) and consistent with our predictions, parenting self-evaluations in this sample elicited greater activity in most CMS of interest compared to control evaluations. The consistency of our results with previous non-parenting-related self-evaluation, coupled with the behavioral results reported above, provides initial proof-of-concept evidence of the PSET as an integrative task to index parenting self-evaluations and associated behavior and neural processes.

It is noteworthy that our self-report measures of parenting stress and parental self-efficacy did not significantly relate to mPFC activity, particularly given the behavioral associations between these measures and positive and negative self-evaluations. This may indicate that mPFC activity specific to parenting self-evaluations compared to malleability evaluations index a different aspect of parental experience than those assessed by self-report questionnaires.

A secondary goal of this study was to explore the relationships between PSET performance, brain activation and self-report measures as a function of parity. Results of our analyses indicated that primiparous mothers reported higher endorsement of positive parenting self-evaluations, lower endorsement of negative self-evaluations, faster reaction times and higher parental self-efficacy compared to multiparous mothers. In addition, higher self-reported self-efficacy related to less mPFC activity during self-evaluations of DU qualities compared to malleability evaluations in first-time mothers, but greater mPFC activity in mothers of more than one child. Although these results are exploratory and preliminary in nature, the greater mPFC activity seen in multiparous mothers may index increased self-knowledge as a parent, greater self-differentiation and/or different neural circuitry than in mothers of only one child.

Study limitations and future directions

Several limitations are important to acknowledge when considering these results. In designing the PSET, we attempted to balance the need for a high-level evaluative control condition with the need for a contrast that would be simple enough to allow for clear interpretation. Using Jankowski *et al.* (2014) paradigm as a model, we selected trait malleability evaluations as our control for this study, reasoning that the evaluation of malleability of qualities requires comparable cognitive engagement to self-evaluations without necessitating self-evaluation *per se*. Despite the aforementioned strengths of this contrast, it is possible that malleability evaluations may activate some degree of self-referential processing. Moreover, the forced choice nature of the task's binary response options may have accentuated overlap in the latter and reduced the ecological validity of the task. Hence, the neuroimaging contrasts presented here must be interpreted with caution; future work, with additional contrasts and continuous response options, is needed to further delineate the neural circuitry involved in different types of self-evaluation independent of and specifically relating to change beliefs. For example, inclusion of additional contrasts that combine self-evaluation with a change evaluation (e.g. to what extent can this quality change *for you* as a parent?) might be of particular utility for intervention work that seeks to characterize parents' openness to change.

Due to the scope of this study, we excluded caregivers who were not biological mothers (e.g. fathers, foster parents, child care providers) and caregivers of older children from participation. Within these constraints, the sample was representative of our region (socioeconomically but not racially diverse). One consequence of this is that the sample did not contain a sufficient number of ethnic minority participants to make inferences about non-white parents. All of these populations warrant investigation with future experimental studies of parenting self-evaluation. Furthermore, due to the cross-sectional nature of this study, it remains unknown whether the parenting self-evaluations elicited by the PSET are stable across time, or conversely, sensitive to change with intervention. As such, future work should examine the PSET's sensitivity to change and ability to predict observed and self-reported parenting behavior. Despite these limitations, this study presents a novel experimental task that can be used to investigate parenting-specific self-evaluation behavior and brain activity. The exploratory findings presented here indicate that individual differences in parenting self-evaluation may vary meaningfully by parity and warrant future attention.

Acknowledgements

The authors are grateful to Melanie Berry and Kyndal Howell for their clinical expertise and collaboration with stimuli selection; to Danielle Cosme and John Flournoy for fMRI task support; and to the University of Oregon LCNI. We are especially grateful to the families who participated in the study and shared their experiences with us.

Funding

This study was supported by funding from the Hemera Foundation and University of Oregon to PF.

Conflict of interest. None declared.

References

Abidin, R.R. (1995). *Parenting Stress Index, Third Edition: Professional Manual*. Odessa, FL: Psychological Assessment Resources, Inc.

Ardelt, M., Eccles, J.S. (2001). Effects of mothers' parental efficacy beliefs and promotive parenting strategies on inner-city youth. *Journal of Family Issues*, **22**(8), 944–72.

Bogenschneider, K., Small, S.A., Tsay, J.C. (1997). Child, parent, and contextual influences on perceived parenting competence among parents of adolescents. *Journal of Marriage and the Family*, **59**(2), 345–62.

Bohlin, G., Hagekull, B. (1987). "Good mothering": maternal attitudes and mother-infant interaction. *Infant Mental Health Journal*, **8**(4), 352–63.

Callaghan, B.L., Tottenham, N. (2016). The stress acceleration hypothesis: effects of early-life adversity on emotion circuits and behavior. *Current Opinions in Behavioral Sciences*, **7**, 76–81.

Coleman, P.K., Karraker, K.H. (1997). Self-efficacy and parenting quality: Findings and future applications. *Developmental Review*, **18**(1), 47–85.

Coleman, P.K., Karraker, K.H. (2000). Parenting self-efficacy among mothers of school-age children: conceptualization, measurement, and correlates. *Family Relations*, **49**(1), 13–24.

Cox, R.W. (1996). AFNI: software for analysis and visualization of functional magnetic resonance neuroimages. *Computers and Biomedical Research*, **29**(3), 162–73.

Crawford, J.R., Henry, J.D. (2004). The Positive and Negative Affect Schedule (PANAS): construct validity, measurement properties and normative data in a large non-clinical sample. *British Journal of Clinical Psychology*, **43**(3), 245–65.

Cunningham, S.J., Turk, D.J. (2017). Editorial: a review of self-processing biases in cognition. *The Quarterly Journal of Experimental Psychology*, **70**(6), 987–95.

Denny, B.T., Kober, H., Wager, T.D., Ochsner, K.N. (2012). A meta-analysis of functional neuroimaging studies of self-and other judgments reveals a spatial gradient for mentalizing in medial prefrontal cortex. *Journal of Cognitive Neuroscience*, **24**(8), 1742–52.

Felitti, V.J., Anda, R.F., Nordenberg, D., *et al.* (1998). Relationship of childhood abuse and household dysfunction to many of the leading causes of death in adults: the Adverse Childhood Experiences (ACE) study. *American Journal of Preventive Medicine*, **14**(4), 245–58.

Fisher, P.A., Frenkel, T.I., Noll, L.K., Berry, M., Yockelson, M. (2016). Promoting healthy child development via a two-generation translational neuroscience framework: the Filming Interactions to Nurture Development video coaching program. *Child Development Perspectives*, **10**(4), 251–6.

Jankowski, K.F., Moore, W.E., Merchant, J.S., Kahn, L.E., Pfeifer, J.H. (2014). But do you think I'm cool?: developmental differences in striatal recruitment during direct and reflected social self-evaluations. *Developmental Cognitive Neuroscience*, **8**, 40–54.

Johnston, C., Mash, E.J. (1989). A measure of parenting satisfaction and efficacy. *Journal of Clinical Child Psychology*, **18**(2), 167–75.

Jones, T.L., Prinz, R.J. (2005). Potential roles of parental self-efficacy in parent and child adjustment: a review. *Clinical Psychology Review*, **25**(3), 341–63.

Junttila, N., Vauras, M., Laakkonen, E. (2007). The role of parenting self-efficacy in children's social and academic behavior. *European Journal of Psychology of Education*, **22**(1), 41–61.

Kim, P., Mayes, L., Feldman, R., Leckman, J.F., Swain, J.E. (2013). Early postpartum parental preoccupation and positive parenting thoughts: relationship with parent–infant interaction. *Infant Mental Health Journal*, **34**(2), 104–16.

Kohlhoff, J., Barnett, B. (2013). Parenting self-efficacy: links with maternal depression, infant behaviour and adult attachment. *Early Human Development*, **89**(4), 249–56.

Kunseler, F.C., Oosterman, M., de Moor, M.H., Verhage, M.L., Schuengel, C. (2016). Weakened resilience in parenting self-efficacy in pregnant women who were abused in childhood: An experimental test. *PloS One*, **11**(2), e0141801.

Lonigan, C.J., Phillips, B.M., Hooe, E.S. (2003). Relations of positive and negative affectivity to anxiety and depression in children: evidence from a latent variable longitudinal study. *Journal of Consulting and Clinical Psychology*, **71**(3), 465.

Maldjian, J.A., Laurienti, P.J., Kraft, R.A. & Burdette, J.H. (2003). An automated method for neuroanatomic and cytoarchitectonic atlas-based interrogation of fMRI data sets. *NeuroImage*, **19**(3), 1233–9.

Maupin, A.N., Rutherford, H.J.V., Landi, N., Potenza, M.N., Mayes, L.C. (2018). Investigating the association between parity and maternal neural response to infant cues. *Social Neuroscience*, **8**, 1–12.

Mash, E.J., Johnston, C., Kovitz, K. (1983). A comparison of the mother-child interactions of physically abused and non-abused children during play and task situations. *Journal of Clinical Child & Adolescent Psychology*, **12**(3), 337–46.

Michl, L.C., Handley, E.D., Rogosch, F., Cicchetti, D., Toth, S.L. (2015). Self-criticism as a mechanism linking childhood maltreatment and maternal efficacy beliefs in low-income mothers with and without depression. *Child Maltreatment*, **20**(4), 291–300.

Mihelic, M., Filus, A., Morawaska, A. (2016). Correlates of prenatal parenting expectations in new mothers: is better self-efficacy a potential target for preventing postnatal adjustment difficulties? *Prevention Science*, **17**(8), 949–59.

Mitchell, J.P., Macrae, C.N., Banaji, M.R. (2006). Dissociable medial prefrontal contributions to judgments of similar and dissimilar others. *Neuron*, **50**(4), 655–63.

Nicolle, A., Klein-Flügge, M.C., Hunt, L.T., Vlaev, I., Dolan, R.J., Behrens, T.E. (2012). An agent independent axis for executed and modeled choice in medial prefrontal cortex. *Neuron*, **75**(6), 1114–21.

Northoff, G., Heinzel, A., De Greck, M., Bermpohl, F., Dobrowolny, H., Panksepp, J. (2006). Self-referential processing in our brain—a meta-analysis of imaging studies on the self. *Neuroimage*, **31**(1), 440–57.

Pereira, M., Ferreira, A. (2016). Neuroanatomical and neurochemical basis of parenting: dynamic coordination of motivational, affective and cognitive processes. *Hormones and Behavior*, **77**, 72–85.

Peterson, L., Tremblay, G., Ewigman, B., Saldana, L. (2003). Multilevel selected primary prevention of child maltreatment. *Journal of Consulting and Clinical Psychology*, **71**(3), 601–11.

Pfeifer, J.H., Lieberman, M.D., Dapretto, M. (2007). "I know you are but what am I?!": neural bases of self-and social knowledge retrieval in children and adults. *Journal of Cognitive Neuroscience*, **19**(8), 1323–37.

Pfeifer, J.H., Masten, C.L., Borofsky, L.A., Dapretto, M., Fuligni, A.J., Lieberman, M.D. (2009). Neural correlates of direct and reflected self-appraisals in adolescents and adults: when social perspective-taking informs self-perception. *Child Development*, **80**(4), 1016–38.

Pfeifer, J.H., Kahn, L.E., Merchant, J.S., *et al.* (2013). Longitudinal change in the neural bases of adolescent social self-evaluations: effects of age and pubertal development. *Journal of Neuroscience*, **33**(17), 7415–9.

Poldrack, R.A., Mumford, J.A. (2009). Independence in ROI analysis: where is the voodoo?. *Social Cognitive and Affective Neuroscience*, **4**(2), 208–13.

Qin, P., Northoff, G. (2011). How is our self related to midline regions and the default-mode network? *Neuroimage*, **57**(3), 1221–33.

Teti, D.M., Gelfand, D.M. (1991). Behavioral competence among mothers of infants in the first year: the mediational role of maternal self-efficacy. *Child Development*, **62**(5), 918–29.

Verhage, M.L., Oosterman, M., Schuengel, C. (2013). Parenting self-efficacy predicts perceptions of infant negative temperament characteristics, not vice versa. *Journal of Family Psychology*, **27**(5), 844.

Wagner, D.D., Haxby, J.V., Heatherton, T.F. (2012). The representation of self and person knowledge in the medial prefrontal cortex. *Wiley Interdisciplinary Reviews: Cognitive Science*, **3**(4), 451–70.

Watson, D., Clark, L.A., Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: the PANAS scales. *Journal of Personality and Social Psychology*, **54**(6), 1063.