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Research paper

Behavioral observations of positive and negative valence systems in early childhood predict physiological measures of emotional processing three years later

Ellen M. Kessel[a,1], Autumn Kujawa[b,1,*], Brandon Goldstein[a], Greg Hajcak[a], Sara J. Bufferd[c], Margaret Dyson[d], Daniel N. Klein[a]

[a] Department of Psychology, Stony Brook University, United States
[b] Department of Psychiatry, Penn State College of Medicine, United States
[c] Department of Psychology, California State University San Marcos, United States
[d] Department of Psychiatry, University of California, San Diego, United States

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ABSTRACT

Background: The Research Domain Criteria (RDoC) constructs of Positive Valence Systems (PVS) and Negative Valence Systems (NVS) are presumed to manifest behaviorally through early-emerging temperamental negative affectivity (NA) and positive affectivity (PA). The late positive potential (LPP) is a physiological measure of attention towards both negative and positive emotional stimuli; however, its associations with behavioral aspects of PVS and NVS have yet to be examined.
Methods: In a community sample of children (N = 340), we examined longitudinal relationships between observational measures of temperamental PA and NA assessed at age 6, and the LPP to both pleasant and unpleasant images assessed at age 9.
Results: Lower PA at age 6 predicted reduced LPP amplitudes to pleasant, but not unpleasant, images. NA as a composite measure was not related to the LPP, but specific associations were observed with facets of NA: greater fear predicted an enhanced LPP to unpleasant images, whereas greater sadness predicted a reduced LPP to unpleasant images.
Limitations: We were unable to evaluate concurrent associations between behavioral observations of temperament and the LPP, and effect sizes were modest.
Conclusions: Results support correspondence between behavioral and physiological measures of emotional processing across development, and provide evidence of discriminant validity in that PA was specifically related to the LPP to pleasant images, while facets of NA were specifically linked to the LPP to unpleasant images. Distinct associations of temperamental sadness and fear with the LPP highlight the importance of further evaluating subconstructs of NVS.

1. Introduction

The National Institute of Mental Health's Research Domain Criteria (RDoC) initiative aims to elucidate the mechanisms underlying psychopathology by focusing on core biobehavioral constructs that are dimensionally distributed and cut across traditional diagnostic boundaries. A key goal of RDoC is to elaborate the biological mechanisms associated with psychological processes by establishing linkages across multiple units of analysis—including brain circuits, physiology, self-report and behavior—in order to develop nomological nets around these constructs (Kozak and Cuthbert, 2016; Sanislow et al., 2010). An important aspect of establishing the validity of these constructs is to determine whether measures of each construct at different units of analysis are related to one another (i.e., convergent validity), and to establish discriminant validity in that units of analysis of one construct should not be related to other constructs (Kozak and Cuthbert, 2016; Shankman and Gorka, 2016).

The RDoC constructs of Negative Valence Systems (NVS) and Positive Valence Systems (PVS) stem from research on temperament, biobehavioral motivational systems, and psychopathology (Clark, 2005; Davidson, 1992; Gray, 1994; Kozak and Cuthbert, 2016; Lang et al., 1990). NVS include responses to acute and sustained threat,

* Correspondence to: Department of Psychiatry, Penn State College of Medicine, 22 Northeast Drive, Hershey, PA 17033, United States.
E-mail address: akujawa@hmc.psu.edu (A. Kujawa).
[1] First and second author contributed equally to this manuscript.

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potential harm, frustrative nonreward, and loss, while PVS include approach motivation, initial and sustained responsiveness to reward, reward learning, and habit (Kozak and Cuthbert, 2016; National Institute of Mental Health, 2016). NVS and PVS have been linked to internalizing and externalizing psychopathology at the behavioral, physiological, and circuit levels of analysis. For example, some forms of depression are characterized by lower activation in PVS, including reduced expression of positive emotions (De Pauw and Mervielde, 2010; Klein et al., 2012; Kotov et al., 2010) and blunted reward responsiveness (Forbes and Dahl, 2012; Pizzagalli, 2014; Proudfit et al., 2015). On the other hand, externalizing symptoms, particularly hyperactivity and impulsivity, have been linked to increased activation in PVS (Tackett et al., 2012). NVS are consistently related to all forms of psychopathology (Tackett et al., 2013), but have the strongest association with symptoms of depression and anxiety, which are characterized by greater behavioral expression of negative emotions (De Pauw and Mervielde, 2010; Klein et al., 2012; Kotov et al., 2010), as well as altered neural processing of negative or threatening stimuli (Goodkind et al., 2013; Proudfit et al., 2015; Swartz and Monk, 2014). Importantly, there is growing evidence that abnormalities in these systems are observable among children at risk for internalizing disorders, prior to the onset of symptoms (Klein et al., 2012; Pine, 2007; Proudfit et al., 2015); thus RDoC constructs of PVS and NVS may inform our understanding of developmental pathways to psychopathology (Casey et al., 2014; Franklin et al., 2015; Shankman and Gorka, 2016).

At the behavioral level, temperament style is particularly relevant to PVS and NVS (Kozak and Cuthbert, 2016; National Institute of Mental Health, 2016). Temperament refers to individual differences in emotional reactivity, expression, and regulation that develop early in life, with strong genetic and biological bases, and substantial stability over time (Caspi and Shiner, 2006; Clark and Watson, 1999; Rothbart and Bates, 2006). Positive affectivity (PA), which includes expression of joy and exuberance, and negative affectivity (NA), which includes sadness, anger, and fear, are two aspects of temperament that are closely related to RDoC's PVS and NVS, respectively (Kozak and Cuthbert, 2016; National Institute of Mental Health, 2016), and can be measured at both the self-report and behavioral levels of analysis. As individual differences in NA and PA emerge early in life, they may be particularly useful units of analysis for informing the developmental origins of these RDoC constructs.

At the physiological level, the late positive potential (LPP) is an event-related potential (ERP) component that provides a neural measure of sustained attention towards motivationally salient stimuli, including positive and negative emotional faces, words, and scenes, and can be reliably and easily assessed in children and across development (Cuthbert et al., 2000; Hajcak et al., 2011; Kujawa et al., 2013; Schupp et al., 2006). A range of psychopathologies, including both anxiety and depression, have been characterized by an altered LPP to emotional stimuli (e.g., Foti et al., 2010; Kujawa et al., 2015a; MacNamara et al., 2015; Moser et al., 2008), suggesting it may be useful as a transdiagnostic measure of emotional processing. Through source localization and combining functional magnetic resonance imaging (fMRI) with ERP measures, the LPP has been linked to an extensive brain network, including visual cortex and coupling between occipitoparietal and frontal cortex, as well as activation in subcortical regions (Keil et al., 2002; Liu et al., 2012; Moratti et al., 2011; Sabatinelli et al., 2013, 2007).[2] Though the LPP is modulated by arousal (Olofsson et al., 2008) and similar brain regions appear to contribute to the LPP to both positive and negative stimuli, there is also evidence of somewhat distinct neural contributions depending on valence. For example, while activation in nucleus accumbens and medial prefrontal cortex (PFC) correlated with the LPP to pleasant images, activation in ventrolateral PFC and insula correlated with the LPP to unpleasant images (Liu et al., 2012).

Despite the need for a neurodevelopmental perspective to inform RDoC and evidence that individual differences in trait emotionality develop early in life, very little work has examined the relationships between observed behavior and physiology or circuits involved in PVS and NVS, an essential step for informing how individual differences in neural measures may relate to real-world functioning and behavior. Most of the developmental literature has focused on behavioral inhibition (BI), a temperament trait specifically characterized by fearfulness and withdrawal in novel situations (Kagan et al., 1987). For example, high BI in early childhood predicts greater right frontal electroencephalogram (EEG) asymmetry, enhanced ERP measures of error monitoring, and greater striatal activation during reward anticipation later in life (Bar-Haim et al., 2009; Fox et al., 2005; Guyer et al., 2006; McDermott et al., 2009).

In addition, we previously reported that lower PA in early childhood predicted a reduced reward positivity, an ERP component sensitive to receipt of reward, in middle to late childhood (Kujawa et al., 2015b). This finding provided evidence of correspondence between behavioral and physiological aspects of PVS, and also indicated discriminant validity in that NA was not related to physiological measures of reward processing. As the LPP is modulated by arousal during the processing of both positive and negative emotional information (Cuthbert et al., 2000; Hajcak et al., 2011; Olofsson et al., 2008), it may provide insight into distinct patterns of associations between behavioral expressions of PA and NA and physiological measures of emotional processing.

Consistent with this, two cross-sectional studies in youth have linked individual differences in the LPP to behavioral and questionnaire measures of NVS and PVS. In a sample of young children, observed fearful behavior was associated with an enhanced LPP specifically to unpleasant images in childhood (Solomon et al., 2012). More recently, in a large sample of adolescent girls, questionnaire measures of PA correlated with an enhanced LPP to both pleasant and unpleasant images, raising the possibility that greater PA corresponds to increased arousal during broad emotion processing (Speed et al., 2015). Compared to questionnaire measures, laboratory assessment of temperament provides an objective, micro-level examination of affective and behavioral responses (Goldsmith and Gagne, 2012); however, no previous studies have examined behavioral indicators of both NVS and PVS in relation to the LPP. In addition, as temperament develops early in life, examining the relationship between early-emerging temperament and the LPP later in life provides a particularly stringent test of the relationship between behavioral and physiological units of analysis.

The current study took a developmental approach to testing the convergent and discriminant validity of behavioral and physiological measures of emotional reactivity and processing. Specifically, at age 6, children completed an observational laboratory assessment of PA and NA. Approximately three years later, children completed an EEG assessment in which the LPP was recorded in response to both unpleasant and pleasant images. We tested whether behavioral measures of NVS and PVS predicted physiological measures of emotional processing three years later by examining observational measures of PA and NA at age 6 as predictors of the LPP to emotional images at age 9. As facets of NA (i.e., fear, sadness, anger) may relate to specific components of NVS (e.g., threat, loss, frustrative non-reward) and show distinct associations with physiological measures, we also examined fear, anger and sadness as predictors of the LPP at age 9. Consistent with prior work (Solomon et al., 2012; Speed et al., 2015), we hypothesized that greater PA would predict an enhanced LPP to pleasant images or to emotional images more broadly and greater fearfulness would predict an enhanced LPP to unpleasant images. Given evidence that fearfulness and anger are distinct with

[2] We refer to the LPP as a physiological measure, consistent with the placement of other ERP measures in the current RDoC Matrix (National Institute of Mental Health, 2016); however, it could also fit within the circuits level of analysis, as several studies have evaluated its relationship with specific brain regions.

regard to the direction of motivational intensity (Carver and Harmon-Jones, 2009), and sadness is characterized by physiological responses consistent with withdrawal and conservation of resources (Kreibig et al., 2007), we hypothesized that anger and sadness may demonstrate distinct associations with the LPP compared to fearfulness.

2. Methods

2.1. Participants

The sample was part of a larger community sample of children, initially recruited when the children were 3 or 6 years old and re-assessed at age 9 (Kujawa et al., 2014; Olino et al., 2010). When the children were 6 years old, 491 children completed a laboratory assessment of temperament. As close as possible to the child's 9th birthday, 451 children returned to the laboratory, and 422 completed the EEG emotional interrupt task (29 families chose not to complete the task). An additional 82 participants were excluded for excessive noise in the EEG data, few artifact-free trials after data processing, or poor behavioral performance. The final sample consisted of 340 children (45.9% female): 88.8% White, 8.5% Black/African American, 2.4% Asian and .3% Native American. With regard to ethnicity, 10.9% were of Hispanic/Latino origin. In 67.9% of the sample, at least one parent had a college degree. At the time of the temperament assessment, the mean child age was 6.64 (SD =.50), and at the follow up EEG assessment, the mean age was 9.14 (SD =.35).

3. Measures

3.1. Laboratory Temperament Assessment Battery (Lab-TAB)

At the age 6 lab visit, participants completed the Lab-TAB (Goldsmith et al., 1995), which included a series of 9 standardized episodes designed to measure temperament by eliciting a variety of behavioral and emotional responses (see Dyson et al., 2015 for more details). PA and NA assessed in the laboratory has shown moderate to high stability across early childhood and significant correlations with ratings of PA and NA from home observations (Durbin et al., 2007). Between each episode children were given a brief break to induce a neutral affective state.

3.1.1. Card sorting

Children completed a pattern recognition task while trials were rewarded or punished.

3.1.2. Mixed-up puzzles

Children were told to complete a puzzle, but were not given adequate pieces to do so.

3.1.3. Story time

Children told a story using a picture book and were given praise for doing so.

3.1.4. Disappointing toy

Children were shown several toys and asked to select their favorite, but were then told it was unavailable at the moment and given a less desirable toy (later, children were given a chance to play with their first choice toy).

3.1.5. Picture tearing

Children were told that a photo was important to a researcher who then left the room. Another experimenter entered the room and encouraged the child to tear the picture.

3.1.6. Dress up

Children were asked to try on various outfits.

3.1.7. Kids' club

Children were told that they were being interviewed for admission to a club that is exclusive for kids. After the interview, children were told that they needed to provide additional information to get into the club. By the end of the task all children were told that they had actually been accepted to the club after the first interview.

3.1.8. Whoopee cushion

Children were encouraged to trick their mothers with a remote controlled whoopee cushion.

3.1.9. Object fear

Children were exposed to a room with fear-eliciting objects.

3.1.10. Behavior coding

Coders were assigned to code a specific episode, received extensive instruction on the coding system and behavioral indicators of each type of affect, and were required to reach at least 80% agreement on all codes within the episode with an experienced rater before coding independently (Dyson et al., 2015). Each instance of facial, bodily, and vocal positive affect, anger, sadness, and fear were rated on a 3-point scale (low, moderate, and high intensity) during all episodes. The scores from each behavioral expression (bodily, vocal, and facial) were summed within each episode for each participant and then averaged across episodes. Next, summed scores for each expression were standardized across participants and averaged across behavioral expression types (e.g., fear = standardized bodily fear + standardized vocal fear + standardized facial fear)/3). The range of coefficient alphas for PA, anger, fear, sadness was .50–.83 (median .73). Thirty-five videos were independently rated by a second coder to provide interrater reliabilities (intraclass correlations; ICC). The range of interrater reliabilities, expressed as ICC, was .68–.95 (median .78); N =35. For the composite NA measure, standardized scores on anger, fear, and sadness were combined (Cronbach's α = .70).

3.2. Emotional interrupt task

At the age 9 visit, participants completed an emotional interrupt task (Kujawa et al., 2016, 2013; Weinberg and Hajcak, 2011), which has previously been shown to reliably elicit an LPP in children and adolescents (Kujawa et al., 2013). The tasks includes presentation of pleasant, unpleasant, and neutral images from the International Affective Picture System (IAPS; Lang et al., 2008). Trials began with the presentation of an 800 ms fixation (+), then an image for 1000 ms followed by a target arrow (< or >). The target arrow remained on screen for 150 ms and was then replaced by the original image for an additional 400 ms. Participants were instructed to press a button to correspond to the direction of the arrow in order to ensure attention to the task and measure emotion effects on reaction time (RT) and accuracy. The task included 60 images (20 of each valence) presented once in each of two blocks for a total of 120 trials. Examples of pleasant pictures included children playing, cute animals, or babies; unpleasant pictures included sad or angry people, threatening animals, or weapons; and neutral pictures included neutral outdoor scenes or household objects.[3] Mean (SD) valence ratings from Lang et al. (2008) were 7.51(.51) for pleasant, 3.09(.76) for unpleasant, and 5.27 (.35) for neutral; mean (SD) arousal ratings were 5.03(.77) for pleasant, 6.12(.58) unpleasant, and 3.02(.19) for neutral.

[3] IAPS image numbers: pleasant images (1463, 1710, 1750, 1811, 2070, 2091, 2092, 2224, 2340, 2345, 2347, 7325, 7330, 7400, 8031, 8200, 8370, 8461, 8496, 8497); neutral images (2514, 2580, 5390,5395, 5500, 5731, 5740, 5900, 7000, 7002, 7009, 7010, 7026, 7038, 7039, 7090, 7100, 7130, 7175, 7190); unpleasant images (1050, 1052, 1200, 1205, 1300, 1304, 1930, 2458, 2691, 2703, 2800, 2811, 2900, 3022, 6190, 6213, 6231, 6510, 6571, 9600).

3.3. EEG recording and analysis

Continuous EEG was recorded using a 34-channel Biosemi system (32 channel cap with additional recording sites for Iz and FCz). An electrode was placed on the left and right mastoids, and four facial electrodes positioned around the eyes recorded eye movements. The ground electrode used during acquisition was formed by the Common Mode Sense active electrode and the Driven Right Leg passive electrode. Recordings were digitized using ActiView software at 24-bit resolution with a LSB value of 31.25 nV and a sampling rate of 1024 Hz. Off-line analysis was performed using Brain Vision Analyzer (Brain Products). Data were converted using a mastoid reference and band-pass filtered with cutoffs at .1 and 30 Hz. The continuous EEG recording was then segmented by trial, beginning 200 ms before each picture onset and continuing for 1000 ms after the initial image was presented. The EEG was corrected for eye blinks (Gratton et al., 1983), and semi-automated artifact rejection was used to remove artifacts with a voltage step of more than 50 μV between sample points, a voltage difference of 300 μV within a trial, or a maximum voltage difference of less than .5 μV within 100 ms intervals. Next, visual inspection was used to remove data in which additional artifacts were observed. ERPs were constructed by separately averaging the responses to pleasant, neutral, and unpleasant images. Trials were only included in the average if the participant correctly selected the direction of the target arrow in order to ensure that children were attending to the images. ERPs were baseline corrected to the 200 ms interval prior to stimulus onset.

The LPP was scored as the mean activity 400–1000 ms after picture onset and using an electrode pooling of O1, O2, Oz, Pz, P3, P4 where the difference between emotional and neutral images are maximal in children (Fig. 1; Kujawa et al., 2013). The LPP was examined as the relative response to unpleasant or pleasant compared to neutral images (i.e., emotional minus neutral difference; ΔLPP).

3.4. Data analysis

Hierarchical multiple regression analyses were computed to examine effects of PA and NA at age 6 on the ΔLPP to unpleasant and pleasant images at age 9. In Step 1 of each model, we controlled for child demographic variables, including sex, exact age at the EEG assessment, and race/ethnicity. In Step 2, we first tested the effects of PA and the NA composite measure. Next, to examine whether specific facets of NA relate to ΔLPP, we repeated the analyses with temperamental sadness, fear, and anger as predictors, rather than NA. These analyses were computed in separate hierarchical regression analyses because of multicollinearity when evaluating the composite NA variable in combination with its facets.

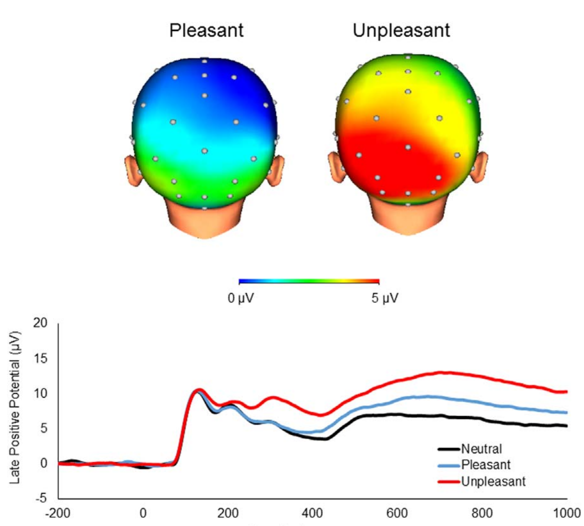

Fig. 1. ERP waveforms in response to pleasant, unpleasant and neutral images, and scalp distributions depicting the response to pleasant and unpleasant compared to neural images 400–1000 ms after stimulus onset in the complete sample.

4. Results

Descriptive statistics and bivariate correlations between child demographics, temperament and ΔLPP measures are presented in Table 1. Child age at the EEG assessment was weakly correlated with age 6 PA, age 6 NA, and age 6 anger, such that children higher in temperamental PA, NA, and anger at age 6 were slightly older at the time of the age 9 assessment, possibly due to other demands on these families that delayed scheduling the visit. Measures of temperament exhibited low-moderate intercorrelations, with the exception of fear with sadness and PA with anger. Greater levels of temperamental PA correlated with an enhanced pleasant ΔLPP, and greater levels of fear correlated with an enhanced unpleasant ΔLPP, respectively.

Next, we examined the effects of composite measures of NA and PA at age 6 on the LPP at age 9 (Table 2). Age was a significant predictor of the unpleasant ΔLPP in Step 1, but was no longer significant after adding temperament variables to the model. Age 6 temperamental PA significantly predicted the pleasant ΔLPP at age 9, such that higher PA predicted an enhanced ΔLPP to pleasant images (Fig. 2). Age 6 temperamental NA did not significantly predict the pleasant or unpleasant ΔLPP at age 9 (Table 2).

Next, the analyses were repeated substituting scores on sadness, fear, and anger for NA (Table 2). PA continued to predict the pleasant ΔLPP. While greater fear predicted an enhanced ΔLPP to unpleasant images, greater sadness predicted a reduced ΔLPP to unpleasant images (Fig. 3). Anger did not significantly predict the ΔLPP. Scatter plots of all significant associations are presented in Fig. 4.[4] None of the effects of PA, fear, or sadness on ΔLPP were moderated by sex (*ps* $> .20$). The effects of PA, NA, and facets of NA on the LPP to neutral images were not significant (*ps* $> .05$), suggesting that effects were not fully accounted for by individual differences in response to neutral images.

5. Discussion

The current study examined associations between behavioral measures of PA and NA and physiological measures of emotional processing across development. Children who exhibited higher levels of PA in the behavioral assessment at age 6 showed an enhanced LPP to pleasant images approximately three years later, consistent with prior findings that adolescents higher in self- and parent-reported PA exhibited an enhanced LPP to emotional stimuli (Speed et al., 2015). While the composite measure of NA was not significantly related to the LPP, temperamental fearfulness at age 6 predicted an enhanced LPP to unpleasant images, consistent with a previous cross-sectional study of fearful behavior in children (Solomon et al., 2012), and temperamental sadness predicted blunted responses to unpleasant images. Importantly, these associations were observable across different domains and across time, providing evidence of correspondence between an in vivo assessment of emotional expression and a neural measure of attention towards emotionally salient images three years later.

These findings provide evidence of convergent validity of behavioral and physiological measures, consistent with RDoC's goal of evaluating constructs across multiple levels of analysis. Children who express higher levels of positive emotions in early childhood exhibit increased physiological responses to pleasant images in later childhood, while

[4] Age 6 temperament variables did not significantly predict reaction time (RT) or accuracy for unpleasant and pleasant (compared to neutral) trials (*ps* $> .21$), suggesting that though individual differences in observed temperament are related to physiological measures, they are not related to behavioral performance in this task.

Table 1
Descriptive Statistics and Pearson's Correlations/Phi Coefficients between Study Variables.

	Race/ Ethnicity	Age	Age 6 PA	Age 6 NA	Age 6 Fear	Age 6 Sadness	Age 6 Anger	Unpleasant ΔLPP	Pleasant ΔLPP
Sex	.01	−.09	.06	−.03	.05	−.07	−.05	−.01	−.03
Race/Ethnicity	__	−.04	−.01	.03	−.06	.06	.05	.04	.01
Age		__	.11*	.15**	.08	.08	.14**	.11	.08
Age 6 PA			__	.26**	.16*	.29**	.07	.07	.11*
Age 6 NA				__	.60**	.73**	.72**	.04	−.05
Age 6 Fear					__	.08	.16**	.12*	−.03
Age 6 Sadness						__	.36**	.02	−.03
Age 6 Anger							__	−.07	−.05
Unpleasant ΔLPP									.50**
	Mean (SD):	9.15 (.35)	.03 (.89)	−.01(.56)	−.02(.76)	−.03(.70)	.03(.81)	5.06(6.63)	1.99(6.27)
	Range:	8.33–10.92	−1.18–4.10	−.74–2.93	−1.02–3.64	−.85–4.25	−.59–6.54	−24.01–26.39	−17.78–22.64

* $p \le .05$.
** $p < .01$; PA= positive affect; NA = negative affect; LPP = late positive potential.

Table 2
Multiple Regression Analyses with Temperament at Age 6 Predicting the Late Positive Potential (LPP) at Age 9.

	Pleasant ΔLPP		Unpleasant ΔLPP	
	b(SE)	*β*	*b(SE)*	*β*
Step 1				
Sex	−.32 (.69)	−.03	.06 (.72)	.01
Ethnicity/Race	−.09 (1.12)	.00	.97 (1.18)	.05
Age	1.35 (.99)	.08	2.05 (1.04)	.11*
	$F(3,336) = .75$, $R^2 = .01$		$F(3,336) = 1.49$, $R^2 = .01$	
Step 2 – Model 1				
Age 6 PA	.90 (.40)	.13*	.42 (.42)	.06
Age 6 NA	−1.22 (.68)	−.10	.06 (.72)	.01
	Change $F(2,334) = 3.37^{*}$, $R^2 = .03$		Change $F(2,334) = .57$, $R^2 = .00$	
Step 2 – Model 2				
Age 6 PA	.91 (.41)	.13*	.27 (.43)	.04
Age 6 Fear	−.40 (.46)	−.05	1.09 (.48)	.13*
Age 6 Sadness	−.40 (.53)	−.05	−1.18 (.56)	−.13*
Age 6 Anger	−.45(.47)	−.06	.25 (.49)	.03
	Change $F(4,332) = 1.71$, $R^2 = .03$		Change $F(4,332) = 2.40^{*}$, $R^2 = .03$	

* $p \le .05$; PA= positive affect; NA = negative affect; LPP = late positive potential.

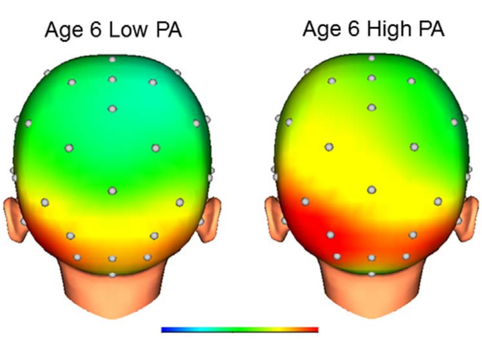

Fig. 2. Scalp distributions depicting the response to pleasant compared to neural images 400–1000 ms after stimulus onset for children with low (left) and high (right) levels of PA at age 6. Note: For illustrative purposes, participants were divided into groups based on the bottom and top 1/3 of PA scores at age 6. Analyses examined PA as a continuous measure.

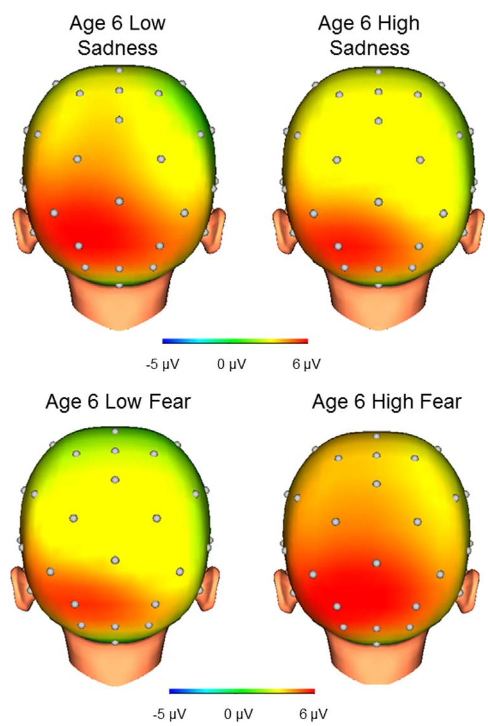

Fig. 3. Scalp distribution depicting the response to unpleasant compared to neutral 400–1000 ms after stimulus onset for children with low (left) and high (right) levels of fear (top) and sadness (bottom) at age 6. Note: For illustrative purposes, residual scores were computed to isolate the unique variance for each facet of NA, and participants were divided into groups based on the bottom and top 1/3 of these scores. Analyses examined fear and sadness as a continuous measure.

children who express more fearfulness exhibit increased reactivity to and attention towards unpleasant or threatening images. On the other hand, children who express greater sadness exhibit blunted responses to unpleasant images, consistent with previous evidence of withdrawal responses following a sad mood induction (Kreibig et al., 2007). Surprisingly, sadness was associated with a blunted response to unpleasant but not pleasant images. These findings suggest that tendencies to express greater sadness may be associated with reduced motivational relevance of and disengagement from unpleasant and threatening images, specifically, with engagement with pleasant stimuli better accounted for by individual differences in PA.

That is, in addition to demonstrating correspondence between behavioral and physiological measures, the current findings also demonstrate discriminant validity of these constructs. Behavioral measures of PA were specifically related to physiological measures of processing of pleasant, rather than unpleasant, images, and facets of NA in early childhood specifically predicted LPP to unpleasant, rather than pleasant, images in later childhood. These findings are somewhat different from a previous study of questionnaire measures of personality in adolescents (Speed et al., 2015), which found an association between PA and the LPP to both pleasant and unpleasant images. Given low correlations between questionnaire and laboratory measures of temperament (Hayden et al., 2005; Mangelsdorf et al., 2000),

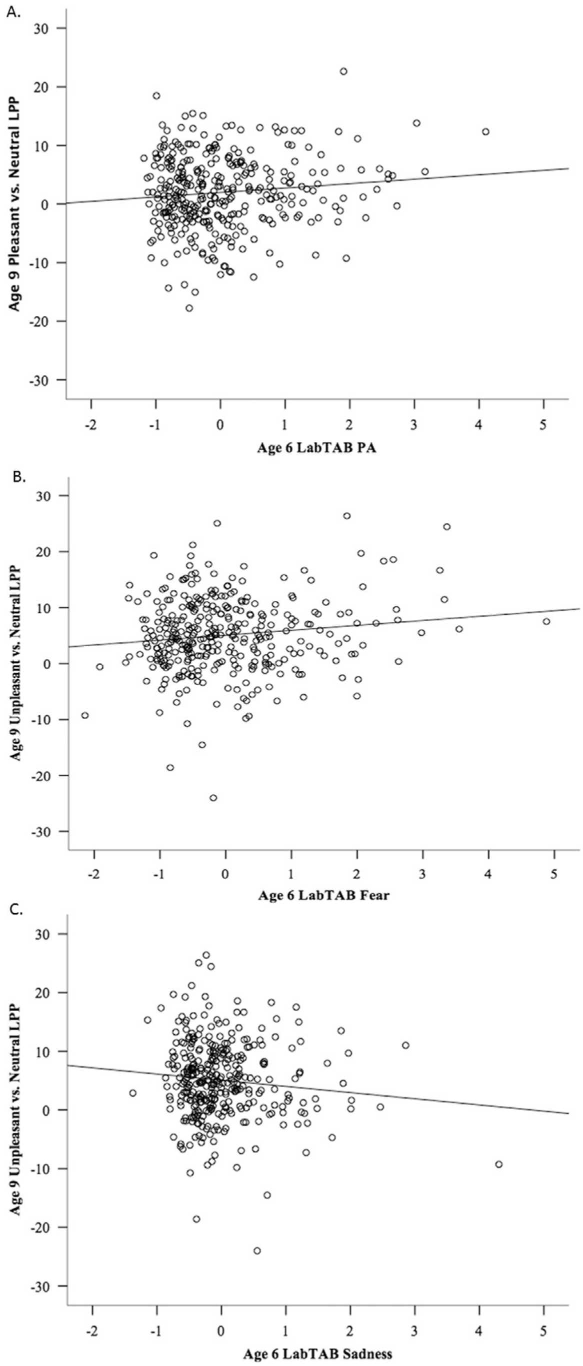

Fig. 4. Scatterplots depicting the associations between: A. age 6 PA and ΔLPP to pleasant images at age 9; B. age 6 fearfulness (residuals adjusting for other NA facets) and ΔLPP to unpleasant images at age 9; C. age 6 sadness (residuals adjusting for other NA facets) and ΔLPP to unpleasant images at age 9.

distinct effects with these measures are not surprising, but highlight the need for ongoing work examining the effects of methodological factors on correspondence between units of analysis in the RDoC matrix.

PA, NA and the LPP have previously been linked to psychopathology and risk. In the current study, fearfulness and sadness demonstrated distinct patterns of associations with the unpleasant LPP in a pattern that parallels previous findings of an enhanced LPP to unpleasant images in anxiety but blunted LPP in depression (Kujawa et al., 2015a; Proudfit et al., 2015; Weinberg et al., 2016). With regard to risk, youth low in PA and high in temperamental sadness are at increased risk of developing depression (De Pauw and Mervielde, 2010; Dougherty et al., 2010; Wetter and Hankin, 2009), and risk for depression has previously been associated with a blunted LPP to emotional images (Kujawa et al., 2012; Nelson et al., 2015). Along similar lines, children high in temperamental fearfulness are at increased risk for developing anxiety symptoms (De Pauw and Mervielde, 2010), and an enhanced LPP to unpleasant images has been observed among offspring of parents with anxiety disorders (Nelson et al., 2015). In addition to internalizing symptoms, temperamental NA is a vulnerability for externalizing symptoms (Tackett et al., 2012), and we have previously shown that an enhanced unpleasant LPP prospectively predicted increases in externalizing symptoms in response to stress (Kujawa et al., 2016).

Examining typical and atypical developmental trajectories of individual differences in emotional processing at both the behavioral and physiological level could provide further insight into the development of psychopathology. For example, it is possible that children who exhibit low behavioral expression of PA and/or high sadness in early childhood in combination with reduced physiological responses to emotional images are at greatest risk for developing depressive symptoms later in life, while those that exhibit enhanced fearfulness and heightened reactivity to unpleasant images may be at greatest risk for anxiety. On the other hand, children who exhibit early temperament styles that predispose to risk for internalizing disorders but who show a typical LPP to emotional images may be at lower risk of developing depression and anxiety. In this way, the LPP and other physiological or circuit measures may be useful for better understanding resilience and multifinality. Alternatively, attention towards unpleasant or pleasant stimuli, as measured by the LPP, may mediate effects of early temperament style on later development of symptoms.

Observational measures of PA and NA were modestly positively correlated with each other, suggesting that children who exhibited greater expressions of affect in one domain also exhibited greater affect in the other domain. While these dimensions have been shown to be correlated with each other in cross-sectional analyses, they do not appear to predict one another across time and development (Durbin et al., 2007). In addition, in the current study, PA and NA demonstrated unique associations with the LPP to each type of emotional image, in a way that fits with the conceptualization that they are distinct constructs (Watson et al., 1999).

A few limitations of the current study should be noted. First, while associations between behavioral and physiological measures were significant across three years, we were unable to examine concurrent associations between measures. In addition, the magnitudes of effects between behavioral measures and the LPP were modest. This is not surprising, given the number of years between assessments and the substantial differences in methods. Indeed, this is consistent with evidence of modest effects when linking physiological to behavioral or self-report measures in large samples, partly due to the lack of shared method variance (Patrick et al., 2013), but also raises challenges for RDoC and associations across levels of analysis (Kozak and Cuthbert, 2016). Despite the small effects, the current findings for PA and fearfulness are generally consistent with previous studies of the LPP in youth (Solomon et al., 2012; Speed et al., 2015); however, as this study is the first to examine associations between observations of sadness and the LPP, future work is needed to replicate this finding.

This study is among the first to examine both the PVS and NVS using multiple units of analysis, with results providing evidence of correspondence between behavioral observations of PA and the LPP to pleasant images, as well as specific associations between facets of NA and the LPP. In addition, the current findings provide evidence of discriminant validity among these measures, in that behavioral measures presumed to reflect one system were unrelated to physiological measures presumed to reflect the other system. Finally, the current study capitalizes on a large sample, spanning three years of development, providing insight into relationships between units of analysis in the RDoC matrix.

Conflicts of interest

The authors declare no conflicts of interest.

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References

Bar-Haim, Y., Fox, N.A., Benson, B., Guyer, A.E., Williams, A., Nelson, E.E., Perez-Edgar, K., Pine, D.S., Ernst, M., 2009. Neural correlates of reward processing in adolescents with a history of inhibited temperament. Psychol. Sci. 20, 1009–1018. http://dx.doi.org/10.1111/j.1467-9280.2009.02401.x.

Carver, C.S., Harmon-Jones, E., 2009. Anger is an approach-related affect: evidence and implications. Psychol. Bull. 135, 183–204. http://dx.doi.org/10.1037/a0013965.

Casey, B.J., Oliveri, M.E., Insel, T., 2014. A neurodevelopmental perspective on the research domain criteria (RDoC) framework. Biol. Psychiatry 76, 350–353. http://dx.doi.org/10.1016/j.biopsych.2014.01.006.

Caspi, A., Shiner, R.L., 2006. Personality development. In: Eisenberg, N., Damon, W., Lerner, R.M. (Eds.), Handbook of Child Psychology: Vol. 3, Social, Emotional, and Personality Development6th ed.. John Wiley & Sons Inc, Hoboken, NJ US, 300–365.

Clark, L.A., 2005. Temperament as a unifying basis for personality and psychopathology. J. Abnorm. Psychol. 114, 505–521. http://dx.doi.org/10.1037/0021-843x.114.4.505.

Clark, L.A., Watson, D., 1999. Temperament: a new paradigm for trait psychology. In: Pervin, L.A., John, O.P. (Eds.), Handbook of Personality. Guilford Press, New York, 399–423.

Cuthbert, B.N., Schupp, H.T., Bradley, M.M., Birbaumer, N., Lang, P.J., 2000. Brain potentials in affective picture processing: covariation with autonomic arousal and affective report. Biol. Psychol. 52, 95–111.

Davidson, R.J., 1992. Emotion and affective style: hemispheric substrates. Psychol. Sci. 3, 39–43. http://dx.doi.org/10.1111/j.1467-9280.1992.tb00254.x.

De Pauw, S.S.W., Mervielde, I., 2010. Temperament, personality and developmental psychopathology: a review based on the conceptual dimensions underlying childhood traits. Child Psychiatry Hum. Dev. 41, 313–329. http://dx.doi.org/10.1007/s10578-009-0171-8.

Dougherty, L.R., Klein, D.N., Durbin, E.C., Hayden, E.P., Olino, T.M., 2010. Temperamental positive and negative emotionality and children's depressive symptoms: a longitudinal prospective study from age three to age ten. J. Soc. Clin. Psychol. 29, 462–488.

Durbin, C.E., Hayden, E.P., Klein, D.N., Olino, T.M., 2007. Stability of laboratory-assessed temperamental emotionality traits from ages 3 to 7. Emotion 7, 388–399. http://dx.doi.org/10.1037/1528-3542.7.2.388.

Dyson, M.W., Olino, T.M., Durbin, C.E., Goldsmith, H.H., Bufferd, S.J., Miller, A.R., Klein, D.N., 2015. The structural and rank-order stability of temperament in young children based on a laboratory-observational measure. Psychol. Assess.

Forbes, E.E., Dahl, R.E., 2012. Research review: altered reward function in adolescent depression: what, when and how? J. Child Psychol. Psychiatry 53, 3–15. http://dx.doi.org/10.1111/j.1469-7610.2011.02477.x.

Foti, D., Olvet, D.M., Klein, D.N., Hajcak, G., 2010. Reduced electrocortical response to threatening faces in major depressive disorder. Depress Anxiety 27, 813–820. http://dx.doi.org/10.1002/da.20712.

Fox, N.A., Henderson, H.A., Marshall, P.J., Nichols, K.E., Ghera, M.M., 2005. Behavioral inhibition: linking biology and behavior within a developmental framework. Annu. Rev. Psychol. 56, 235–262. http://dx.doi.org/10.1146/annurev.psych.55.090902.141532.

Franklin, J.C., Jamieson, J.P., Glenn, C.R., Nock, M.K., 2015. How developmental psychopathology theory and research can inform the Research Domain Criteria (RDoC) project. J. Clin. Child Adolesc. Psychol. 44, 280–290. http://dx.doi.org/10.1080/15374416.2013.873981.

Goldsmith, H.H., Gagne, J.R., 2012. In: Zentner, M., Shiner, R.L. (Eds.), Behavioral Assessment of Temperament, Handbook of Temperament. Guilford Press, New York.

Goldsmith, H.H., Reilly, J., Lemery, K., Longley, S., Prescott, A., Goldsmith Reilly, J., Lemery, K.S., Longley, S., Prescott, A., H.H, 1995. Lab. Temperam. Assess. Battery.: Presch. Version, (Unpublished manuscript).

Goodkind, M.S., Gyurak, A., Etkin, A., 2013. Functional neurocircuitry and neuroimaging studies of anxiety disorders. In: Charney, D.S., Sklar, P., Buxbaum, J.D., Nestler, E.J. (Eds.), Neurobiology of Mental Illness. Oxford University Press, New York, NY, 606–620.

Gratton, G., Coles, M.G., Donchin, E., 1983. A new method for off-line removal of ocular artifact. Electroencephalogr. Clin. Neurophysiol. 55, 468–484.

Gray, J.A., 1994. Framework for a taxonomy of psychiatric disorder. In: van Goozen, S.H.M., Van de Poll, N.E., Sergeant, J.A. (Eds.), Emotions: Essays on Emotion Theory. Lawrence Erlbaum Associates, Inc, Hillsdale, NJ England, 29–59.

Guyer, A.E., Nelson, E.E., Perez-Edgar, K., Hardin, M.G., Roberson-Nay, R., Monk, C.S., Bjork, J.M., Henderson, H.A., Pine, D.S., Fox, N.A., Ernst, M., 2006. Striatal functional alteration in adolescents characterized by early childhood behavioral inhibition. J. Neurosci. 26, 6399–6405. http://dx.doi.org/10.1523/jneurosci.0666-06.2006.

Hajcak, G., Weinberg, A., MacNamara, A., Foti, D., 2011. ERPs and the study of emotion. In: Luck, S.J., Kappenman, E. (Eds.), Handbook of Event-Related Potential Components. Oxford University Press, New York, 441–472.

Hayden, E.P., Klein, D.N., Durbin, C.E., 2005. Parent reports and laboratory assessments of child temperament: a comparison of their associations with risk for depression and externalizing disorders. J. Psychopathol. Behav. Assess. 27, 89–100. http://dx.doi.org/10.1007/s10862-005-5383-z.

Kagan, J., Reznick, J.S., Snidman, N., 1987. The physiology and psychology of behavioral inhibition in children. Child Dev. 58, 1459–1473. http://dx.doi.org/10.2307/1130685.

Keil, A., Bradley, M.M., Hauk, O., Rockstroh, B., Elbert, T., Lang, P.J., 2002. Large-scale neural correlates of affective picture-processing. Psychophysiology 39, 641–649. http://dx.doi.org/10.1017/s0048577202394162.

Klein, D.N., Dyson, M.W., Kujawa, A.J., Kotov, R., 2012. Temperament and internalizing disorders. In: Zentner, M., Shiner, R.L. (Eds.), Handbook of Temperament. Guilford Press, New York, NY, 541–561.

Kotov, R., Gamez, W., Schmidt, F., Watson, D., 2010. Linking “big” personality traits to anxiety, depressive, and substance use disorders: a meta-analysis. Psychol. Bull. 136, 768–821. http://dx.doi.org/10.1037/a0020327.

Kozak, M.J., Cuthbert, B.N., 2016. The NIMH Research Domain Criteria Initiative: background, issues, and pragmatics. Psychophysiology 53, 286–297. http://dx.doi.org/10.1111/psyp.12518.

Kreibig, S.D., Wilhelm, F.H., Roth, W.T., Gross, J.J., 2007. Cardiovascular, electrodermal, and respiratory response patterns to fear- and sadness-inducing films. Psychophysiology 44, 787–806. http://dx.doi.org/10.1111/j.1469-8986.2007.00550.x.

Kujawa, A., Hajcak, G., Danzig, A.P., Black, S.R., Bromet, E.J., Carlson, G.A., Kotov, R., Klein, D.N., 2016. Neural reactivity to emotional stimuli prospectively predicts the impact of a natural disaster on psychiatric symptoms in children. Biol. Psychiatry. http://dx.doi.org/10.1016/j.biopsych.2015.09.008.

Kujawa, A., Hajcak, G., Torpey, D., Kim, J., Klein, D.N., 2012. Electrocortical reactivity to emotional faces in young children and associations with maternal and paternal depression. J. Child Psychol. Psychiatry 53, 207–215. http://dx.doi.org/10.1111/j.1469-7610.2011.02461.x.

Kujawa, A., Klein, D.N., Proudfit, G.H., 2013. Two-year stability of the late positive potential across middle childhood and adolescence. Biol. Psychol. 94, 290–296. http://dx.doi.org/10.1002/dev.21058.

Kujawa, A., MacNamara, A., Fitzgerald, K.D., Monk, C.S., Phan, K.L., 2015a. Enhanced neural reactivity to threatening faces in anxious youth: Evidence from event-related potentials. J. Abnorm. Child Psychol.

Kujawa, A., Proudfit, G.H., Kessel, E.M., Dyson, M., Olino, T., Klein, D.N., 2015b. Neural reactivity to monetary rewards and losses in childhood: longitudinal and concurrent associations with observed and self-reported positive emotionality. Biol. Psychol. 104, 41–47. http://dx.doi.org/10.1016/j.biopsycho.2014.11.008.

Kujawa, A., Proudfit, G.H., Klein, D.N., 2014. Neural reactivity to rewards and losses in offspring of mothers and fathers with histories of depressive and anxiety disorders. J. Abnorm. Psychol. 123, 287–297. http://dx.doi.org/10.1037/a0036285.

Lang, P.J., Bradley, M.M., Cuthbert, B.N., 2008. International Affective Picture System (IAPS): affective ratings of pictures and instructional manual. . Technical Report A-8. University of Florida, Gainesville, FL.

Lang, P.J., Bradley, M.M., Cuthbert, B.N., 1990. Emotion, attention, and the startle reflex. Psychol. Rev. 97, 377–395. http://dx.doi.org/10.1037/0033-295x.97.3.377.

Liu, Y., Huang, H., McGinnis-Deweese, M., Keil, A., Ding, M., 2012. Neural substrate of the late positive potential in emotional processing. J. Neurosci. 32, 14563–14572. http://dx.doi.org/10.1523/JNEUROSCI.3109-12.2012.

MacNamara, A., Kotov, R., Hajcak, G., 2015. Diagnostic and symptom-based predictors of emotional processing in generalized anxiety disorder and major depressive disorder: an event-related potential study. Cogn. Ther. Res.. http://dx.doi.org/10.1007/s10608-015-9717-1.

Mangelsdorf, S.C., Schoppe, S.J., Buur, H., 2000. The meaning of parental reports: a contextual approach to the study of temperament and behavior problems in childhood. In: Molfese, V.J., Molfese, D.L. (Eds.), Temperament and Personality. Development across the Lifespan, Erlbaum, Hillsdale, NJ, 121–140.

McDermott, J.M., Perez-Edgar, K., Henderson, H.A., Chronis-Tuscano, A., Pine, D.S., Fox, N. a., 2009. A history of childhood behavioral inhibition and enhanced response monitoring in adolescence are linked to clinical anxiety. Biol. Psychiatry 65, 445–448 . http://dx.doi.org/10.1016/j.biopsych.2008.10.043.

Moratti, S., Saugar, C., Strange, B.A., 2011. Prefrontal-occipitoparietal coupling underlies late latency human neuronal responses to emotion. J. Neurosci. 31, 17278–17286. http://dx.doi.org/10.1523/JNEUROSCI.2917-11.2011.

Moser, J.S., Huppert, J.D., Duval, E., Simons, R.F., 2008. Face processing biases in social anxiety: an electrophysiological study. Biol. Psychol. 78, 93–103. http://dx.doi.org/10.1016/j.biopsycho.2008.01.005.

National Institute of Mental Health, 2016. RDoC Matrix [WWW Document]. URL ⟨http://www.nimh.nih.gov/research-priorities/rdoc/constructs/rdoc-matrix.shtml⟩ (accessed 23.03.16).

Nelson, B.D., Perlman, G., Hajcak, G., Klein, D.N., Kotov, R., 2015. Familial risk for distress and fear disorders and emotional reactivity in adolescence: an event-related potential investigation. Psychol. Med. 45, 2545–2556. http://dx.doi.org/10.1017/S0033291715000471.

Olino, T.M., Klein, D.N., Dyson, M.W., Rose, S.A., Durbin, C.E., 2010. Temperamental emotionality in preschool-aged children and depressive disorders in parents: associations in a large community sample. J. Abnorm. Psychol. 119, 468–478. http://dx.doi.org/10.1037/a0020112.

Olofsson, J.K., Nordin, S., Sequeira, H., Polich, J., 2008. Affective picture processing: an integrative review of ERP findings. Biol. Psychol. 77, 247–265. http://dx.doi.org/10.1016/j.biopsycho.2007.11.006.

Patrick, C.J., Venables, N.C., Yancey, J.R., Hicks, B.M., Nelson, L.D., Kramer, M.D., 2013. A construct-network approach to bridging diagnostic and physiological domains: application to assessment of externalizing psychopathology. J. Abnorm. Psychol. 122, 902. http://dx.doi.org/10.1037/a0032807.

Pine, D.S., 2007. Research Review: a neuroscience framework for pediatric anxiety disorders. J. Child Psychol. Psychiatry Allied Discip. 48, 631–648. http://dx.doi.org/10.1111/j.1469-7610.2007.01751.x.

Pizzagalli, D. a., 2014. Depression, stress, and anhedonia: toward a synthesis and integrated model. Annu. Rev. Clin. Psychol. 10, 393–423. http://dx.doi.org/10.1146/annurev-clinpsy-050212-185606.

Proudfit, G.H., Bress, J.N., Foti, D., Kujawa, A., Klein, D.N., 2015. Depression and event-related potentials: Emotional disengagement and reward insensitivity. Curr. Opin. Psychol.

Rothbart, M.K., Bates, J.E., 2006. Temperament. In: Eisenberg, N., Damon, W. (Eds.), Handbook of Child Psychology: Vol. 3, Social, Emotional, and Personality Development6th ed.. John Wiley & Sons Inc, Hoboken, NJ US, 99–166.

Sabatinelli, D., Keil, A., Frank, D.W., Lang, P.J., 2013. Emotional perception: correspondence of early and late event-related potentials with cortical and subcortical functional MRI. Biol. Psychol. 92, 513–519. http://dx.doi.org/10.1016/j.biopsycho.2012.04.005.

Sabatinelli, D., Lang, P.J., Keil, A., Bradley, M.M., 2007. Emotional perception: correlation of functional MRI and event-related potentials. Cereb. Cortex 17, 1085–1091. http://dx.doi.org/10.1093/cercor/bhl017.

Sanislow, C.A., Pine, D.S., Quinn, K.J., Kozak, M.J., Garvey, M.A., Heinssen, R.K., Wang, P.S., Cuthbert, B.N., 2010. Developing constructs for psychopathology research: research domain criteria. J. Abnorm. Psychol. 119, 631–639. http://dx.doi.org/10.1037/a0020909.

Schupp, H.T., Flaisch, T., Stockburger, J., Junghöfer, M., Jungho, M., Junghöfer, M., 2006. Emotion and attention: event-related brain potential studies. Prog. Brain Res. 156, 31–51. http://dx.doi.org/10.1016/S0079-6123(06)56002-9.

Shankman, S.A., Gorka, S.M., 2016. Psychopathology research in the RDoC era: unanswered questions and the importance of the psychophysiological unit of analysis. Int. J. Psychophysiol. 98, 330–337. http://dx.doi.org/10.1016/j.ijpsycho.2015.01.001.

Solomon, B., DeCicco, J.M., Dennis, T.A., 2012. Emotional picture processing in children: an ERP study. Dev. Cogn. Neurosci. 2, 110–119. http://dx.doi.org/10.1016/j.dcn.2011.04.002.

Speed, B.C., Nelson, B.D., Perlman, G., Klein, D.N., Kotov, R., Hajcak, G., 2015. Personality and emotional processing: a relationship between extraversion and the late positive potential in adolescence. Psychophysiology 52, 1039–1047. http://dx.doi.org/10.1111/psyp.12436.

Swartz, J.R., Monk, C.S., 2014. The role of corticolimbic circuitry in the development of anxiety disorders in children and adolescents. In: Andersen, S.L., Pine, D.S. (Eds.), The Neurobiology of Childhood. Springer, 133–148.

Tackett, J.L., Lahey, B.B., van Hulle, C., Waldman, I., Krueger, R.F., Rathouz, P.J., 2013. Common genetic influences on negative emotionality and a general psychopathology factor in childhood and adolescence. J. Abnorm. Psychol. 122, 1142–1153.

Tackett, J.L., Martel, M.M., Kushner, S.C., 2012. Temperament, externalizing disorders, and attention-deficit/hyperactivity disorder. In: Zentner, M., Shiner, R.L. (Eds.), Handbook of Temperament. Guilford Press, New York, 562–580.

Watson, D., Wiese, D., Vaidya, J., Tellegen, A., 1999. The two general activation systems of affect: structural findings, evolutionary considerations, and psychobiological evidence. J. Pers. Soc. Psychol. 76, 820–838. http://dx.doi.org/10.1037/0022-3514.76.5.820.

Weinberg, A., Hajcak, G., 2011. The late positive potential predicts subsequent interference with target processing. J. Cogn. Neurosci. 23, 2994–3007. http://dx.doi.org/10.1162/jocn.2011.21630.

Weinberg, A., Perlman, G., Kotov, R., Hajcak, G., 2016. Depression and reduced neural response to emotional images: Distinction from anxiety and importance of symptom dimensions and age of onset 125, 26–39. http://dx.doi.org/10.1037/abn0000118.

Wetter, E.K., Hankin, B.L., 2009. Mediational pathways through which positive and negative emotionality contribute to anhedonic symptoms of depression: a prospective study of adolescents. J. Abnorm. Child Psychol. 37, 507–520. http://dx.doi.org/10.1007/s10802-009-9299-z.