Perception is key?

Does perceptual sensitivity and parenting behavior predict children's reactivity to others' emotions?

Weeland, J.; Van den Akker, A.; Slagt, M.; Putnam, S.

Published in:
Journal of Experimental Child Psychology

DOI:
10.1016/j.jecp.2017.06.012

Journal of Experimental Child Psychology 163 (2017) 53–68

Contents lists available at ScienceDirect

Journal of Experimental Child Psychology

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

Perception is key? Does perceptual sensitivity and parenting behavior predict children's reactivity to others' emotions?

Joyce Weeland [a,*], Alithe Van den Akker [a], Meike Slagt [b], Samuel Putnam [c]

[a] *Research Institute of Child Development and Education, University of Amsterdam, 1001 NH Amsterdam, The Netherlands*
[b] *Utrecht Centre for Child and Adolescent Studies, Utrecht University, 3584 CS Utrecht, The Netherlands*
[c] *Department of Psychology, Bowdoin College, Brunswick, ME 04011, USA*

A R T I C L E I N F O

Article history:
Received 11 January 2017
Revised 23 June 2017
Available online 21 July 2017

Keywords:
Emotion expressions
Facial electromyography
Parenting
Perceptual sensitivity
Reactivity
Temperament

A B S T R A C T

When interacting with other people, both children's biological predispositions and past experiences play a role in how they will process and respond to social–emotional cues. Children may partly differ in their reactions to such cues because they differ in the threshold for perceiving such cues in general. Theoretically, perceptual sensitivity (i.e., the amount of detection of slight, low-intensity stimuli from the external environment independent of visual and auditory ability) might, therefore, provide us with specific information on individual differences in susceptibility to the environment. However, the temperament trait of perceptual sensitivity is highly understudied. In an experiment, we tested whether school-aged children's ($N = 521$, 52.5% boys, $M_{age} = 9.72$ years, $SD = 1.51$) motor (facial electromyography) and affective (self-report) reactivities to dynamic facial expressions and vocalizations is predicted by their (parent-reported) perceptual sensitivity. Our results indicate that children's perceptual sensitivity predicts their motor reactivity to both happy and angry expressions and vocalizations. In addition, perceptual sensitivity interacted with positive (but not negative) parenting behavior in predicting children's motor reactivity to these emotions. Our findings suggest that perceptual sensitivity might indeed provide us with information on individual differences in reactivity to social–emotional cues, both alone and in interaction with parenting behavior. Because perceptual sensitivity focuses specifically on whether children perceive cues from their environment, and not on whether these cues cause

* Corresponding author.
E-mail address: j.weeland@uva.nl (J. Weeland).

http://dx.doi.org/10.1016/j.jecp.2017.06.012

arousal and/or whether children are able to regulate this arousal, it should be considered that perceptual sensitivity lies at the root of such individual differences.

Introduction

When interacting with other people, both children's biological predispositions and past experiences play a role in how they will process and respond to social–emotional cues (Crick & Dodge, 1994; Dishion & Patterson, 2006). Although attentional, perceptual, affective, and regulatory processes work together in contributing to children's eventual reactions to such cues (Lemerise & Arsenio, 2000), research on child development has mostly focused on the regulation of arousal and behavioral response (Gross, 2015). However, the initial perception of social–emotional information might largely determine the nature of the arousal and implications for regulation (Phillips, Drevets, Rauch, & Lane, 2003). Perceptual sensitivity is included as a temperament trait in the highly influential model of Rothbart, Ahadi, Hershey, and Fisher (2001), but this trait has seldom been studied in isolation or in the context of the processing of social–emotional information. The current study addressed this shortcoming, testing whether school-aged children scoring high on perceptual sensitivity show stronger motor (facial electromyography [*f*EMG]) and affective (self-report) reactivities to emotional facial expressions and vocalizations compared with children scoring low on this trait.

Perceptual sensitivity

Children may partly differ in how strongly they react to social–emotional cues because they differ in the threshold for perceiving stimuli from the environment in general (Phillips et al., 2003). Perceptual sensitivity reflects such differences in the detection of slight, low-intensity stimuli from the external environment (independent of individual differences in visual and auditory ability) (Rothbart et al., 2001). In the current study, we assessed this trait using the Temperament in Middle Childhood Questionnaire (TMCQ), which uses parents' responses to items such as "Notices things that other people don't notice" and "Notices small changes in the environment like lights getting brighter in a room" (Rothbart et al., 2001; Simonds & Rothbart, 2004). The scale is part of the higher-order factor of effortful control during middle childhood (Simonds & Rothbart, 2004) and has been shown to be relatively stable over time (Putnam, Rothbart, & Gartstein, 2008).

Conceptually, perceptual sensitivity (not to be confused with sensory processing disorder; see, e.g., Grapel, Cicchetti, & Volkmar, 2015) is a somewhat odd construct within the other lower-order scales that make up effortful control during middle childhood (i.e., attentional focusing, inhibitory control, low-intensity pleasure, and activation control). What makes this scale unique is that it addresses not the experience or regulation of arousal due to environmental stimuli but rather whether children detect these stimuli in the first place. Theoretically, it might, therefore, lie at the root of individual differences in susceptibility to the environment (i.e., differential susceptibility hypothesis; Belsky, 1997). Perceptual sensitivity has indeed been related to other relatively stable "susceptibility markers" such as respiratory sinus arrhythmia (RSA) during infancy, negative affectivity during early childhood (Putnam et al., 2008), and orienting sensitivity during adulthood (Evans & Rothbart, 2007). For example, in infants perceptual sensitivity was shown to be positively related to children's RSA (Conradt, Measelle, & Ablow, 2013). Subsequently, RSA was shown to predict children's differential response to their caregiving environment (Conradt et al., 2013).

To date, temperamental perceptual sensitivity has received very little scientific attention, particularly as it is manifested in children. Moreover, most studies have important methodological limitations due to the use of parent-reported measures for both sensitivity and behavior, which introduces rater bias shared between the measures. However, research on related traits does suggest that perceptual sensitivity may play a role in children's daily functioning and specifically individual differences in responses to social–emotional cues. For example, perceptual sensitivity might also be closely related to other sensitivity measures such as sensory processing sensitivity assessed with the Highly Sensitive Person Scale (HSPS). This scale includes a "low sensory threshold" factor and a sensory processing sensitivity (SPS) scale in adults (Aron & Aron, 1997; Aron, Aron, & Jagiellowicz, 2012; Smolewska, McCabe, & Woody, 2006) and the factors "overreaction to stimuli" and "depth of processing" in children (Boterberg & Warreyn, 2016). In an adult sample, Evans and Rothbart (2008) indeed concluded that the HSPS reflects constructs of the Adult Temperament Questionnaire, specifically negative affect and orienting sensitivity. In children, parent-reported HSPS has been associated with children's internalizing problems (Boterberg & Warreyn, 2016). In adults, high scores on sensory processing sensitivity have been related to stronger reactivity to emotional stimuli (Jagiellowicz, Aron, & Aron, 2016) as well as heightened awareness and integration of sensory information after exposure to specifically positive facial expressions(functional magnetic resonance imaging [fMRI] research by Acevedo et al., 2014). But sensory processing sensitivity also was related to longer response time to minor changes in the offered images and to more activation, suggesting greater effort in visual attentional areas of the brain when responding to these minor changes (fMRI research by Jagiellowicz et al., 2010). Similarly, sensory processing was found to moderate cultural differences (Asian vs. European American) in neural responses of brain areas known to support sustained attentional control (but not in areas related to early visual processes). The authors suggested that this might indicate that individuals high on sensory processing sensitivity are attending more closely to the subtle stimuli but that they are not necessarily faster at picking up the related cues (Aron et al., 2010). A recent review described several possible explanations for this differential response in individuals high on sensory processing sensitivity, including stronger emotional reactions, deeper processing of sensory information, and stronger awareness of environmental subtleties as well as being easily overstimulated (Homberg, Schubert, Asan, & Aron, 2016).

Although intriguing, most of these studies have important limitations when it comes to generalizability to temperamental perceptual sensitivity measured with the commonly used Rothbart scales (vs. observed perceptual sensitivity or measured with the HSPS), which have been developed to measure perceptual sensitivity from infancy through adulthood. Many studies also have limitations regarding generalizability to children. In this randomized, between-groups experiment, therefore, we exposed school-aged children to different emotional facial expressions and vocalizations, and subsequently tested whether parent-reported perceptual sensitivity (using the TMCQ) predicted children's motor (*f*EMG) and self-reported affective reactivities to these expressions. Children's motor reactivity might be an important measure of differences in the perception of and reactivity to social–emotional cues because this reaction is thought to happen very quickly, possibly even before conscious cognitive processing of the respective emotions (Dimberg, Thunberg, & Elmehed, 2000; Gainotti, 2012; Wexler, Warrenburg, Schwartz, & Janer, 1992). Motor reactivity has in turn been argued to be related to emotion perception (Neal & Chartrand, 2011), affect (Hess & Blairy, 2001), and empathy (Dimberg, Andréasson, & Thunberg, 2011). We expected that children who scored high on perceptual sensitivity would show higher motor reactivity, and subsequent affective reactivity, to both positive and negative emotions than children who scored lower on this trait.

Temperament–parenting interactions

In addition to child temperament, the environment in which children grow up contributes to the development of their perceptions of, and responses to, social–emotional cues (Dishion & Patterson, 2006; Lemerise & Arsenio, 2000). Specifically, exposure to positive or negative parental emotions, frequently accompanying positive and negative parenting behavior, has been negatively related to children's processing of social–emotional cues (Aktar et al., 2016; De Haan, Belsky, Reid, Volein, & Johnson, 2004; Field, Diego, & Hernandez-Reif, 2009; Joormann, Talbot, & Gotlib, 2007). Frequent exposure to certain emotions in the parenting context, therefore, might affect children's reactivity to these emotions. For example, young children with highly positive mothers were found to pay less visual attention to happy facial expressions than children of mothers with less positive emotions (De Haan et al., 2004). Similarly, maternal negative affect was found to decrease infants' attention (measured with infants' pupil dilation) to neutral objects that had been previously paired with different emotional facial expressions (Aktar et al., 2016). It might be that, besides temperamental dispositions, parenting behavior also affects how (quickly and/or thoroughly) children process social–emotional cues and/or how sensitive children are to these cues.

In addition to the individual contributions of temperament and parenting behavior, these factors may work together in predicting reactivity to emotional facial expressions and vocalizations. A recent meta-analysis indeed shows that parenting experiences and temperament consistently interact in predicting child behavior (Slagt, Dubas, Deković, & Aken, 2016). For example, infants' temperament moderated the effects of mothers' negative affect on infants' responses to emotion facial expressions (Aktar et al., 2016). Similarly, during adolescence it was shown that sensory sensitivity moderated the relation between positive parenting experiences during childhood and current reactivity to positive emotions (Jagiellowicz et al., 2016).

Therefore, in the current study we also looked at the interplay between perceptual sensitivity and positive and negative parenting behavior in predicting children's reactivity to emotions. Our analyses on these temperament by parenting interactions are, however, exploratory in nature. It might be that the direction and/or strength of the relation between parenting and reactivity to emotions depend on children's perceptual sensitivity. One possibility is that perceptual sensitivity causes children to be more susceptible to their surroundings and specifically parenting behavior. Because highly perceptual children are faster at picking up and processing social–emotional cues, it might be that the relation between parenting behavior and children's reactivity to social–emotional cues is stronger (for better and for worse) for children high on perceptual sensitivity than for children low on perceptual sensitivity (i.e., differential susceptibility; Belsky, 1997). Another possibility is that parenting has differential effects on reactivity to emotions for children based on their perceptual sensitivity. For example, parental behavior might have an additive effect on reactivity for some children (i.e., positive relationship) but a buffering effect for other children (i.e., negative relation) due to their perceptual sensitivity (for previous indications of such crossover effects, see Aktar et al., 2016; Jagiellowicz et al., 2016).

Method

Participants

Participants were 521 children (52.5% boys) aged 6–13 years (M = 9.72 years, SD = 1.51) and one of their parents (61.1% mothers; M_{age} = 42.45 years, SD = 4.68) recruited in Science Centre NEMO Amsterdam in The Netherlands. Most children (90.0%) were from Dutch ancestry and were living with both parents (84.8%). More than half of parents (63.7%) were higher educated (i.e., completed university or higher vocational educational tracks), around a third (30.8%) completed lower vocational training, and 5.1% completed primary or high school (0.4% were classified as "other").

Procedure

For all children, we obtained active, informed, written parental consent. Only children accompanied by their parent(s) or legal guardian(s) were allowed to participate in the study. Children aged 12 or 13 years also signed an active informed consent form. Based on their ID numbers, children were randomly assigned to one of three experimental conditions: happy, angry, or neutral. Children took part in a 30-min pretest–posttest experimental procedure in which their motor and affective reactivities to video clips of dynamic facial expressions and vocalizations were assessed. Children's motor reactivity was assessed through *f*EMG measures of the zygomaticus or "smile" muscle (an electrode was placed on the cheek) and the corrugator or "frown" muscle (an electrode was placed just above the eyebrow) before and during exposure to the video clips. Children's affective reactivity was assessed through self-reported affect both before and after exposure to the video clips. In a separate room, parents completed a digital questionnaire on their parenting behavior and children's temperament. Approval for this study was received from the medical ethical board of the Utrecht Medical Center (Protocol No. 12-634/K).

Stimulus material

Children watched four standardized video clips, each lasting approximately 400 ms, displaying either happy, angry, or neutral facial expressions (Amsterdam Dynamic Facial Expression Set; Van der Schalk, Hawk, Fischer, & Doosje, 2011). The clips showed two Dutch male and two Dutch female models starting with neutral facial expressions, after which they gradually started to express the target emotion while turning toward the viewer. The clips were synchronized with nonlinguistic vocalizations of the target emotion that were intense yet natural—laughing in the happy condition, growling in the angry condition, or clicking of the tongue in the neutral condition (Hawk, Fischer, & Van Kleef, 2012).

Measures

Motor reactivity: fEMG measure

During exposure to the stimulus material, bipolar EMG recordings were made from children's left zygomaticus major and left corrugator supercilii muscles (guidelines by Fridlund & Cacioppo, 1986) using five 2-mm surface Ag/AgCl electrodes filled with conductive paste. Raw EMG recordings were made with a portable digital recorder for preprocessing and storage of physiological data (Vitaport 3, TEMEC Instruments, Kerkrade, The Netherlands). Signals were anti-aliasing filtered using a 512-Hz low-pass filter and were digitized at 1024 Hz.

Differential EMG signals were filtered offline (high-pass 20 Hz, 48 dB/octave) and rectified using Brain Vision Analyzer software (Brain Products, Munich, Germany). Raw EMG data were segmented into 100-ms epochs. For each video clip, a 100-ms baseline (i.e., neutral expression at the start of the clip) and a 100-ms reaction epoch (i.e., at the onset of the dynamic expression) was selected (cf. Deschamps, Munsters, Kenemans, Schutter, & Matthys, 2014), resulting in four baseline and four reaction epochs per child. For each child, these epochs were taken together, resulting in one mean baseline score and one mean reaction score. Because we applied this very strict *f*EMG baseline measure consisting of separate baseline epochs of all four clips, conditions did differ on baseline scores of both muscles ($ps < .01$). These differences can be explained by "carryover" effects of muscle response to previous clips to baseline measure of the next clip (e.g., corrugator muscle frown to anger clip 1 onto baseline epoch of anger clip 2). Absolute scores of 3 standard deviations above the mean were considered extreme outliers and removed. Due to technical problems and measurement errors, measures from 47 children on both muscles were missing. These measures were mostly unsuccessful due to (a) equipment failure (e.g., empty batteries, technological problems), (b) inability to sufficiently reduce environmental "noise" coming from the science center interfering with the measurement, or (c) children moving during or wishing to prematurely terminate the *f*EMG procedure. These 47 children did not differ from children with successful *f*EMG measures on age, gender, or parent-reported parenting or temperament ($ps > .11$).

Affective reactivity: child self-report

Twice, both before and after exposure to the stimulus material (i.e., baseline and response), children answered questions about their affective state (i.e., mood) using a visualized 5-point Likert scale (1 = *not at all* to 5 = *totally*) adapted from Reijntjes et al. (2011). The questionnaire consisted of 3 questions (synonyms) capturing the basic emotions of anger, fear, sadness, and happiness. All 12 items were formulated in the same way (e.g., "At this moment I feel *angry*") and together formed four scales. Responses were averaged per emotion. Reliability was satisfactory for all separate emotions (Cronbach αs between .76 and .85) and did not vary by children's age. Because of high correlations ($rs = .61–.71$) among the three negative emotions of anger, fear, and sadness, these emotions were grouped together to form a negative affect scale (vs. happiness as a positive affect scale) for further analyses. Pretest and posttest mean scores were between 1 and 5. Reliability of this negative affect scale was good (Cronbach $\alpha s = .89$ at baseline and .91 at response).

Perceptual sensitivity

The perceptual sensitivity scale of the TMCQ (Simonds, Kieras, Rueda, & Rothbart, 2007; Simonds & Rothbart, 2004) was used. The scale was translated (as well as back-translated by a native speaker) for use in this study. This questionnaire is based on the Child Behavior Questionnaire and assesses characteristics of temperament in school-aged children. The items were answered by parents on a 5-point Likert scale (1 = *almost never true for my child* to 5 = *almost always true for my child*) or with "not applicable." The scale score was formed by averaging item scores for all completed items. Scale scores ranged from 1.60 to 5.00. Reliability of the scale was satisfactory (Cronbach $\alpha = .82$). For analyses, perceptual sensitivity was coded into three groups: low (0: 1 SD below the mean; $n = 70$), medium (1: mean ± 1 SD; $n = 313$), and high (2: 1 SD above the mean; $n = 82$).

Parenting behavior

The Alabama Parenting Questionnaire (APQ; Shelton, Frick, & Wootton, 1996; Dutch translation by Van Lier, Verhulst, Ende, & Crijnen, 2003) was used to measure positive and negative parenting behavior. Negative parenting behaviors, such as harsh parenting and corporal punishment, are related to negative parental expressed emotions. Similarly, positive parenting behaviors, such as involvement and praise, are related to positive parental expressed emotions (Crandall, Deater-Deckard, & Riley, 2015; Dix, 1991; Duncombe, Havighurst, Holland, & Frankling, 2012). The questionnaire consists of 35 items that make up the scales involvement (10 items; e.g., "You have a friendly talk with your child"), poor monitoring (10 items; e.g., "Your child is out with friends you do not know"), positive parenting (6 items; e.g., "You praise your child if he/she behaves well"), corporal punishment (3 items; e.g., "You slap your child if he/she has done something wrong"), inconsistent discipline (6 items; e.g., "The punishment you give your child depends on your mood"), and "other." Parents filled out how often they use the described practices using a 5-point Likert scale (1 = *never* to 5 = *always*). Following previous studies (e.g., Prevatt, 2003), scores from items on the involvement and positive parenting scales were combined to create a "supportive/positive parenting" scale and scores from the corporal punishment, poor monitoring, and inconsistent discipline scales were combined to create a "harsh/negative parenting" scale. The "other" scale was not used because of its lack of specificity. Scale scores were between 2.63 and 4.88 for positive parenting and between 1.06 and 3.00 for negative parenting. Reliability of both scales was good (Cronbach αs of .81 for positive parenting and .76 for negative parenting).

Results

Preliminary analyses

Table 1 shows that boys in our sample were a little older than girls. In addition, parents who reported more positive parenting behavior also reported less negative parenting behavior, had younger children, and scored their children higher on perceptual sensitivity. Parents who reported

Table 1
Correlations among descriptive variables, child temperament, baseline muscle activity, affect, and parenting measures.

	M (*SD*)	1	2	3	4	5	6	7	8	9
1. Gender	52.5% boys	–	−.10*	.07	−.04	.00	−.01	.07	.07	−.00
2. Age	9.72 (1.51)	–	–	−.08	−.06	.05	−.25**	.05	−.12*	.13**
3. Perceptual sensitivity	3.47 (0.69)	–	–	–	−.05	−.06	−.05	.03	.29**	−.07
4. Baseline corrugator	7.82 (5.17)	–	–	–	–	.18**	.05	.01	.02	−.05
5. Baseline zygomaticus	10.58 (8.15)	–	–	–	–	–	.07	.07	−.03	−.06
6. Pretest negative affect (self-report)	1.36 (0.69)	–	–	–	–	–	–	−.32**	.03	−.05
7. Pretest positive affect (self-report)	4.24 (0.77)	–	–	–	–	–	–	–	−.02	.02
8. Positive parenting	3.99 (0.36)	–	–	–	–	–	–	–	–	−.26**
9. Negative parenting	1.77 (0.32)	–	–	–	–	–	–	–	–	–

Note: * $p < .05$; ** $p < .10$.

more negative parenting had older children. Older children reported less negative affectivity at pretest. Children who reported less negative affect at pretest also reported more positive affect at pretest. Finally, higher zygomaticus activity (i.e., more zygomaticus muscle activity) at baseline was related to higher corrugator activity at baseline. Both *f*EMG and self-reported data had skewed distributions; negative affect (2.75, *SD* = 0.12), zygomaticus response (1.45, *SD* = 0.12), and corrugator response (1.17, *SD* = 0.12) were positively skewed, and positive affect (−1.24, *SD* = 0.12) was negatively skewed. Therefore, we used a bootstrapping procedure for the analyses.

Randomization check

Chi-square and multivariate analysis of variance (MANOVA) tests showed no differences between conditions on children's age, gender, and child-reported emotions at baseline or on parent-reported parenting behavior or child temperament (*ps* > .54), indicating successful randomization.

Manipulation check

We examined the effect of experimental condition on children's motor and affective responses to the facial expressions using multivariate analyses of covariance (MANCOVAs) with condition as predictor, controlling for baseline *f*EMG activity and self-reported emotion scores by taking them into account as covariates in the model. Separate analyses were conducted for motor and affective reactivities because they were not systematically related (as found in previous studies; e.g., Hubbard et al., 2004). Analyses showed that condition (happy, angry, or neutral facial expressions and vocalizations) had a small but significant effect on both motor reactivity [$N = 449$; Wilks' lambda = .90, $F(4, 886) = 12.55$, $p < .001$, partial $\eta^2 = .05$] and affective reactivity [$N = 518$; Wilks' lambda = .93, $F(4, 1024) = 9.43$, $p < .001$, partial $\eta^2 = .04$]. Children exposed to the happy expressions showed the highest zygomaticus response (i.e., strongest smile) and the highest response score for positive affect (i.e., happiness) but showed the lowest for negative affect (i.e., anger, sadness, and fear) of all conditions. Children exposed to angry expressions showed the highest corrugator response (i.e., strongest frown) and the lowest response score for positive affect but showed the highest for negative affect of all conditions. Overall, these findings indicate successful manipulation of emotional reactivity. See Table 2 for descriptive statistics of the outcome measures per condition and per perceptual sensitivity group.

Effects of perceptual sensitivity and parenting effects on children's fEMG

We examined the effect of children's perceptual sensitivity and parenting on children's motor reactivity (i.e., *f*EMG), and the interaction between the two, using MANCOVAs, again controlling for baseline (Tables 3 and 4). Results showed that perceptual sensitivity had a significant effect on children's motor reactivity to stimuli both across conditions (i.e., direct effect of perceptual sensitivity independent of emotion) and between conditions (i.e., Condition × Perceptual Sensitivity Effect) (Table 4). Moreover, there were perceptual sensitivity × Positive Parenting and Condition × Perceptual Sensitivity × Positive Parenting interactions (Table 4). Perceptual sensitivity worked together with parents' positive parenting behavior in predicting children's motor reactivity, again both independent of the type of emotion children were exposed to and specifically across the different emotions.

Post hoc exploration of the results on perceptual sensitivity showed that these were specifically significant for zygomaticus reactivity. Univariate analyses on zygomaticus response for each separate experimental condition showed that in both the anger and joy conditions, but not in the neutral condition, there was a significant effect of perceptual sensitivity [joy: $n = 145$, $F(2, 125) = 4.77$, $p = .01$, partial $\eta^2 = .07$, $\beta - 1 = .79$; anger: $n = 132$, $F(2, 137) = 4.71$, $p = .01$, partial $\eta^2 = .06$, $\beta - 1 = .78$; neutral: $n = 145$, $F(2, 145) = 0.26$, $p = .77$, partial $\eta^2 = .00$, $\beta - 1 = .09$]. See Table 2 for descriptive statistics per condition and per perceptual sensitivity group. Because our grouping procedure was exploratory, we conducted a robustness check by rerunning the analysis using perceptual sensitivity both as a continuum and as a dichotomous measure (1 SD above the mean vs. others) to see whether the way in which perceptual sensitivity was grouped influenced our findings. We replicated the above-described finding using perceptual sensitivity as a continuous score (see Table S1 in online supplementary material). However, when analyzing perceptual sensitivity as a dichotomous score, the findings on parenting remained ($p = .04$), but the findings on perceptual sensitivity ($p = .09$) and the

Table 2
Mean outcome measures at posttest per condition and per perceptual sensitivity group (high, medium, or low).

Variable	Happy (n = 170)								Angry (n = 172)								Neutral (n = 179)							
	All		High PS		Medium PS		Low PS		All		High PS		Medium PS		Low PS		All		High PS		Medium PS		Low PS	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Zygomaticus	12.13	7.35	13.96	8.73	11.64	6.90	12.67	8.11	10.40	6.91	9.06	4.95	10.21	6.74	12.04	7.49	7.06	6.56	7.56	6.65	6.98	6.70	7.28	7.03
Corrugator	6.11	3.18	7.01	3.97	6.26	3.16	4.82	2.13	9.42	5.22	8.50	4.59	9.61	5.49	9.83	5.02	7.52	6.30	10.74	7.36	6.66	5.76	7.20	6.53
Positive affect	4.27	0.85	4.50	0.56	4.19	0.88	4.25	0.93	4.01	0.93	3.99	0.88	4.02	0.95	4.05	0.92	4.21	0.82	4.13	0.95	4.20	0.85	4.22	0.69
Negative affect	1.26	0.49	1.30	0.74	1.23	0.48	1.38	0.89	1.46	0.70	1.39	0.58	1.49	0.77	1.42	0.49	1.32	0.60	1.40	0.60	1.33	0.69	1.23	0.40

Table 3
Multivariate results of condition, perceptual sensitivity, and positive parenting on fEMG response, controlled for baseline measures.

	Wilks' lambda	F	df	df_{error}	p	Partial η^2	$\beta - 1$
All children with complete data (n = 409)							
Condition	.98	1.95	4.00	772.00	.10	.01	
Perceptual sensitivity	.95	4.86	4.00	772.00	.001	.03	
Positive parenting	.99	1.73	2.00	386.00	.18	.01	
Perceptual Sensitivity × Positive Parenting	.95	4.72	4.00	772.00	.001	.02	.95
Condition × Perceptual Sensitivity	.96	2.19	8.00	772.00	.03	.02	.86
Condition × Positive Parenting	.99	1.49	4.00	772.00	.20	.01	.46
Condition × Perceptual Sensitivity × Positive Parenting	.96	2.13	8.00	772.00	.03	.02	.85

Table 4
Multivariate results of condition, perceptual sensitivity, and negative parenting on fEMG response, controlled for baseline measures.

	Wilks' lambda	F	df	df_{error}	p	Partial η^2	$\beta - 1$
All children with complete data (n = 409)							
Condition	.99	0.79	4.00	772.00	.53	<.01	
Perceptual sensitivity	.98	2.12	4.00	772.00	.08	.01	
Negative parenting	1.00	0.34	2.00	386.00	.71	<.00	
Perceptual Sensitivity × Negative Parenting	.98	2.44	4.00	772.00	.05	.01	.71
Condition × Perceptual Sensitivity	.97	1.49	8.00	772.00	.16	.02	.67
Condition × Negative Parenting	.99	1.04	4.00	772.00	.39	.01	.33
Condition × Perceptual Sensitivity × Negative Parenting	.97	1.45	8.00	772.00	.17	.02	.66

interaction between perceptual sensitivity and parenting (p = .08) became nonsignificant. This might indicate that the findings are sensitive to different groupings. More likely, however, this difference is due to the lower power found in the dichotomous analysis compared with the categorical analysis, specifically in the joy condition (it has been shown that dichotomizing a variable can decrease power; see MacCallum, Zhang, Preacher, & Rucker, 2002).

In the joy condition, children relatively high on perceptual sensitivity (i.e., scoring at least 1 SD above the mean) ($M_{zygomaticus}$ = 13.96, SD = 8.73, 95% confidence interval [CI] = 10.28–18.21) showed the highest zygomaticus activity (i.e., representing the strongest smile) after exposure to the happy facial expressions, followed by children scoring relatively low on perceptual sensitivity (i.e., scoring at least 1 SD below the mean) ($M_{zygomaticus}$ = 12.67, SD = 8.11, 95% CI = 9.56–15.79) and finally children scoring around the mean ($M_{zygomaticus}$ = 11.64, SD = 6.90, 95% CI = 10.26–13.07). This might indicate that perceptual sensitivity is not linearly related to reactivity to positive emotion cues but rather that this relation might be U-shaped. U-shaped relations between emotion and cognition have also been proposed for memory and impulsivity (e.g., Helminen, Pasanen, & Hietanen, 2016; Plichta & Scheres, 2014). However, empirical evidence for such U-shaped relations is largely missing (for a review, see Plichta & Scheres, 2014). Therefore, we tested for nonlinear relations between perceptual sensitivity and zygomaticus activity (both alone and in interaction with positive parenting) in the joy condition using a quadratic continuous score for perceptual sensitivity. The results were not significant (see Table S3 in supplementary material).

In the anger condition, children scoring high on perceptual sensitivity showed the lowest zygomaticus activity ($M_{zygomaticus}$ = 9.06, SD = 4.95, 95% CI = 7.21–11.33) after exposure to angry facial expressions, followed by children scoring around the mean ($M_{zygomaticus}$ = 9.87, SD = 6.12, 95% CI = 8.71–11.16) and children scoring low on perceptual sensitivity ($M_{zygomaticus}$ = 12.05, SD = 7.48, 95% CI = 9.37–15.14).

Post hoc analyses of the interaction effects with positive parenting showed that in both the anger and joy conditions, but not in the neutral condition, there was a significant interaction effect between perceptual sensitivity and positive parenting [joy: $F(2, 125) = 4.42$, $p = .01$, partial $\eta^2 = .07$, $\beta - 1 = .75$; anger: $F(2, 137) = 4.41$, $p = .01$, partial $\eta^2 = .06$, $\beta - 1 = .75$; neutral: $F(2, 145) = 0.37$, $p = .69$, partial $\eta^2 = .01$, $\beta - 1 = .11$]. Again, this finding was replicated using perceptual sensitivity both as a dichotomous score (1 SD above the mean vs. others) and as a continuous score (see Tables S1 and S2 in supplementary material). Inspection of Figs. 1 and 2 shows that positive parenting behavior has seemingly opposite effects for children scoring high on perceptual sensitivity and children scoring low or around the mean. To further explore the effects of positive parenting on children's reactivity to joy and anger, we tested the effect of positive parenting within the three perceptual sensitivity groups. In the joy condition, for children scoring high or around the mean on perceptual sensitivity, positive parenting had no significant effect on their reactivity to joy (high: $\beta = .04$, $p = .58$; mean: $\beta = -.01$, $p = .72$), whereas for children scoring low on perceptual sensitivity, positive parenting behavior seemed to lower their reactivity to joy ($\beta = -.16$, $p = .03$).

In the anger condition, for children scoring low on perceptual sensitivity, positive parenting seemed to have no effect on their reactivity to anger ($\beta = -.08$, $p = .42$). For children scoring around the mean on perceptual sensitivity, positive parenting behavior seemed to lower their reactivity to anger ($\beta = -.11$, $p = .03$), whereas a (marginally significant) positive effect suggested that positive parenting raised reactivity to anger among highly perceptual sensitive children ($\beta = .29$, $p = .06$). The simple slopes of positive parenting for the medium and high perceptual sensitivity groups indeed significantly differed from one another ($t = 2.69$, $df = 121$, $p < .01$).

Effects of perceptual sensitivity and parenting effects on children's self-reported affect

We examined the effects of children's perceptual sensitivity and parenting on children's self-reported affective reactivity, and the interaction between the two, using MANCOVAs, again controlling for baseline (Tables 5 and 6). The results showed that positive parenting predicted children's self-reported affect at posttest independent of condition (Table 5). Post hoc analyses showed that it specifically predicted positive affect ($\beta = .14$, $p < .001$). Negative parenting did not have a significant effect. In addition, no effects of perceptual sensitivity, either alone or in interaction with parenting behavior, on self-reported affective reactivity were found.

Discussion and conclusion

Children may partly differ in reactivity to social–emotional information because they differ in the threshold for perceiving such information in general (Phillips et al., 2003). Although such perceptual sensitivity is part of the highly influential model of temperament by Rothbart (Rothbart & Derryberry,

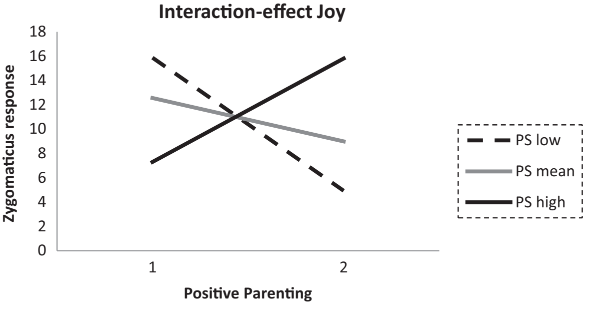

Fig. 1. Interaction effect between perceptual sensitivity (PS) and positive parenting (1 = below mean, 2 = above mean) on zygomaticus effectivity to happy facial expressions.

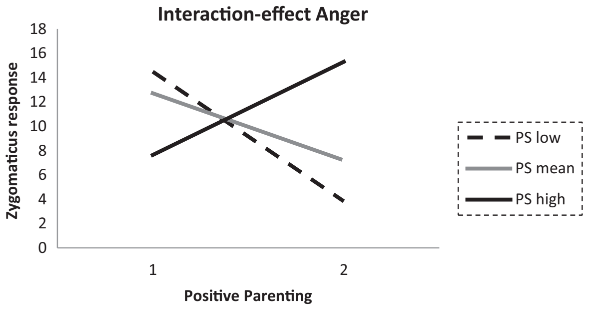

Fig. 2. Interaction effect between perceptual sensitivity (PS) and positive parenting (1 = below mean, 2 = above mean) on zygomaticus effectivity to angry facial expressions.

Table 5
Multivariate results of condition, perceptual sensitivity, and positive parenting on self-reported affective response, controlled for baseline measures.

	Wilks' lambda	*F*	*df*	df_{error}	*p*	Partial η^2	$\beta - 1$
All children with complete data (n = 464)							
Condition	.98	2.05	4.00	882.00	.09	.01	
Perceptual sensitivity	1.00	0.30	4.00	882.00	.88	<.01	
Positive parenting	.98	5.29	2.00	441.00	<.01	.02	
Perceptual Sensitivity × Positive Parenting	1.00	0.30	4.00	882.00	.88	<.01	.12
Condition × Perceptual Sensitivity	.98	1.03	8.00	882.00	.41	.01	.49
Condition × Positive Parenting	.99	1.57	4.00	882.00	.18	.01	.49
Condition × Perceptual Sensitivity × Positive Parenting	.98	0.98	8.00	882.00	.45	.01	.46

Table 6
Multivariate results of condition, perceptual sensitivity, and negative parenting on self-reported affective response, controlled for baseline measures.

	Wilks' lambda	*F*	*df*	df_{error}	*p*	Partial η^2	$\beta - 1$
All children with complete data (n = 464)							
Condition	.99	1.18	4.00	882.00	.32	.01	
Perceptual sensitivity	.98	2.14	4.00	882.00	.07	.01	
Negative parenting	.99	2.41	2.00	441.00	.09	.01	
Perceptual Sensitivity × Negative Parenting	.98	2.29	4.00	882.00	.06	.01	.67
Condition × Perceptual Sensitivity	.99	0.69	8.00	882.00	.70	.01	.33
Condition × Negative Parenting	.99	1.59	4.00	882.00	.17	.01	.50
Condition × Perceptual Sensitivity × Negative Parenting	.99	0.75	8.00	882.00	.65	.01	.35

1981), it has seldom been specifically studied in children. In a between-participant experiment, we tested whether the perceptual sensitivity of school-aged children predicted their motor (*f*EMG) and self-reported affective reactivity to emotional facial expressions and vocalizations. Confirming our primary hypothesis, perceptual sensitivity predicted individual differences in motor reactivity to emotional facial expressions and vocalizations. Furthermore, perceptual sensitivity interacted with positive parenting behavior in predicting this motor reactivity. Therefore, our findings suggest that perceptual sensitivity might indeed provide us with specific information on individual differences in reactivity to social–emotional cues and that this temperament trait interacts with parenting in predicting these differences. Although these findings are intriguing, they also leave us with some questions regarding how exactly these variables contribute to these differences. First we discuss these questions regarding the main effects of perceptual sensitivity, and thereafter we discuss these questions regarding the interaction effects of perceptual sensitivity and parenting behavior.

Main effects of perceptual sensitivity

First of all, the differences in reactivity based on perceptual sensitivity were specific to motor reactivity. No differences were found in self-reported affective reactivity between children based on their perceptual sensitivity score. This might indicate that, although perceptual sensitivity predicted how easily children process positive emotions, it might not predict how strongly children subsequently reflect these emotions in their own emotional state. This is in line with the previous findings of Jagiellowicz et al. (2016) that highly sensitive individuals rate emotionally evocative pictures more quickly, as well as significantly more valenced, than less sensitive individuals but that they are not more aroused by them. The authors suggested that this might be explained by highly perceptual individuals having a high general level of arousal (and, therefore, experiencing smaller changes in arousal after exposure to emotions). Although this is an intriguing thought, in our study we found no evidence for this explanation because perceptual sensitivity was not associated with children's self-reported affect at baseline. An alternative explanation might lie in emotion regulation. Perceptually sensitive individuals might be faster at picking up emotional information and/or might be paying closer attention to such information, facilitating faster and more thorough processing and, as a consequence, faster regulation of emotional arousal (see also Aron et al., 2012; Jagiellowicz et al., 2016). Future research could explore such possible correlates of perceptual sensitivity.

Second, the mean scores of motor reactivity to the happy expressions and vocalizations suggest that children high on perceptual sensitivity showed the strongest smile, followed by children low on perceptual sensitivity and finally children scoring around the mean. Although at first glance the relation between perceptual sensitivity and reactivity might seem to be nonlinear, our post hoc tests showed no quadratic effects. This might indicate that highly perceptually sensitive children show increased reactivity to positive emotion cues compared with less sensitive children. Children high on perceptual sensitivity might have more narrow attention to, processing of, and reactivity to fewer elements in their environment, making them reactive to subtle stimuli. This explanation is, however, speculative. Future research could investigate whether children high on perceptual sensitivity indeed show faster or increased attention to subtle social–emotional cues such as changes in facial expressions. Furthermore, future research could consider taking into account other (related) constructs such as temperamental orienting (see, e.g., Nakagawa & Sukigara, 2012).

In reaction to angry facial expressions and vocalizations, children scoring high on perceptual sensitivity showed the lowest activity of the zygomaticus or the weakest smile, followed by children scoring around the mean and finally children low on perceptual sensitivity. It is important to note that zygomaticus activity in response to anger is difficult to interpret (Lundqvist & Dimberg, 1995). Decreased zygomaticus activity after exposure to anger can be interpreted as a natural side effect of tension in the corrugator muscle, meaning that low activity of the zygomaticus indicates heightened reactivity to anger. Again speculating, this might suggest that children high on perceptual sensitivity show increased reactivity to not only happy emotions but also angry emotions. However, in our experiment prestimuli to poststimuli changes in activity in the two muscles were not related ($r = -.05$, $p = .31$). An alternative explanation is that activity of the zygomaticus in response to anger indicates an ambivalent reaction to anger (e.g., a nervous smile or tension in the jaw). High activity of the zygomaticus after exposure to ambivalent stimuli has been previously found (Nohlen, van Harreveld, Rotteveel, Barends, & Larsen, 2016). This could mean that children high on perceptual sensitivity show decreased reactivity (low activity of the zygomaticus) to angry expressions but show increased reactivity (high activity of the zygomaticus) to happy ones compared with less perceptually sensitive children. Depending on the explanation chosen, highly perceptually sensitive children show increased reactivity to specifically positive emotions or to both positive and negative emotions.

Effects of perceptual sensitivity by parenting behavior

In line with our hypotheses, our results also show that perceptual sensitivity interacts with parenting in predicting motor reactivity to joy and anger. This is consistent with findings of a recent meta-analysis showing that temperament interacts with parenting behavior in predicting child behavior (Slagt et al., 2016). The found interaction was specific for positive parenting (no interaction was found with negative parenting). Our findings suggest that positive parenting has differential effects on children's motor reactivity depending on children's perceptual sensitivity. Positive parenting had a small negative effect on reactivity to joy in children low on perceptual sensitivity but had no effects on children scoring higher on this trait. There are different explanations possible. One possibility is that children low on perceptual sensitivity (compared with children scoring around the mean) are more reactive only to joy when they experience low levels of positive emotions in the family environment. Parental positive emotions might further desensitize these children for positive social–emotional cues. Furthermore, positive parenting seemed to further decrease zygomaticus reactivity to anger in children scoring around the mean on perceptual sensitivity, but possibly raised reactivity to angry faces in children who are higher on this temperamental trait.

Our findings on parenting are therefore not in line with our hypothesis that perceptually sensitive children are uniformly more susceptible to parenting experiences. Rather, they suggest that these children may become particularly insensitive to expressions of anger when their parents are less positive. Alternatively, parents who report a lot of positive parenting might provide children with a sensitive family climate that enables, or even encourages, children to be attuned to the emotions of others independent of how perceptually sensitive these children are naturally.

Limitations

Our findings need to be interpreted in light of some limitations. First of all, as could be expected, the emotional stimuli had only small effects on motor reactivity and specifically affective reactivity. Therefore, individual differences in reactivity to these stimuli were also small. Our study included an experimental design in a lab setting with very brief stimuli of emotion expressions of strangers. It is to be expected that reactivity in real-life situations, including familiar people (such as parents), would evoke stronger reactivity in children. Future research could include observational measures of reactivity to social–emotional cues during parent–child interactions. Although our sample size was large, these small effects of the manipulation are likely to influence power in a negative way (in our case specifically our analyses including children's self-reported affect yielded low power). Future research should keep in mind that large samples might be necessary to further investigate the effects of perceptual sensitivity on reactivity to subtle cues. Furthermore, although dichotomizing or categorizing a variable such as perceptual sensitivity can help with the interpretation of moderation effects (i.e., interactions), it can also lead to a further decrease of power (and has other methodological drawbacks; see MacCallum et al., 2002).

Second, on average, our sample consisted of highly educated Dutch parents who reported relatively low levels of negative parenting behavior and high levels of positive parenting behavior. Therefore, parents scoring below average on positive parenting behavior might overall still have been parents who frequently show positive behavior and emotions toward their children. Compared with a German norm group (data of parents of 1219 German schoolchildren; Essau, Sasagawa, & Frick, 2006), our sample scored relatively high not only on positive parenting and involvement (above the 90th percentile) but also on inconsistent discipline (above the 90th percentile) and poor monitoring and scored low on corporal punishment. Our sample, therefore, might also not be generalizable to other samples or countries. Moreover, parents might have a general tendency to report more positively about their own behaviors than other informers would (Gardner, 2000). Future research could avoid this limitation by using a multi-informant approach for the assessment of parenting behavior.

Third, parents reported on both child perceptual sensitivity and their own parenting behavior. These reports are likely to be interrelated. We indeed found positive parenting to be (modestly) positively related to children's perceptual sensitivity. Parents who report high positive parenting might be more sensitive parents who more readily notice their children being perceptive in comparison with parents who report low levels of positive parenting. Moreover, it has been found that parenting by temperament interactions are more pronounced when parenting is assessed using observations instead of parental self-reports (Slagt et al., 2016). Therefore, using observations on parenting behavior might increase power to detect such temperament by parenting interactions and provide us with more clear information on the unique contribution of parenting here. Furthermore, it would be interesting to compare our results on perceptual sensitivity with results for other temperament traits. Future research could explore the specificity of the relationship between perceptual sensitivity and reactivity to emotion cues or whether this relation might be (partly) explained by confounding traits such as negative emotionality and orienting.

Strengths

An important strength of our study is the use of a large controlled experiment to assess reactivity to emotion cues in a large community sample. We successfully assessed children's reactivity to standardized stimuli containing expressions of both negative and positive emotions. We used a multi-method, multi-informant approach using both observed motor and self-reported affective reactivity measures as well as parent reports on perceptual sensitivity and parenting. As a result, we are able to rule out alternative explanations for the relation between sensitivity and reactivity, for example, that individuals who report that they are sensitive will also report that they are more reactive. Furthermore, we took into account a largely overlooked process of reactivity to emotional stimuli by looking at perceptual sensitivity. In addition, in investigating individual differences in reactivity to emotion cues, we took into account not only children's temperament but also parenting and the interaction between the two. Our findings add to the evidence that temperament interacts with parenting experiences in shaping individual differences in reactivity to the environment (Slagt et al., 2016).

In sum, our findings suggest that perceptual sensitivity has implications for children's reaction to social–emotional cues in their environment beyond the mere detection of low-intensity stimuli. In addition, this temperament trait interacts with positive parenting behavior in predicting individual differences in reactivity to others' emotions. Parenting behavior had differential effects on children's reactivity depending on children's perceptual sensitivity. Because perceptual sensitivity focuses specifically on the perception of cues from the environment, and not on whether these cues cause arousal or whether this arousal is regulated, it might lie at the root of such individual differences.

Acknowledgments

We thank Susan Branje, Jolien van der Graaff, and Dennis Schutter for their help with the collection and processing of the *f*EMG data. We thank Science Centre NEMO Amsterdam (Science Live) for hosting our study.

Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.jecp.2017.06.012.

References

Acevedo, B. P., Aron, E. N., Aron, A., Sangster, M.-D., Collins, N., & Brown, L. L. (2014). The highly sensitive brain: An fMRI study of sensory processing sensitivity and response to others' emotions. *Brain and Behavior, 4*, 580–594.

Aktar, E., Mandell, D. J., de Vente, W., Majdandžić, M., Raijmakers, M. E. J., & Bögels, S. M. (2016). Infants' temperament and mothers' and fathers' depression predict infants' attention to objects paired with emotional faces. *Journal of Abnormal Child Psychology, 44*, 975–990.

Aron, E., & Aron, A. (1997). Sensory-processing sensitivity and its relation to introversion and emotionality. *Journal of Personality and Social Psychology, 73*, 345–368.

Aron, E. N., Aron, A., & Jagiellowicz, J. (2012). Sensory processing sensitivity: A review in the light of the evolution of biological responsivity. *Personality and Social Psychology Review, 16*, 262–282.

Aron, A., Ketay, S., Hedden, T., Aron, E. N., Markus, H. R., & Gabrieli, J. D. (2010). Temperament trait of sensory processing sensitivity moderates cultural differences in neural response. *Social Cognitive and Affective Neuroscience, 5*, 219–226.

Belsky, J. (1997). Theory testing, effect-size evaluation, and differential susceptibility to rearing influence: The case of mothering and attachment. *Child Development, 68*, 598–600.

Boterberg, S., & Warreyn, P. (2016). Making sense of it all: The impact of sensory processing sensitivity on daily functioning of children. *Personality and Individual Differences, 92*, 80–86.

Conradt, E., Measelle, J., & Ablow, J. C. (2013). Poverty, problem behavior, and promise: Differential susceptibility among infants reared in poverty. *Psychological Science, 24*, 235–242.

Crandall, A., Deater-Deckard, K., & Riley, A. W. (2015). Maternal emotion and cognitive control capacities and parenting: A conceptual framework. *Developmental Review, 36*, 105–126.

Crick, N. R., & Dodge, K. A. (1994). A review and reformulation of social information-processing mechanisms in children's social adjustment. *Psychological Bulletin, 115*, 74–101.

De Haan, M., Belsky, J., Reid, V., Volein, A., & Johnson, M. H. (2004). Maternal personality and infants' neural and visual responsivity to facial expressions of emotion. *Journal of Child Psychology and Psychiatry, 45*, 1209–1218.

Deschamps, P., Munsters, N., Kenemans, L., Schutter, D., & Matthys, W. (2014). Facial mimicry in 6–7 year old children with disruptive behavior disorder and ADHD. *PloS One, 9*(1), e84965. http://dx.doi.org/10.1371/journal.pone.0084965.

Dimberg, U., Andréasson, P., & Thunberg, M. (2011). Emotional empathy and facial reactions to facial expressions. *Journal of Psychophysiology, 25*, 26–31.

Dimberg, U., Thunberg, M., & Elmehed, K. (2000). Unconscious facial reactions to emotional facial expressions. *Psychological Science, 11*, 86–89.

Dishion, T., & Patterson, G. (2006). The development and ecology of antisocial behavior. In D. Cicchetti & D. Cohen (Eds.), *Developmental psychopathology, volume 3, risk, disorder, and adaptation* (2nd ed., pp. 503–541). Hoboken, NJ: John Wiley.

Dix, T. (1991). The affective organization of parenting: Adaptive and maladaptative processes. *Psychological Bulletin, 110*, 3–25.

Duncombe, M. E., Havighurst, S. S., Holland, K. A., & Frankling, E. J. (2012). The contribution of parenting practices and parent emotion factors in children at risk for disruptive behavior disorders. *Child Psychiatry and Human Development, 43*, 715–733.

Essau, C. A., Sasagawa, S., & Frick, P. J. (2006). Psychometric properties of the Alabama Parenting Questionnaire. *Journal of Child and Family Studies, 15*, 595–614.

Evans, D. E., & Rothbart, M. K. (2007). Developing a model for adult temperament. *Journal of Research in Personality, 41*, 868–888.

Evans, D. E., & Rothbart, M. K. (2008). Temperamental sensitivity: Two constructs or one? *Personality and Individual Differences, 44*, 108–118.

Field, T., Diego, M., & Hernandez-Reif, M. (2009). Depressed mothers' infants are less responsive to faces and voices. *Infant Behavior and Development, 32*, 239–244.

Fridlund, A. J., & Cacioppo, J. T. (1986). Guidelines for human electromyographic research. *Psychophysiology, 23*, 567–589.

Gainotti, G. (2012). Unconscious processing of emotions and the right hemisphere. *Neuropsychologia, 50*, 205–218.

Gardner, F. (2000). Methodological issues in the direct observation of parent–child interaction: Do observational findings reflect the natural behavior of participants? *Clinical Child and Family Psychology Review, 3*, 185–198.

Grapel, J. N., Cicchetti, D. V., & Volkmar, F. R. (2015). Sensory features as diagnostic criteria for autism: Sensory features in autism. *Yale Journal of Biology and Medicine, 88*, 69–71.

Gross, J. J. (2015). Emotion regulation: Current status and future prospects. *Psychological Inquiry, 26*, 1–26.

Hawk, S. T., Fischer, A. H., & Van Kleef, G. A. (2012). Face the noise: Embodied responses to nonverbal vocalizations of discrete emotions. *Journal of Personality and Social Psychology, 102*, 796–814.

Helminen, T. M., Pasanen, T. P., & Hietanen, J. K. (2016). Learning under your gaze: The mediating role of affective arousal between perceived direct gaze and memory performance. *Psychological Research Psychologische Forschung, 80*, 159–171.

Hess, U., & Blairy, S. (2001). Facial mimicry and emotional contagion to dynamic emotional facial expressions and their influence on decoding accuracy. *International Journal of Psychophysiology, 40*, 129–141.

Homberg, J. R., Schubert, D., Asan, E., & Aron, E. N. (2016). Sensory processing sensitivity and serotonin gene variance: Insights into mechanisms shaping environmental sensitivity. *Neuroscience & Biobehavioral Reviews, 71*, 472–483.

Hubbard, J. A., Parker, E. H., Ramsden, S. R., Flanagan, K. D., Relyea, N., Dearing, K. F., & Ellipsis Hyde, C. T. (2004). The relations among observational, physiological, and self-report measures of children's anger. *Social Development, 13*, 14–39.

Jagiellowicz, J., Aron, A., & Aron, E. N. (2016). Relationship between the temperament trait of sensory processing sensitivity and emotional reactivity. *Social Behavior and Personality: An International Journal, 44*(2), 185–199.

Jagiellowicz, J., Xu, X., Aron, A., Aron, E., Cao, G., Feng, T., & Weng, X. (2010). The trait of sensory processing sensitivity and neural responses to changes in visual scenes. *Social Cognitive and Affective Neuroscience, 6*, 38–47.

Joormann, J., Talbot, L., & Gotlib, I. H. (2007). Biased processing of emotional information in girls at risk for depression. *Journal of Abnormal Psychology, 116*, 135–143.

Lemerise, E. A., & Arsenio, W. F. (2000). An integrated model of emotion processes and cognition in social information processing. *Child Development, 71*, 107–118.

Lundqvist, L.-O., & Dimberg, U. (1995). Facial expressions are contagious. *Journal of Psychophysiology, 9*, 203–211.

MacCallum, R. C., Zhang, S., Preacher, K. J., & Rucker, D. D. (2002). On the practice of dichotomization of quantitative variables. *Psychological Methods, 7*, 19–40.

Nakagawa, A., & Sukigara, M. (2012). Difficulty in disengaging from threat and temperamental negative affectivity in early life: A longitudinal study of infants aged 12–36 months. *Behavioral and Brain Functions, 8*, e40.

Neal, D. T., & Chartrand, T. L. (2011). Embodied emotion perception: Amplifying and dampening facial feedback modulates emotion perception accuracy. *Social Psychological and Personality Science, 2*, 673–678.

Nohlen, H. U., van Harreveld, F., Rotteveel, M., Barends, A. J., & Larsen, J. T. (2016). Affective responses to ambivalence are context-dependent: A facial EMG study on the role of inconsistency and evaluative context in shaping affective responses to ambivalence. *Journal of Experimental Social Psychology, 65*, 42–51.

Phillips, M. L., Drevets, W. C., Rauch, S. L., & Lane, R. (2003). Neurobiology of emotion perception: I. The neural basis of normal emotion perception. *Biological Psychiatry, 54*, 504–514.

Plichta, M. M., & Scheres, A. (2014). Ventral–striatal responsiveness during reward anticipation in ADHD and its relation to trait impulsivity in the healthy population: A meta-analytic review of the fMRI literature. *Neuroscience & Biobehavioral Reviews, 38*, 125–134.

Prevatt, F. F. (2003). The contribution of parenting practices in a risk and resiliency model of children's adjustment. *British Journal of Developmental Psychology, 21*(4), 469–480. http://dx.doi.org/10.1348/026151003322535174.
Putnam, S. P., Rothbart, M. K., & Gartstein, M. A. (2008). Homotypic and heterotypic continuity of fine-grained temperament during infancy, toddlerhood, and early childhood. *Infant and Child Development, 17*, 387–405.
Reijntjes, A., Thomaes, S., Kamphuis, J. H., Bushman, B. J., de Castro, B. O., & Telch, M. J. (2011). Explaining the paradoxical rejection–aggression link: The mediating effects of hostile intent attributions, anger, and decreases in state self-esteem on peer rejection-induced aggression in youth. *Personality & Social Psychology Bulletin, 37*, 955–963.
Rothbart, M. K., Ahadi, S. A., Hershey, K. L., & Fisher, P. (2001). Investigations of temperament at three to seven years: The Children's Behavior Questionnaire. *Child Development, 72*, 1394–1408.
Rothbart, M. K., & Derryberry, D. (1981). Development of individual differences in temperament. In M. E. Lamb & A. L. Brown (Eds.). *Advances in developmental psychology* (Vol. 1, pp. 37–66). Hillsdale, NJ: Lawrence Erlbaum.
Shelton, K. K., Frick, P. J., & Wootton, J. (1996). Assessment of parenting practices in families of elementary school-age children. *Journal of Clinical Child Psychology, 25*, 317–329.
Simonds, J., & Rothbart, M. K. (2004, October). *The Temperament in Middle Childhood Questionnaire (TMCQ): A computerized self-report measure of temperament for ages 7–10*. Poster presented at the Occasional Temperament Conference, Athens, GA.
Simonds, J., Kieras, J. E., Rueda, M. R., & Rothbart, M. K. (2007). Effortful control, executive attention, and emotional regulation in 7- to 10-year-old children. *Cognitive Development, 22*, 474–488.
Slagt, M., Dubas, J., Deković, M., & Aken, Van. (2016). Differences in sensitivity to parenting depending on child temperament: A meta-analysis. *Psychological Bulletin, 142*, 1068–1110.
Smolewska, K. A., McCabe, S. B., & Woody, E. Z. (2006). A psychometric evaluation of the Highly Sensitive Person Scale: The components of sensory-processing sensitivity and their relation to the BIS/BAS and "Big Five". *Personality and Individual Differences, 40*, 1269–1279.
Van der Schalk, J., Hawk, S. T., Fischer, A. H., & Doosje, B. (2011). Moving faces, looking places: Validation of the Amsterdam Dynamic Facial Expression Set (ADFES). *Emotion, 11*, 907–920.
Van Lier, P. A., Verhulst, F. C., Ende, J., & Crijnen, A. A. (2003). Classes of disruptive behaviour in a sample of young elementary school children. *Journal of Child Psychology and Psychiatry, 44*(3), 377–387. http://dx.doi.org/10.1111/1469-7610.00128.
Wexler, B. E., Warrenburg, S., Schwartz, G. E., & Janer, L. D. (1992). EEG and EMG responses to emotion-evoking stimuli processed without conscious awareness. *Neuropsychologia, 30*, 1065–1079.