Biological Psychology 103 (2014) 242–247

Contents lists available at ScienceDirect

Biological Psychology

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

Oppositionality and sympathetic skin response in adolescents: Specific associations with the headstrong/hurtful dimension

Nanucha Teixeira da Silva[a,d,*], Pedro Schestatsky[a,b], Pablo Brea Winckler[c], Giovanni Abrahão Salum[a], Alana Wypyszynski Petroceli[d], Elizeth Paz da Silva Heldt[a,d]

[a] Postgraduate Program in Medical Sciences: Psychiatry, School of Medicine, Federal University of Rio Grande do Sul (UFRGS), 2400 Ramiro Barcelo Street, 90035-003 Porto Alegre, RS, Brazil
[b] Department of Internal Medicine, UFRGS, 2400 Ramiro Barcelo Street, 90035-003 Porto Alegre, RS, Brazil
[c] Postgraduate Program in Medical Sciences, School of Medicine, Federal University of Rio Grande do Sul (UFRGS), 2400 Ramiro Barcelo Street, 90035-003 Porto Alegre, RS, Brazil
[d] Research Group on Child and Adolescence Behavior (GECIA), Hospital de Clínicas de Porto Alegre, 2350 Ramiro Barcelos Street, 90035-903 Porto Alegre, RS, Brazil

A R T I C L E I N F O

Article history:
Received 7 January 2014
Accepted 16 September 2014
Available online 5 October 2014

Keywords:
Oppositional defiant disorder
Aggression
Adolescent
Sympathetic skin responses
Electrodermal response

A B S T R A C T

Oppositionality encompasses distinct dimensions, and few studies have investigated the validity of such distinctions from a pathophysiological perspective. Our aim was to investigate the association between sympathetic skin responses (SSR) and distinct oppositional dimensions in a community sample of adolescents. Forty adolescents aged 13.84 ± 1.46 years participated in this study. Oppositionality was measured by externalizing behavior and bullying scores (dependent variables), while SSR was recorded by electrical changes at the skin level (independent variables). Results showed that increased SSRs were associated with oppositionality; however, these associations were specific to the headstrong/hurtful dimension. Further exploratory analyses demonstrated that increased SSRs were associated with several types of headstrong/hurtful behaviors and underscore the importance of the first aversive stimuli to differentiate groups with low and high headstrong/hurtful behaviors. There were no differences between groups regarding time until habituation. This study provides insights about how dysfunctions in autonomic balance may contribute to the emergence of oppositional behavior among adolescents.

1. Introduction

Pathological oppositional behaviors in childhood are common and can lead to a variety of negative outcomes in early adult life, such as antisocial and criminal behavior (Aebi, Plattner, Metzke, Bessler, & Steinhausen, 2013; Moffitt, Caspi, Harrington, & Milne, 2002), bullying behavior (Vaughn et al., 2010), major depression, and substance abuse and dependence (Aebi et al., 2013; Biederman et al., 2008). In children, oppositionality is associated with both internalizing and externalizing symptoms (Burke, 2012; Kessler, Petukhova, & Zaslavsky, 2011; Nobile et al., 2013). This pattern of associations has led to the proposition that oppositionality is a heterogeneous psychopathological dimension that might encompass qualitatively distinct expressions of disruptive behaviors (Rowe, Costello, Angold, Copeland, & Maughan, 2010). Understanding distinct sub-dimensions within oppositionality might have important implications for both etiology and therapeutic strategies.

Recently, a study proposed that oppositionality encompasses three distinct dimensions with different predictive values regarding comorbid psychopathology: *irritable*, *headstrong*, and *hurtful* (Stringaris & Goodman, 2009). The *irritable* dimension is associated with emotional disorders that include symptoms of temperamental outbursts, anger, and touchiness. The *hurtful* dimension is associated with callousness and is characterized by vindictiveness and spitefulness. The *headstrong* dimension is associated with ADHD and aggressive behaviors that include behaviors such as arguing with authority figures, annoying others on purpose, and refusing to follow rules. Such classifications, with some modifications, were recently adopted by the 5th edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) and were validated in different cultural contexts (Krieger et al., 2013). However, until now, few studies have investigated the validity of such distinctions from a pathophysiological perspective (Scarpa & Raine, 1997).

* Corresponding author at: Postgraduate Program in Medical Sciences: Psychiatry, School of Medicine, Federal University of Rio Grande do Sul (UFRGS), 2400 Ramiro Barcelo Street, 90035-003. Porto Alegre, RS, Brazil. Tel.: +55 5191992905.
E-mail address: nanuchats@gmail.com (N.T.d. Silva).

http://dx.doi.org/10.1016/j.biopsycho.2014.09.009
0301-0511/

In fact, little is known about the pathophysiological basis of disruptive behavior. Longitudinal studies have shown a relationship between reduced electrodermal responses and antisocial behavior in early adolescence (Fung et al., 2005) and crime involvement and arrests in early adult life (Gao, Raine, Venables, Dawson, & Mednick, 2010; Raine, Venables, & Williams, 1996). Another study found that girls with blunted skin conductance responses (SCRs) are more prone to relational aggression, while girls with heightened SCRs are more prone to physical aggression (Sijtsema, Shoulberg, & Murray-Close, 2011). A study with children demonstrated associations between high levels of reactive aggression and higher SCRs during a video game task where participants lost because of cheating (Hubbard et al., 2002). These studies suggest that the way arousal relates to oppositionality may differ from one dimension to another.

Electrodermal activity (EDA) is a general term used for defining autonomic spontaneous activities recorded by electrical changes at the skin level. When this background activity is abruptly synchronized, either by electrical (external) stimuli or by emotional (internal) trigger, this activation gives raise to galvanic skin response or sympathetic skin response (SSR) that is more easily recorded with skin electrodes (Critchley, 2002). Usually the SSR is measured by the peak-to-peak amplitude, preferably from the first skin potential, considering the habituation of SSR to repetitive stimuli (Schestatsky, Ehlers, Rieder, & Gomes, 2006; Schestatsky, Kumru et al., 2007; Schestatsky, Valls-Sole et al., 2007; Schestatsky et al., 2009, 2013).

The SSR, can be defined as the summation of function within the sympathetic cholinergic sudomotor glands after a phasic stimulus (Schestatsky, Kumru et al., 2007; Schestatsky, Valls-Sole et al., 2007). This measurement is a simple index of peripheral arousal associated with emotional and attentional states (Vetrugno, Liguori, Cortelli, & Montagna, 2003). The SSR is the net result of eccrine sweat gland activation (EDA–SSR) in response to physical activity, stressful stimuli or situations and by cognitive-emotional process (Dawson, Schell & Filion, 2000). Therefore SSR might relate more closely to more ‘anger out’ forms of emotion dysregulation (i.e., reactive aggression) within oppositionality (such as headstrong/hurtful behavior), which have been linked to physiological hyperreactivity and hostile behavior toward non-harmful stimuli (Hubbard et al., 2002; Loney, Frick, Clements, Ellis & Kerlin, 2003; Marsee & Frick, 2007), instead of more ‘anger in’ forms of emotion dysregulation (that does not necessarily result in aggression) such as irritability.

In the current study, we investigated the validity of distinct oppositional dimensions in a community adolescent sample using electrodermal responses to mild electrical stimuli. These stimuli did not cause pain or discomfort, just an annoying sensation to generate an autonomic response that tends to habituate over time. Through examination of previous findings, we developed two hypotheses: (a) oppositionality is associated with increased levels of SSR; (b) this association is specific to headstrong/hurtful behaviors and not to irritability. Related to hypotheses (a) and (b), we addressed three related questions: (i) Are there specific types of headstrong/hurtful behaviors, such as verbal, physical, and social aggression, associated with increased responses? (ii) Is the trajectory of habituation associated with headstrong/hurtful behaviors? (iii) Is the number of stimuli necessary for habituation associated with headstrong/hurtful behaviors?

2. Methods

2.1. Participants

A total of 40 6th–10th grade school students participated in this study. We selected a random sample of participants from a larger community study (Salum et al., 2011) performed in six public schools in the coverage area of Hospital de Clínicas de Porto Alegre (HCPA), Porto Alegre city, south Brazil. All participants were contacted previously by phone about the experiment and visited the laboratory to clarify possible doubts.

We explained by phone that participants would be asked to respond to some questionnaires; afterwards, they would be invited to enter a dimly lit room of neutral temperature and asked to lie down on a bed. A researcher (NTS), who was a trained nurse, attached electrodes to each participant's skin, which was followed by a sequence of ten mildly unpleasant sensations provoked by a very mild electric current (10 mA) applied by a trained neurologist (PBW) in order to access SSRs to external stimuli. We explained that these stimuli would not cause pain, but would merely provide an annoying sensation. Adolescents were instructed to interrupt the experiment if they were feeling any discomfort, emphasizing that interruptions would not lead to any sort of punishment. No student interrupted the experiment or reported any type of pain. Participation in this study was voluntary, and no monetary reward was offered.

We decided to use a mild electrical current (10 mA) as a stimulus because it generates SSRs without pain. This stimulus is able to modify the SSR wave form, making it possible to observe habituation (Toyokura, 2006). Trials for adults tend to use higher electric currents, such as 20–30 mA (Schestatsky et al., 2006; Toyokura, 2006). One study, encompassing subjects aged 15–60 years old, used electrical stimuli of 20–100 mA (Gomes et al., 2003). Students and their parents were previously interviewed to assess students' health status. All students gave verbal informed consent, and their parents gave written informed consent. The HCPA institutional review board approved this study (registration number: 120074).

2.2. Oppositionality assessment

Oppositionality was measured using two instruments. The first was the Youth Self Report (YSR; Achenbach & Dumenci, 2001). The YSR is a self-report measure with 113 items composed of statements with three response options: *not true* (score 0), *somewhat true* (score 1), and *very true* (score 2). The YSR has been validated for use with Brazilian Portuguese-speaking participants (Bordin, Mari, & Caeiro, 1995). In order to investigate dimensions within oppositionality, we used the two-dimensional structure proposed by Stringaris, Zavos, Leibenluft, Maughan, and Eley (2012) for this instrument: irritability and headstrong/hurtful. The irritability scale is formed by summing five items from the YSR aggression subscale: *argues a lot*, *hot tempered*, *easily annoyed*, *stubborn*, and *experiences sudden changes in mood or feelings*. The headstrong/hurtful dimension is formed by summing five items from the YSR aggression subscale (*argues a lot*, *teases a lot*, *disobeys at home*, *disobeys at school*, and *destroys things belonging to one's family or others*), one from the rule-breaking behavior scale (*breaks rules at home*, *school*, *or elsewhere*), and one from the other problems scale (*engages in cruelty*, *bullying*, or *meanness to others*).

The second instrument was the Brazilian modified version of the Olweus Bully/Victim Questionnaire (Olweus, 1993; Fischer et al., 2010). We only used the Bully questionnaire to measure aggressive behavior through frequency in bullying behavior. This measure is a self-report questionnaire consisting of 24 items that measure physical (e.g., how often the child physically hurts or took belongings away), verbal (e.g., name calling, teasing in a hurtful way, or threatening), social (e.g., spreading rumors, not talking to someone on purpose or excluding them from their group of friends), sexual (e.g., sexual harassment), and cyber bullying (e.g., the use of internet and mobile phones to hurt others). Due to a very low frequency of sexual and cyber bullying, we restricted our analysis to the physical, verbal, and social subtypes of bullying. Response options included: (0) *never*, (1) *once or twice in the previous year*, (2) *3–6 times in the previous year*, (3) *many times a week*, and (4) *every day*. Recorded answers were rated on a continuous scale, ranging from zero to 96 points.

2.3. Sympathetic skin response

The SSR data (represented by wave's oscillation in response to a stimulus) were collected under controlled environmental conditions, within a silent room with a constant temperature and dim lighting. Equipment included Ag/AgCl electrodes and electrolyte isotonic gel to attach electrodes to the skin surface (Boucsein et al., 2012). After preparing the participant, we applied a sequence of 10 very mild electric stimuli of 10 mA, with an interval of approximately 30 s. Upper limb recordings were performed with surface Ag/AgCl electrodes placed on the right side palmar region (second interdigital space, 3 cm proximally to the metacarpophalangeal articulation), and reference electrodes were placed on the dorsum of the hand. A 5-s screen with 200–1000 μV sensitivity and amplifier bandpass filter was of 0.1 and 2 kHz. SSR recording was conducted using Nihon Kohden Neuropack MEB 9400® equipment and software, and data were collected and analyzed by two researches (NTS and PS).

We measured the latency and amplitude of the first wave generated (the wave after the first of 10 stimuli). Habituation to a stimulus refers to the phenomenon whereby wave amplitude reaches 50% of the first wave amplitude after exposure to several aversive stimuli.

2.4. Statistical analysis

In order to investigate if overall oppositionality was associated with SSR we used a multivariate general linear model (MGLM) with both irritability and

Table 1
Demographic and psychophysiological sample characteristics ($n = 38$).

	n (%)	Mean	SD
Demographic variables			
Age (years)	–	13.84	1.46
Ethnicity (White)	24 (63)	–	–
Sex (male)	20 (53)	–	–
Psychophysiological variables			
Amplitude of 1st wave (mV)		0.76	0.38
Mean amplitude until habituation (mV)		0.60	0.29
Physical aggression score		3.02	6.97
Verbal aggression score		5.35	6.85
Social aggression score		2.28	3.99
YSR: irritability		4.32	1.77
YSR: head/hurt		3.50	2.25
YSR			
Internalizing score		16.92	6.91
Externalizing score		19.16	6.71
Total score		78.08	20.30

Note: SD, standard deviation; YSR, youth self report, Stringaris dimension proposition for argumentative or defiant behavior; head/hurt, headstrong and hurtful dimensions.

headstrong/hurtful continuous scores as dependent variables, and the continuous mean amplitude until habituation as the independent variable, while controlling for age (in years), gender (male/female), and ethnicity (caucasian/non-caucasian). Further exploratory analyses were performed for three specific questions. *First*, we repeated the MGLM model now using continuous subtypes of headstrong and hurtful behaviors subsumed under the bullying construct (physical, verbal, and social – all continuous scores) as dependent variables, investigating for the main effect of the continuous mean amplitude until habituation (independent variable). *Second*, we investigated if the trajectories of mean amplitudes differ between groups of participants with low and high headstrong/hurtful dimensions (median split of the continuous score, 2 level between subjects factor: high/low) using a repeated measures analysis of variance with the time factor being a within-subject effect with 10 levels and repeated measures analysis of covariance, which added the continuous mean amplitude of the first wave as a covariate in the same model. Differences in habituation trajectories were investigated with interactions with the time factor. *Third*, we investigated differences in the number of stimuli needed for habituation between subjects with low and high headstrong/hurtful dimensions (median split) using a Cox proportional hazards regression. All exploratory analyses included age, gender, and ethnicity as covariates.

3. Results

The initially sample consisted of 40 students; however, two were excluded from the analyses because of the presence of artifacts in the sympathetic skin response waves. Thus, the final sample consisted of 38 students. The demographics and behavioral characteristics of the sample are depicted in Table 1.

3.1. Hypothesis 1: oppositionality is associated with an increased SSR

First, we investigated whether oppositionality was associated with an increased SSR. The multivariate test revealed that increased SSR is associated with higher levels of oppositionality (Pillai's Trace = 0.234, $F(2,33) = 5.037$, $p = 0.012$, $\eta_p^2 = 0.234$). Higher levels of oppositionality were also found among female adolescents (Pillai's Trace = 0.219, $F(2,33) = 4.637$, $p = 0.017$, $\eta_p^2 = 0.219$). Oppositionality was unrelated to age ($p > 0.05$). No significant interactions emerged from the model.

3.2. Hypothesis 2: increased SSR is associated specifically with headstrong/hurtful behaviors but not with irritability

Second, bivariate models were used to investigate which dimension of oppositionality was driving the association with increased SSR. The headstrong/hurtful dimension was significantly associated with increased arousal ($F(1,34) = 7.802$, $p = 0.009$, $\eta_p^2 = 0.187$). No associations were found between irritability and SSR ($F(1,34) = 0.817$, $p = 0.372$, $\eta_p^2 = 0.023$). Again, age was unrelated to any dimension ($p > 0.05$), and female gender was specifically associated with irritability ($F(1,34) = 9.217$, $p = 0.005$, $\eta_p^2 = 0.213$) but not headstrong/hurtful ($p > 0.05$).

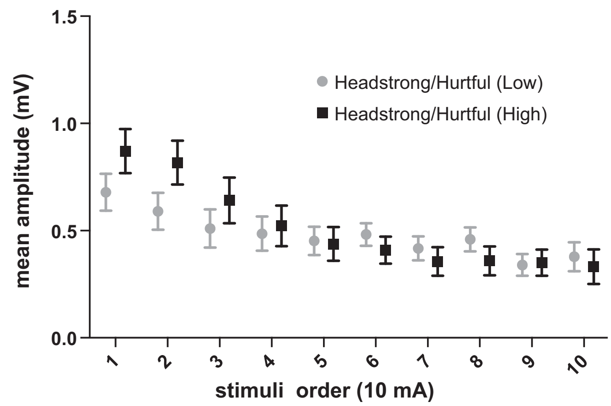

Fig. 1. SSR difference between high and low headstrong/hurtful behavior groups (expressed as wave amplitude differences) without controlling for the mean amplitude of the first skin potential wave. Note that the group with high Headstrong/hurtful behavior showed higher amplitude, understood here as higher SSR.

3.3. Exploratory analysis 1: is SSR variation associated with any specific type of hurtful/headstrong behaviors?

We then investigated whether specific headstrong/hurtful behaviors would be associated with increased SSR. Increased SSR was positively associated with another overall index of headstrong/hurtful behaviors subsumed under the bullying construct (Pillai's Trace = 0.487, $F(3,29) = 9.189$, $p < 0.001$, $\eta_p^2 = 0.487$). Gender and age were unrelated to this index.

We found that the mean amplitude until habituation was related to all subtypes of behaviors from this questionnaire: physical ($F(1,31) = 15.124$, $p < 0.001$, $\eta_p^2 = 0.328$), verbal ($F(1,31) = 25.984$, $p < 0.0001$, $\eta_p^2 = 0.456$), and social ($F(1,31) = 8.722$, $p = 0.006$, $\eta_p^2 = 0.220$).

3.4. Exploratory analysis 2: is the headstrong/hurtful dimension associated with habituation trajectories across the stimuli?

We further investigated whether the trajectory of the mean amplitude differed across the 10 stimuli between subjects with low and high headstrong/hurtful behaviors (assessed using a median split).

We observed a time × headstrong/hurtful interaction for the mean amplitudes ($F(9,197) = 2.548$, $p = 0.008$), indicating that for those subjects with high scores on the headstrong/hurtful dimension, the mean amplitudes of the first waves were higher than for the subjects with low scores on the headstrong/hurtful dimension, at least if compared to the mean amplitudes of the last waves (Fig. 1). After controlling for the mean amplitude of the first wave, no trajectory effects were detected (all *ps* > 0.05; Fig. 2).

As expected, the amplitude of the first wave was correlated with the headstrong/hurtful dimension ($r = 0.363$, $p = 0.025$; Fig. 3).

3.5. Exploratory analysis 3: is the headstrong/hurtful dimension associated with the number of stimuli until habituation?

A Cox proportional hazards regression revealed that there were no differences in the number of stimuli necessary for habituation between subjects high and low on the headstrong/hurtful dimension (HR = 1.55 95% CI: 0.68–3.54; $p = 0.293$, Wald = 1.104, $df = 1$).

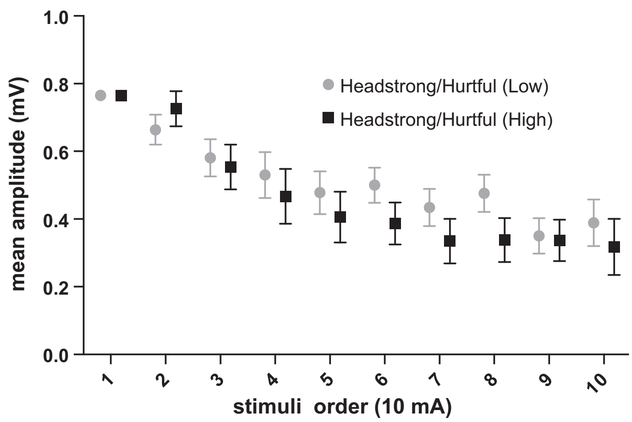

Fig. 2. SSR difference between high and low headstrong/hurtful behavior groups (expressed as wave amplitude differences) after controlling for the mean amplitude of the first skin potential wave. Note that controlling for the first mean amplitude, the SSR difference between groups disappear, suggesting that the first stimulus is responsible for the differences.

4. Discussion

We observed that oppositionality was associated with arousal as measured by changes in SSRs. In addition, we showed that this association was specific to the headstrong/hurtful dimension of oppositionality and not associated with irritability. Our exploratory analyses revealed that a heightened SSR was associated with several types of behaviors within the headstrong/hurtful dimension (verbal, social, and physical bullying). The mean amplitude of the first wave was responsible for different trajectories within subjects high and low in the headstrong/hurtful dimension, and these groups did not differ with regard to the number of stimuli until habituation.

As hypothesized, oppositionality was associated with increased SSR. Previous studies have suggested that antisocial behavior is associated with decreased SCRs (Beauchaine, Hong, & Marsh, 2008; Herpertz et al., 2003; Posthumus, Bocker, Raaijmakers, Van Engeland, & Matthys, 2009). However, there are several important differences between our study and studies assessing antisocial behavior in adults that should be taken into account: (a) we used a community sample with mild scores on measures of psychopathology; therefore, a curvilinear relationship between aggression and SSR responses cannot be ruled out (decreased SSRs would likely be observed in more severe forms of aggression or callousness). (b) To the best of our knowledge, this is the first study investigating SSRs to a very mild, unpleasant stimulus among adolescents; therefore, results are not exactly comparable. (c) Most previous studies did not observe heterogeneity within oppositionality.

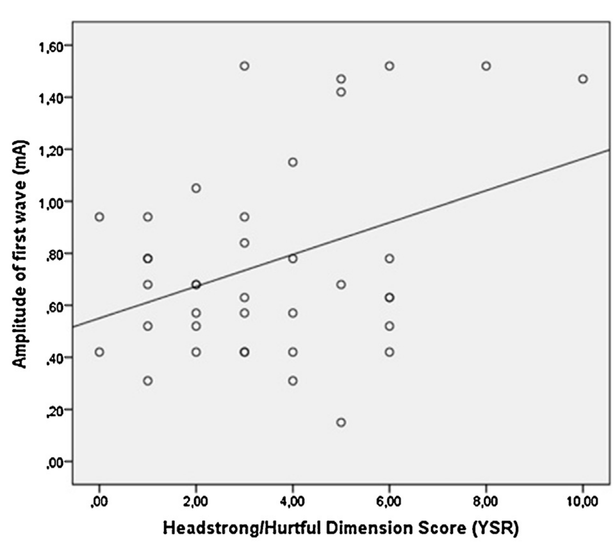

Fig. 3. Correlation between the amplitude of the first stimulus wave and the headstrong/hurtful behavior scored as proposed by Stringaris et al. (2012).

Regarding the oppositionality dimensions, we found a specific association of heightened SSRs with the headstrong/hurtful dimension but not with the irritability dimension. This pattern of association provides further evidence for the utility of heterogeneity within oppositionality. In addition, it gives insight into the association between arousal and psychopathology, since it is the headstrong/hurtful dimension—which includes behaviors closely related to aggression—that increases arousal. In line with this assumption is data suggesting that reactive aggression is associated with antisocial behavior (Blair, 2004; Blair, Peschardt, Budhani, Mitchell & Pine, 2006). Our results are in accordance with findings from Dindo and Fowles (2011), who investigated the association between skin conductance reactivity (through an anticipatory paradigm that used regressive counts and loud noises and measurements of skin conductance reactivity across five trials) and psychopathic traits among college students according to two factors from the Psychopathic Personality Inventory (PPI). Factor 1 evaluates dysfunctional affective interpersonal features, and Factor 2 evaluates impulsive-antisocial behavior (Lilienfeld & Andrews, 1996). PPI Factor 1 was found to be associated with non-aggressive infractions, whereas PPI Factor 2 was associated with all externalizing behaviors and low emotional control (high stress reaction). Furthermore, the authors found an increased skin conductance reactivity among young subjects with high PPI Factor 2 scores (Dindo & Fowles, 2011).

We also investigated whether verbal, physical, and social aggression is associated with increased SSRs. We accessed hurtful/headstrong behaviors by means of self-reported types of bullying behavior. Bullying is a specific type of aggression where behavior is intended to hurt or disturb others and is strongly associated with oppositional defiant disorder (Nansel et al., 2001; Vaughn et al., 2010). We observed a positive association between all types of headstrong and hurtful behaviors and heightened SSRs. These patterns of associations strengthen our confidence that the latent headstrong/hurtful construct was associated with increased arousal rather than any specific type of behavior encompassed by these concepts. We suggest that, in contrast to theories related to psychophysiological hyporeactivity (see Zuckerman, 1974, for sensation-seeking theory), individuals with psychophysiological hyperreactivity are more prone to exaggerated verbal, physical, or social responses to several types of events, even when the events are not threatening, because of information processing deficits in response to environmental stimuli (Lochman & Dodge, 1998). We hypothesize that this association reflects heightened arousability, as perceived by increased SSRs to mild aversive stimuli, which is similar to what is ascribed to reactive aggression.

Finally, we did not find an association of the number of stimuli necessary for habituation to an aversive stimulus with headstrong/hurtful scores. Nevertheless, we did find an association between the amplitude of the wave generated after the first stimulus and high headstrong/hurtful behaviors. When we controlled for the mean amplitude of the first wave within subjects, we did not find differences in groups' trajectories. This suggests that the reaction to the first stimulus is mostly responsible for the arousal differences between high and low headstrong/hurtful groups. This is consistent with studies showing that the first stimulus more reliably evokes SSRs than do subsequent stimuli (Schestatsky, Kumru et al., 2007).

A few limitations should be noted. First, we were limited by a small sample size, and the possibility for type II error should be considered for some analyses. However, the small sample size did not limit our ability to observe important associations between arousal and oppositionality. Second, we were limited by a cross-sectional design; thus, we were not able to assess how oppositionality and arousal relate to each other over time. Third, the SSR is notably affected by external factors such as age, skin thickness, temperature and other environmental and subjects' intrinsic factors. However such variables are supposed to be similar in both groups. Therefore, we strongly believe that those parameters did not affect our neurophysiological responses and, therefore, our conclusions. Finally, we only used self-rated measures of oppositionality. However, studies using the YSR and Child Behavior Checklist within different cultural settings found moderate to high concordance between child and parent reports, with children reporting more externalizing problems than their parents (Achenbach & Dumenci, 2001; Medina et al., 2007; Wong, Jenvey, & Lill, 2012). In spite of these limitations, our design had some strength. For instance, this is the first study to show differences in the physiological aspects oppositionality within a community sample. Additionally, our use of a mild electric current to evoke an annoying sensation as an aversive stimulus is considered a good choice for producing SSRs to evaluate habituation (Toyokura, 2006).

5. Conclusions

The current study further advances distinctions between dimensions of oppositionality, showing that participants who are high in the headstrong/hurtful dimension, but not in the irritability dimension, display higher levels of SSR. The current study also provides insights into how dysfunctions in autonomic balance might contribute to the emergence of oppositional behaviors among adolescents. The results suggest that individuals with increased SSR overreact to aversive behaviors of others as occurs with oppositional behavior, especially with headstrong/hurtful dimension.

References

Achenbach, T. M., & Dumenci, L. (2001). Advances in empirically based assessment: Revised cross-informant syndromes and new DSM-oriented scales for the CBCL, YSR, and TRF: Comment on Lengua, Sadowksi, Friedrich, and Fisher (2001). *Journal of Consulting and Clinical Psychology*, *69*(4), 699–702.

Aebi, M., Plattner, B., Metzke, C. W., Bessler, C., & Steinhausen, H.-C. (2013). Parent- and self-reported dimensions of oppositionality in youth: Construct validity, concurrent validity, and the prediction of criminal outcomes in adulthood. *Journal of Child Psychology and Psychiatry*, *54*(9), 941–949.

Beauchaine, T. P., Hong, J., & Marsh, P. (2008). Sex differences in autonomic correlates of conduct problems and aggression. *Journal of the American Academy of Child and Adolescent Psychiatry*, *47*, 788–796 (United States).

Biederman, J., Petty, C. R., Dolan, C., Hughes, S., Mick, E., Monuteaux, M. C., et al. (2008). The long-term longitudinal course of oppositional defiant disorder and conduct disorder in ADHD boys: Findings from a controlled 10-year prospective longitudinal follow-up study. *Psychological Medicine*, *38*(7), 1027–1036.

Blair, R. J. R. (2004). The roles of orbital frontal cortex in the modulation of antisocial behavior. *Brain and Cognition*, *55*(1), 198–208.

Blair, R. J., Peschardt, K. S., Budhani, S., Mitchell, D. G., & Pine, D. S. (2006). The development of psychopathy. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *47*(3–4), 262–276.

Bordin, I. A. S., Mari, J. J., & Caeiro, M. F. (1995). Validation of the Brazilian version of the Child Behavior Checklist (CBCL). *Revista ABP-APAL*, *17*(2), 55–66.

Boucsein, W., Fowles, D. C., Grimnes, S., Ben-Shakhar, G., Roth, W. T., Dawson, M. E., et al. (2012). Publication recommendations for electrodermal measurements. *Psychophysiology*, *49*(8), 1017–1034.

Burke, J. D. (2012). An affective dimension within oppositional defiant disorder symptoms among boys: Personality and psychopathology outcomes into early adulthood. *Journal of Child Psychology and Psychiatry*, *53*(11), 1176–1183.

Critchley, H. D. (2002). Electrodermal responses: What happens in the brain. *Neuroscientist*, *8*(2), 132–142.

Dawson, M. E., Schell, A. M., & Filion, D. L. (2000). The electrodermal system. In J. T. Cacioppo, L. G. Tassinary, & G. G. Berntson (Eds.), *Handbook of psychophysiology* (2nd ed., pp. 200–223). Cambridge, England: Cambridge University Press.

Dindo, L., & Fowles, D. (2011). Dual temperamental risk factors for psychopathic personality: Evidence from self-report and skin conductance. *Journal of Personality and Social Psychology*, *100*(3), 557–566.

Fischer, R. M., Lorenzi, G. W., Pedreira, L. S., Bose, M., Fante, C., Berthoud, C., et al. (2010). *Relatório de pesquisa: Bullying escolar no Brasil*.

Fung, M. T., Raine, A., Loeber, R., Lynam, D. R., Steinhauer, S. R., Venables, P. H., et al. (2005). Reduced electrodermal activity in psychopathy-prone adolescents. *Journal of Abnormal Psychology*, *114*(2), 187–196.

Gao, Y., Raine, A., Venables, P. H., Dawson, M. E., & Mednick, S. A. (2010). Association of poor childhood fear conditioning and adult crime. *American Journal of Psychiatry*, *167*(1), 56–60.

Gomes, I., Nora, D. B., Becker, J., Ehlers, J. A. C., Schwartz, I. V. D., Giugliani, R., et al. (2003). Nerve conduction studies, electromyography and sympathetic skin response in Fabry's disease. *Journal of the Neurological Sciences*, *214*(1–2), 21–25.

Herpertz, S. C., Mueller, B., Wenning, B., Qunaibi, M., Lichterfeld, C., & Herpertz-Dahlmann, B. (2003). Autonomic responses in boys with externalizing disorders. *Journal of Neural Transmission*, *110*(10), 1181–1195.

Hubbard, J. A., Smithmyer, C. M., Ramsden, S. R., Parker, E. H., Flanagan, K. D., Dearing, K. F., et al. (2002). Observational, physiological, and self-report measures of children's anger: Relations to reactive versus proactive aggression. *Child Development*, *73*(4), 1101–1118.

Kessler, R. C., Petukhova, M., & Zaslavsky, A. M. (2011). The role of latent internalizing and externalizing predispositions in accounting for the development of comorbidity among common mental disorders. *Current Opinion in Psychiatry*, *24*(4), 307–312.

Krieger, F. V., Polanczyk, G. V., Goodman, R., Rohde, L. A., Graeff-Martins, A. S., Salum, G., et al. (2013). Dimensions of oppositionalay in a Brazilian community sample: Testing the DSM-5 proposal and etiological links. *Journal of the American Academy of Child and Adolescent Psychiatry*, *52*(4), 389–400.

Lilienfeld, S. O., & Andrews, B. P. (1996). Development and preliminary validation of a self-report measure of psychopathic personality traits in noncriminal populations. *Journal of Personality Assessment*, *66*(3), 488–524.

Lochman, J. E., & Dodge, K. A. (1998). Distorted perceptions in dyadic interactions of aggressive and nonaggressive boys: Effects of prior expectations, context, and boys' age. *Development and Psychopathology*, *10*(3), 495–512.

Loney, B. R., Frick, P. J., Clements, C. B., Ellis, M. L., & Kerlin, K. (2003). Callous-unemotional traits, impulsivity, and emotional processing in adolescents with antisocial behavior problems. *Journal of Clinical Child and Adolescent Psychology*, *32*(1), 66–80.

Marsee, M. A., & Frick, P. J. (2007). Exploring the cognitive and emotional correlates to proactive and reactive aggression in a sample of detained girls. *Journal of Abnormal Child Psychology*, *35*(6), 969–981.

Medina, C., Navarro, J. B., Martinena, P., Banos, I., Vicens-Vilanova, J., Barrantes-Vidal, N., et al. (2007). Assessment of the adolescent behavior with Achenbach's scales; is there a concordance 33 between different informants? *Salud Mental*, *30*(5), 33–39.

Moffitt, T. E., Caspi, A., Harrington, H., & Milne, B. J. (2002). Males on the life-course-persistent and adolescence-limited antisocial pathways: Follow-up at age 26 years. *Development and Psychopathology*, *14*(1), 179–207.

Nansel, T. R., Overpeck, M., Pilla, R. S., June Ruan, W., Simons-Morton, B., & Scheidt, P. (2001). Bullying behaviors among US Youth: Prevalence and association with psychosocial adjustment. *The Journal of the American Medical Association*, *285*(16), 7.

Nobile, M., Colombo, P., Bellina, M., Molteni, M., Simone, D., Nardocci, F., et al. (2013). Psychopathology and adversities from early- to late-adolescence: A general population follow-up study with the CBCL DSM-Oriented Scales. *Epidemiology and Psychiatric Sciences*, *22*(1), 63–73.

Olweus, D. (1993). *Bullying at school*. Malden, MA: Blackwell Publishers.

Posthumus, J. A., Bocker, K. B. E., Raaijmakers, M. A. J., Van Engeland, H., & Matthys, W. (2009). Heart rate and skin conductance in four-year-old children with aggressive behavior. *Biological Psychology*, *82*(2), 164–168.

Raine, A., Venables, P. H., & Williams, M. (1996). Better autonomic conditioning and faster electrodermal half-recovery time at age 15 years as possible protective factors against crime at age 29 years. *Developmental Psychology*, *32*(4), 624–630.

Rowe, R., Costello, E. J., Angold, A., Copeland, W. E., & Maughan, B. (2010). Developmental pathways in oppositional defiant disorder and conduct disorder. *Journal of Abnormal Psychology*, *119*(4), 726–738.

Salum, G. A., Isolan, L. R., Bosa, V. L., Tocchetto, A. G., Teche, S. P., Schuch, I., et al. (2011). The multidimensional evaluation and treatment of anxiety in children and adolescents: Rationale, design, methods and preliminary findings. *Revista Brasileira De Psiquiatria*, *33*(2), 181–195.

Scarpa, A., & Raine, A. (1997). Psychophysiology of anger and violent behavior. *Psychiatric Clinics of North America*, *20*(2), 375.

Schestatsky, P., Ehlers, J. A., Rieder, C. R. M., & Gomes, I. (2006). Evaluation of sympathetic skin response in Parkinson's disease. *Parkinsonism & Related Disorders*, *12*(8), 486–491.

Schestatsky, P., Kumru, H., Valls-Sole, J., Valldeoriola, F., Marti, M. J., Tolosa, E., et al. (2007). Neurophysiologic study of central pain in patients with Parkinson disease. *Neurology*, *69*(23), 2162–2169.

Schestatsky, P., Valls-Sole, J., Costa, J., Leon, L., Veciana, M., & Chaves, M. L. (2007). Skin autonomic reactivity to thermoalgesic stimuli. *Clinical Autonomic Research*, *17*(6), 349–355.

Schestatsky, P., Valls-Solé, J., Felix-Torres, V., Guarany, F. C., Castellote, J. M., Pérez, D., et al. (2009). Sympathetic skin responses evoked by muscle contraction. *Neuroscience Letters*, *463*(2), 140–144.

Schestatsky, P., Dall-Agnol, L., Gheller, L., Stefani, L. C., Sanches, P. R., de Souza, I. C., et al. (2013). Pain-autonomic interaction after work-induced sleep restriction. *European Journal of Neurology*, *20*(4), 638–646.

Sijtsema, J. J., Shoulberg, E. K., & Murray-Close, D. (2011). Physiological reactivity and different forms of aggression in girls: Moderating roles of rejection sensitivity and peer rejection. *Biological Psychology*, *86*(3), 181–192.

Stringaris, A., & Goodman, R. (2009). Three dimensions of oppositionality in youth. *Journal of Child Psychology and Psychiatry*, *50*(3), 216–223.

Stringaris, A., Zavos, H., Leibenluft, E., Maughan, B., & Eley, T. C. (2012). Adolescent irritability: Phenotypic associations and genetic links with depressed mood. *American Journal of Psychiatry*, *169*(1), 47–54.

Toyokura, M. (2006). Sympathetic skin responses: The influence of electrical stimulus intensity and habituation on the waveform. *Clinical Autonomic Research*, *16*(2), 130–135.

Vaughn, M. G., Fu, Q., Bender, K., DeLisi, M., Beaver, K. M., Perron, B. E., et al. (2010). Psychiatric correlates of bullying in the United States: Findings from a national sample. *Psychiatric Quarterly*, *81*(3), 183–195.

Vetrugno, R., Liguori, R., Cortelli, P., & Montagna, P. (2003). Sympathetic skin response – basic mechanisms and clinical applications. *Clinical Autonomic Research*, *13*(4), 256–270.

Wong, H. Y., Jenvey, V., & Lill, A. (2012). Children's self-reports and parents' reports of internalising and externalising problems in Chinese and Anglo-Celtic children in Australia. *Australian Journal of Psychology*, *64*(3), 155–163.

Zuckerman, M. (1974). The sensation seeking motive. In B. A. Maher (Ed.), *Experimental personality research* (Vol. 7) (pp. 80–140). New York\San Francisco\London: Academic Press.