Published in final edited form as:

J Youth Adolesc. 2015 November ; 44(11): 1999–2011. doi:10.1007/s10964-015-0331-z.

The Relationship Between Autonomy and Relatedness and Adolescents' Adrenocortical and Cardiovascular Stress Response

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Abstract

Developing autonomy and maintaining relatedness within the parent–adolescent relationship marks a realignment process that shifts adolescents' decision making and regulation from parents to youth. This process may be stressful for some adolescents, particularly those who perceive their daily lives as stressful. This study examined the associations of autonomy, relatedness and perceived stress with adolescents' cortisol and blood pressure response to conflict in a mother–adolescent interaction task among 100 adolescents ($M_{\text{age}} = 15.09$; 68 % girls, 78 % Caucasian). Few direct associations were found, but results indicated that perceived stress moderated the effect of autonomy and relatedness such that youth who reported more perceived stress and whose mothers' restricted their autonomy and undermined their relatedness evidenced increased cortisol and systolic blood pressure when compared to youth lower in perceived stress. The results highlight the importance of examining individual differences in the association between normative developmental transitions and adolescents' neurobiological response to stress.

Keywords

Adolescence; Autonomy; Perceived stress; Relatedness; Physiological stress response

Introduction

An important developmental task during adolescence is developing autonomy while maintaining emotional connectedness within the parent–adolescent relationship (i.e., autonomy and relatedness; Allen et al. 1994). Developing autonomy within the parent–adolescent relationship marks a realignment process that shifts adolescents' decision making

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Compliance with Ethical Standards

Author contributions E.C. conceived of this study, participated in the design and data collection, and drafted the manuscript. T.C. helped in the interpretation of the data and review of the manuscript. L.S. helped by providing comments to E.C. in the conception of the study, interpretation of the data, and review of the manuscript. All authors read and approved the final manuscript.

Conflict of interest The authors report no conflicts of interest.

and regulation from parents to youth. Although developing autonomy is a normative task, feelings of conflict and ambiguity are often experienced during this process, and as such, adolescents may find this process stressful, particularly when parents are not supportive (Spear and Kulbok 2004). In turn, this stressful experience of developing autonomy and relatedness may impact underlying physiological and biological systems, with some adolescents evidencing a heightened response to stress. Research has neglected to examine whether developing autonomy while maintaining relatedness may be a stressful experience for some youth that is evidenced by a heightened physiological response to stress. This is surprising given the salience of this task to development, as well as the known associations between heightened reactivity to stress and psychopathology (Kuhlman et al. 2014).

It is important to recognize that certain youth may be more vulnerable to the effects of stress that are associated with developmental changes. Youth who already perceive themselves as having to manage several stressors in their daily lives and view those stressors as unpredictable and uncontrollable may be more likely to respond to new stressors in a manner consistent with dysregulation (Evans et al. 2007; Kemeny 2003; Stawski et al. 2008). Research, although limited, has generally supported the view that individuals who report higher perceived stress are more likely to evince stress reactivity when confronted with acute stressors in laboratory or natural settings (Stawski et al. 2008; van Eck et al. 1998; von Känel et al. 2003). The proposed study will contribute to research by examining the relationship between problems with developing autonomy and relatedness in the parent–adolescent relationship and adolescents’ stress response, as measured by cortisol and blood pressure, and if this relationship is stronger for youth who perceive more stress in their daily lives. Given evidence that adolescents’ brains are susceptible to stress and stress-related disorders (Lupien et al. 2009), it is important to examine empirically how normative adolescent transitions within the family may be associated with adolescents’ physiological response to stress.

Autonomy Relatedness and Stress Response

Autonomy and Relatedness

As adolescents transition into a new developmental stage, they encounter developmental tasks (e.g., developing autonomy, identity development) that are important to successfully negotiate to adjust to new demands or take advantage of new opportunities within the current developmental stage, as well as subsequent stages (Erikson 1968; Oudekerk et al. 2015). Failure to resolve a developmental task can put youth at risk for solving other important tasks and impact outcomes in a variety of areas (Masten and Cicchetti 2010). During adolescence, the development of autonomy while maintaining relatedness is a particularly important developmental task. Autonomy and relatedness can be defined as adolescents exerting independence in decision making while maintaining close and supportive relationships with their parents (Allen et al. 1994). In order for adolescents to successfully develop autonomy, parents should allow opportunities for youth to take on more decision making, grant adolescents more independence in the way they spend their time and in the choices they make, and do this in a supportive manner where emotional closeness is maintained (Seiffge-Krenke and Pakalniskiene 2010). Parental control and autonomy are

subjects of conflict in the parent–adolescent relationship and how this process is negotiated has been associated with adolescent adjustment, such that in parent–adolescent relationships marked by restriction of autonomy and low levels of relatedness, youth report problems in domains such as internalizing behavior (Inguglia et al. 2015) and risk behavior (Turner et al. 1993).

Given the importance of developmental tasks for youth's adjustment it is clear that these tasks may be stressful as youth have to take on new roles within the family and develop new skills that challenge their concept of self. Negotiating autonomy and relatedness may be particularly stressful to youth due to the salience of maintaining interpersonal relationships with parents but also developing a sense of self outside of the family (Collins and Laursen 2004). To date, however, researchers have not examined how this important developmental task may be associated with adolescents' ability to regulate their stress response.

Autonomy Relatedness and Stress Response

Stressors are experiences that threaten a major goal (e.g., safety, social status) of an individual and include physical stressors or psychological stressors (Kemeny 2003). Stressors that stem from life transitions and/or developmental changes may serve as one type of psychological stressor. The process of developing autonomy involves a movement toward self-regulation and independent decision making, which can be a stressful process for adolescents (Zimmermann et al. 2009). That stress may result from family conflict elicited when parents and adolescents are attempting to change their roles and realign the placement of regulation and decision making from parents to youth.

Theory and research have outlined characteristics of stressors that are capable of contributing to the onset or exacerbation of a dysregulated stress response. Characteristics include (a) central goals to the self are threatened, (b) stressors are ambiguous, (c) stressors are uncontrollable, (d) stressors present threat to the social self, particularly social status, and (e) stressors are novel (Dickerson and Kemeny 2004; Lazarus and Folkman 1984). The development of autonomy shares several elements recognized as important in eliciting a physiological stress reaction. Specifically, autonomy is an important developmental goal (McElhaney et al. 2009). The process of autonomy development also may be uncertain (i.e., ambiguous) and uncontrollable given that adolescents have no specific guide for developing a sense of self outside the family and very little control over whether or not parents grant them the autonomy to do so. Finally, as adolescents challenge dominance hierarchies, if parents do not grant some of this challenge, then this dominance may threaten adolescents' social self. Thus, adolescents whose parents undermine autonomy and relatedness will find the process of autonomy development stressful (Allen et al. 1994), which may challenge adolescents' regulatory capabilities and ultimately how their bodies handle stress (e.g., stress response).

One important system involved in adolescents' physiological response to stress is the Hypothalamic–pituitary–adrenal axis (HPA). The HPA-axis plays an important role in mobilizing resources needed to act in response to stress, regulating and mitigating the stress response, and excreting hormones on brain systems associated with memory, learning, and emotions. One class of hormones released by the HPA-axis in response to stress is

glucocorticoids, known as cortisol in humans. Another important system involved in the stress response is the autonomic nervous system (ANS). The ANS is important for supporting the flight/fight response and is often assessed by changes in cardiovascular measures (e.g., heart rate or blood pressure). Activation of the stress response, both the HPA-axis and the ANS, serve an adaptive function in the short-term. However, over time, frequent exposure to stress, problems regulating arousal, or difficulty shutting off the stress response after stress has been terminated can result in increased allostatic load (i.e., cumulative effect of stress on underlying systems). Increased allostatic load may be evident when the body evidences hyper-arousal to acute stressors and trouble down regulating when stressful events have ceased (e.g., sustained and elevated salivary cortisol or blood pressure; Adam and Kumari 2009; McEwen 2007).

Despite the stress that negotiating autonomy and relatedness may induce, research has generally not examined the effect that problems developing autonomy and relatedness have on adolescents' stress response as measured by neurobiological indicators. Research using self-report has found that arguments with parents and the development of autonomy are rated as very stressful by youth (Gure et al. 2006; Mortimer and Call 2001, Seiffge-Krenke et al. 2013). Furthermore, researchers have suggested that families characterized by parental overregulation of children's behavior may result in adolescents failing to regulate their responses to stress properly (McEwen and Seeman 1999) and that adolescents who perceive less support for autonomy development are more likely to use negative coping strategies when faced with stress (Seiffge-Krenke and Pakalniskiene 2010). These studies, however, are limited due to being based on self-report, or theoretical conjectures, and thus are not empirically evaluating the association between autonomy and relatedness and adolescents' physiological stress response during the critical time of adolescence when autonomy and relatedness is a key developmental concern.

Although research has not specifically examined autonomy and relatedness and the association with adolescents' stress response, studies have examined adolescents' neurobiological response to parent-adolescent conflict interaction tasks with some research finding increased reactivity to the parent-adolescent task suggesting an association between typical conflict experienced in families and adolescents' neurobiological stress response (Marceau et al. 2014; Weichold et al. 2008). Moreover, studies have examined associations between problematic family functioning (e.g., marital conflict and parenting) and adolescents' increased physiological stress response to an acute stressor during adolescence (Allen et al. 2012b; Chaplin et al. 2014; Lucas-Thompson 2012; Marceau et al. 2012; Willemsen et al. 2009). Most germane to the current study, are researchers who examine the effect of parenting or parent-adolescent relationship quality on adolescents' neurobiological response to stress. Byrd-Craven, Auer, Granger, and Massey (2012) examined the effect of positive father-daughter relationships on cortisol response during a friendship interaction task among 88 undergraduate women. Results indicated that positive father-daughter relationships were associated with lower pre-task cortisol levels but not reactivity to the interaction task. Chaplin et al. (2012) found cross-sectionally among 58 adolescents that lower observed parental structure and support were associated with greater systolic blood pressure (SBP) response to a parent-adolescent conflict task. Similarly, Spies et al. (2011) found that adolescents who reported distress to a conflict interaction task with mothers

evidenced higher cortisol reactivity to the interaction. Taken together, these results provide preliminary evidence that lower autonomy and relatedness in the parent–adolescent relationship may influence adolescents’ response to stress; an important but unstudied topic.

Perceived Stress and Stress Response

Perceived stress in one’s daily life may exacerbate the impact of negotiating a new developmental task on adolescents’ stress response, a relationship that has not been studied during adolescence. In the current study, perceived stress is defined as the degree to which situations in one’s life are thought to be stressful in relationship to the individual’s perception of their capacity to cope with stressors and is measured by assessing adolescents’ report of their capacity to handle stress over the last month. Individuals who view stressors as unpredictable, uncontrollable, and overloading may perceive a great deal of stress in their daily lives, which in turn may impact their ability to cope with new stressors (Cohen et al. 1983). Thus, perceived stress may represent the cognitive appraisal process discussed by Lazarus and Folkman (1984), and provide an important individual risk factor that conditionalizes individuals’ stress responses to everyday stressors (Van Eck et al. 1998). Furthermore, there is some evidence to suggest that those who report higher perceived stress also experience more daily stress, thus providing a possible measure of cumulative stress that would exasperate the effect of acute stressors on stress response (Chen et al. 2004; Van Eck et al. 1998). Despite the importance of perceived stress for understanding individual differences in physiological response to stress, this construct has received little attention in the adolescent literature.

A small body of research has found that an individuals’ level of perceived stress is related to stress responses in both community and laboratory settings. van Eck et al. (1998) examined if individual differences in perceived stress as measured by self-report on the perceived stress scale moderated the relationship between stressful events in everyday life (measured by event sampling) and negative affect as a measure of stress response. The results from this sample of 85 adult males indicated that individuals higher in perceived stress were more likely to evidence increased and sustained negative affect in response to stressful current events than individuals lower in stress. Similarly, Stawski et al. (2008) examined if self-report of perceived stress moderated the relationship between exposure to daily stressors and reactivity to those stressors as measured by negative affect in a sample of 67 college students and 116 older adults. The findings indicated that for college students, increases in negative affect to daily stressors were more elevated for those reporting higher perceived stress than for those reporting lower perceived stress. Finally, von Känel et al. (2003) measured the effect of perceived stress on physiological stress response to a speech stressor in a sample of 37 Alzheimer caregivers and found that higher self-reports of perceived stress in the preceding four weeks were associated with increased physiological reactivity to the stressor. Although these studies provide preliminary support, none examined perceived stress during adolescence or how it may interact with autonomy and relatedness pressures.

To our knowledge, studies examining the interaction of perceived stress and autonomy relatedness on youth’s physiological response to an acute stressor during adolescence do not exist. However, a study by Evans et al. (2007) examined if maternal responsiveness

moderated the impact of cumulative stress, a construct that may be related to perceived stress, on allostatic load in a longitudinal sample of 207 middle school adolescents. The results suggested that cumulative stress was associated with allostatic load but that the effect for allostatic load was only found for youth with mothers low in responsiveness. Taken together, this literature suggests that for youth who perceive high amounts of daily stress, negotiating a new stressor may be overloading and exasperate an already sensitive stress response resulting in increased physiological reactivity as measured by overall cortisol and blood pressure output at baseline, peak, and recovery to an ecologically-valid parent–adolescent interaction task.

Adolescent's Gender and Puberty Status

Past research has suggested that gender is associated with adolescents' stress response (Chaplin et al. 2010; Stroud et al. 2011), particularly in regards to girls evidencing heightened reactivity to interpersonal stressors (Stroud et al. 2002). Autonomy and relatedness can be conceptualized as an interpersonal stressor as the process may involve increased conflict within the parent–adolescent relationship that may be more strongly associated with emotional responses in girls than boys (Zimmer-Gembeck et al. 2009). Pubertal status also has been associated with adolescents' stress response such that youth who have begun puberty evidence increased reactivity to stressors (Romeo 2010; Stroud et al. 2011). Furthermore, puberty is associated with increased conflict in the family and decreased autonomy and relatedness (Steinberg 1987; Weichold et al. 2008). Thus, it is particularly important to control for these covariates given the known associations with both autonomy and relatedness and adolescents' stress response.

Hypotheses

Research to date has generally neglected to examine how normative developmental transitions may be stressful for youth and impact their neurobiological response to stress. Furthermore, few studies during adolescence have examined whether perceived stress may exasperate the influence of potential stressors in adolescents' lives on adolescents' acute physiological response to stress. These gaps in the literature are surprising given self-report research and theoretical accounts that new developmental tasks such as autonomy and relatedness may be stressful for youth (Gure et al. 2006), as well as the known increase in perceived stress that occurs during adolescence (Compas et al. 2001). Thus, the purpose of this study was to address two main gaps in the literature. First, given theory (Allen et al. 1994) and self-report research (Gure et al. 2006) suggesting that autonomy and relatedness may be a stressful process for adolescents when parents have trouble granting autonomy while maintaining relatedness we examined three related hypotheses: (a) maternal undermining of autonomy during the conflict interaction task will be associated with increased cortisol and blood pressure response among adolescents; (b) maternal undermining of relatedness during the conflict interaction task will be associated with increased cortisol and blood pressure among adolescents; and (c) higher maternal behaviors that promote autonomy and relatedness during the conflict interaction task will be associated with decreased cortisol and blood pressure among adolescents. Second, because past research suggests that perceived stress may conditionalize the effect of acute stress on

neurobiological responses to stress (Stawski et al. 2008) we hypothesized that the association between measures of autonomy and relatedness and adolescents' cortisol and blood pressure will be stronger for youth who perceive more daily life stress than youth who perceive less daily life stress. We tested these associations while controlling for gender and puberty status given the known associations with study variables. In addition to substantive contributions, this study utilizes multiple methods to assess constructs.

Methods

Sample

Participants were 100 adolescents and their maternal caregivers (91 % biological mother) living within a 20 mile radius of an urban area in the Northeastern part of the United States. Families were recruited through several methods including community postings, a commercial mailing list (American Student List), community outreach, and school partnerships. Adolescents were in grades 9th–11th ($M = 15.09$ years, $SD = .98$) and primarily self-identified as European American (78 %) with fewer youth identifying as other races/ethnicities. The adolescent participants were predominately female (68 %). Seventy-four percent of the mothers reported being married, with 64 % reporting that this was their first marriage. The median level of education for mothers was a college degree (41 %), considerably higher than state norms (27.1 %; U.S. Census, Table S1501). The median household income for the family was reported as falling between \$80,000 and \$89,999. This level of income is slightly higher than families within the state (\$72,872) but similar to married-couple families (\$88,243; U.S. Census, Table S1901).

Procedures

Data was collected through home visits. Prior to the home visit, consent/assent was obtained from parents and adolescents. The home visit was approximately 2.5 h long and youth were asked not to eat anything 2 h prior to the visit. The majority of data collection started at 3:30 to minimize the amount of cortisol variation due to time of the day. For adolescents the first part of the visit involved a relaxation period, which lasted 30 min. To aid in the relaxation adolescents either watched a G-rated cartoon (21 %) or a nature DVD (79 %); choice of video was unrelated to measures of stress response. The purpose of this relaxation period was to obtain baseline levels of stress (blood pressure, cortisol) that were taken 40 min into data collection following the relaxation video so that any changes in stress response could be attributed to the parent–adolescent interaction.

Following the relaxation period adolescents engaged in two 8-min interactions that involved mothers and adolescents discussing an issue of conflict within the home and discussing an issue adolescents were having outside of the home. The order of the interactions was counter-balanced. The purpose of these interactions was twofold. First, the interaction was used as a means to induce a possible stress response in adolescents that would mirror what might occur in conflict with parents in their daily lives (Allen et al. 2012a; Chaplin et al. 2012) and second, the interactions provided a means in which to observe autonomy granting and relatedness in the parent–adolescent relationship. The issue of conflict within the home was identified through a Family Issues Checklist (Robin and Foster 1989) that asked

participants about topics of conflict that occurred within the last month. Both mothers and adolescents separately marked the topics they discussed and then rated their feelings while discussing that task on a scale from 1 (*calm*) to 5 (*angry*). The overall highest rated conflict for mothers and adolescents was chosen and within this study the issues most often chosen were “cleaning the house” and “fighting with brothers and sisters.” The issue of conflict outside of the home was obtained by asking the adolescent to identify an issue (e.g. a problem with a friend) that they are experiencing outside of the home. For purposes of the current study only the parent–adolescent conflict task was coded for autonomy and relatedness. To obtain peak measures of stress response blood pressure was taken between and immediately following the interactions and cortisol was taken 15 min following both the tasks. Following the interaction, adolescents again relaxed while watching their chosen video and recovery measures of blood pressure were taken twice (every 20 min) and cortisol once (40 min post stressor). After all physiological data was collected, adolescents filled out a survey. Mothers and adolescents were compensated \$40 each.

Measures

Autonomy and Relatedness—The Autonomy and Relatedness Coding System (ARCS; Allen et al. 2012a) was used to assess restricting autonomy and restricting relatedness in the parent–adolescent relationship, as well as a combined measure of promoting autonomy and relatedness. Past research has shown that it is important to not only assess the individual effects of restricting autonomy and inhibiting relatedness (McElhaney and Allen 2001) but also to examine the combined impact that experiencing both promotion of autonomy and relatedness may have on adjustment (Allen et al. 1994). Video-tapes of the 8 min parent–adolescent interaction were observed and coded by trained coders using the ARCS, which yields scores for both mothers and adolescents on 10 different subscales in four different categories a) displaying/promoting autonomy, which includes behaviors reflecting independence of thought; b) displaying/promoting relatedness, which includes expressions of interest and engagement in another person’s thoughts and feelings; c) undermining autonomy, which reflects pressuring and overpersonalizing behaviors that make it difficult or impossible to discuss disagreements; and d) undermining relatedness, which reflects rude and hostile behaviors. For purposes of the current study we used three scales representing observation of mothers’ undermining of autonomy, mothers’ undermining of relatedness, and a combined scale utilizing scores from two different categories to represent mother’s promoting of both autonomy and relatedness (autonomy and relatedness, AR). Depending on the scale scores can range from 0 to 4. The AR scale is a summative scale and can range from 0 to 12, with higher scores indicative of more promoting of both autonomy and relatedness. Thirty percent of tasks were coded by an independent coder to assess interrater reliability by calculating intraclass correlation coefficients (ICCs). The ICC for the rating scales ranged from .73 to .88 (avg = .78), which is comparable to other studies that have used the ARCS (Allen et al. 1994; McElhaney and Allen 2001).

Stress Response—To assess the cardiovascular stress response, a Contec 08C blood pressure cuff (China) was used to assess systolic blood pressure (SBP) and diastolic blood pressure (DBP) at several points throughout data collection to include: two measures of baseline, in between the two interaction tasks, directly following both interactions, and at

two recovery time points. For purposes of the current article only SBP is examined as there were no significant associations in any analyses between study variables and DBP. SBP has been used in previous studies as a valid marker of individual differences of stress response to an acute stressor (Chida and Hamer 2008). Salivary cortisol was assessed to obtain an indicator of HPA axis response. Salivary cortisol is a well-established non-invasive measure of HPA axis functioning that is highly correlated with plasma cortisol (Adam and Kumari 2009). Salivary samples were obtained using a cotton strip that adolescents were asked to stick between their back molars and the inside of their cheek. Assay kits were purchased from Salimetrics Laboratories (State College, PA). Samples were stored at -40°C . Saliva was collected at several time points, which included baseline following the relaxation period (40 min into the session), directly following both the interactions (65 min into the visit), and at two points spaced 20 min apart toward the end of data collection (80 min into the visit and 100 min into the visit). Saliva was assayed in duplicate for cortisol at the Laboratory for Biological Health Psychology (Brandeis University, Waltham, MA) using a competitive chemiluminescence immunoassay (CLIA; IBL-International, Toronto, ON, Canada). The intra-assay coefficients of variation for the assay kits ranged from 3.9 to 6.6 % and the inter-assay coefficients of variation ranged from 2.6 to 5.5 %. Winsoring was used for the stress reactivity measures that were three standard deviations from the mean.

For the current study, area under the curve in response to ground was used for SBP and cortisol response. Area under the curve ground (AUCg) provides a summative measure of changes that occurred over time with respect to adolescents' stress response (Pruessner et al. 2003). AUC provides a valid measure of overall stress response output and a way to use data collected over many time points when the time interval between those points is not identical; thus, capturing participants' response to the entire stress-paradigm (Pruessner et al. 2003). In the current study, AUCg is a particularly useful measure, as participants did not show a linear cortisol increase to the parent-adolescent interaction task and evidenced a small linear increase for blood pressure. To compute AUCg, formulas from Pruessner et al. (2003) were used. Although AUC has not previously been used for blood pressure, research has highlighted the importance of capturing peak, as well as recovery response for blood pressure, as this assessment may provide a good indicator of individual differences in how well the body handles stress (Hocking Schuler and O'Brien 1997; Stewart and France 2001). AUCg, thus, provides a measure that accounts for not only individual differences in reactivity to a stressor but differences in recovery, which would not be captured by simple peak-baseline or peak-recovery indicators.

Perceived Stress—Adolescents reported on the Short Form of the Perceived Stress Scale to measure how much within the last month they appraised events in their lives as unpredictable, uncontrollable, and overloading (PSS; Cohen et al. 1983). Although the PSS was collected during in-home data collection, it does not measure perceived stress in reference to anticipatory feelings regarding the in-home data collection and instead captures perceived stress in adolescents' daily lives over the past month. The PSS was originally developed based off Lazarus's transactional model that argues that a person's response to stress involves the appraisal of the stressor and one's ability to cope. Adolescents responded to 10 items on a 1 (*Never*) to 5 (*Very Often*) scale with higher scores indicating more

perceived stress to items such as “felt that you were unable to control the important things in your life.” This scale has previously been used in previous research to measure secondary appraisal and been correlated with the number of daily stressful events (van Eck et al. 1998). In the current study the measure demonstrated good reliability ($\alpha = .87$).

Pubertal Status—Puberty was measured with self-report on five questions on the Pubertal Development Scale (PDS; Shirtcliff et al. 2009). Response options range from 1 (*no*) to 4 (*development seems complete*). In general, youth reported that they had started or were nearly done with pubertal development (Girls = $M = 3.55$, $SD = .29$ and Boys = $M = 2.91$, $SD = .52$). This scale has been used to capture gonadal and adrenal hormonal signals of puberty and is associated with hormones used to assess pubertal development (Shirtcliff et al. 2009). The measure demonstrated good reliability ($\alpha = .83$).

Analytic Approach

Data were analyzed by performing a series of hierarchical multiple regressions in SPSS 22.0. Due to concerns of multicollinearity (initial analyses showed tolerance below .10 and VIF above 13 when all predictors were considered in the same analyses) a total of four multiple regressions were estimated and included (a) regressing undermining relatedness and undermining autonomy on AUCg SBP (b) regressing undermining relatedness and undermining autonomy on AUCg cortisol and (c) two separate analyses regressing promoting autonomy and relatedness on AUCg SBP and then on AUCg cortisol. All variables were centered before interactions were created to further lessen concerns of multicollinearity and aid in interpretation. For all models predictors were entered in two steps. Step 1 included all controls (puberty and gender) and main effects. Step 2 included controls, main effects, and interactions between perceived stress and autonomy and relatedness variables. Given the well-documented difficulties detecting interaction effects in observational research we adopted a $p < .10$ to indicate significance and warrant further probing of the interaction (Whisman and McClelland 2005). Statistical significance for all the controls and main effects were set at $p < .05$. There was very little missing data in the current study (3 participants were missing cortisol data) and thus listwise deletion was used.

Results

Correlations and means and standard deviations are presented in Table 1.

Autonomy and Relatedness on SBP and Cortisol AUC

To examine the associations between autonomy and relatedness and adolescents' SBP and cortisol response main effects from the regression models were examined. Results suggested few significant main effects of autonomy and relatedness (AR) on SBP and cortisol AUCg (Table 2). Higher observed promoting of AR was associated with lower cortisol stress response ($\beta = -.27$, $p < .05$) suggesting support for the hypothesis that problems with autonomy and relatedness are associated with increased reactivity to stress during adolescence.

Interaction Effects of Autonomy and Relatedness and Perceived Stress on AUC ground

To examine if perceived stress moderated the effect of autonomy and relatedness on adolescents' stress response the interactions from Step 2 of the regression analyses were examined (Table 2). Significant interactions were found for AR by perceived stress and undermining relatedness by perceived stress predicting adolescents' stress response. Probing of the interactions followed recommendations by Aiken and West (1991) and used www.jeremydawson.co.uk/slopes.htm excel program. As shown in Fig. 1, adolescents who reported higher perceived stress and whose mothers were lower in observed AR evidenced increased SBP output during the visit when compared to youth who were higher in perceived stress and who had mothers who promoted AR within the task. For those lower in perceived stress, mothers' AR did not seem to have a strong impact on differences in SBP during the visit. A similar pattern of findings was found for cortisol, with those higher in perceived stress and lower in AR evidencing the most cortisol output during the visit.

As shown in Fig. 2, youth who were higher in perceived stress and whose mothers undermined relatedness during the interaction task evidenced the most SBP output during the visit when compared to youth both lower in perceived stress and higher in perceived stress but whose mothers did not undermine relatedness during the task. Taken together, these results support our hypothesis and suggest that problems with autonomy and relatedness may only be associated with adolescents' stress response for youth who perceive or perhaps actually experience more daily stress.

Discussion

The development of autonomy during adolescence is an important developmental task for youth, a task that may be stressful depending on how much perceived stress youth experience in their daily lives. Despite the importance of understanding how developmental transitions in adolescents' lives may affect neurobiological responses to stress, research has neglected this topic area. Our results suggest that when mothers and adolescents have difficulty negotiating new roles within the parent–adolescent relationship these difficulties may influence adolescents' physiological stress response. Furthermore, we demonstrated that adolescents who perceive more stress in their lives may experience more adverse effects when confronted with mothers who exhibit low levels of autonomy and relatedness toward youth. This study contributes to the existing literature by utilizing a developmentally-valid interaction task to examine individual differences in the effect of a developmental stressor on youth's stress response.

Autonomy, Relatedness, and Stress Response

To our knowledge, this is the first study to examine the effect that problems with autonomy and relatedness in the parent–adolescent relationship may have on adolescents' stress response. The results provide support for the hypothesis that adolescents whose mothers' did not promote autonomy and relatedness in the task were more likely to evidence increased cortisol output. We did not find associations when we considered restricting autonomy and restricting relatedness as two separate predictors. Allen and colleagues (e.g., Allen et al. 1994; Marsh et al. 2003) have emphasized the importance of examining the combined effect

of both autonomy and relatedness on adolescent development when compared to just examining the individual influence of autonomy. Thus, our findings concur with this previous research that the restriction of autonomy in and of itself does not appear to be problematic for adolescent development but that the combination of low autonomy and low relatedness may be associated with adverse outcomes.

Although these findings are similar to previous research that has demonstrated associations between parenting behaviors in a interaction task and adolescents' stress response (Byrd-Craven et al., Chaplin et al. 2012), autonomy is a distinct construct from other parenting variables that have been examined and marks a realignment in the relationship that is crucial to adolescents' movement toward self-regulation (Ryan et al. 1997). Thus, our findings mark an important contribution to the literature by demonstrating that a normative developmental process for parents and adolescents may be stressful when parents and youth have difficulty with this renegotiation of power. Furthermore, our research contributes to existing research that has relied on self-report data to suggest that autonomy and relatedness may be stressful for youth (Gure et al. 2006; Seiffge-Krenke et al. 2013) by providing alternative measures to demonstrate an association between a key developmental task and adolescents' neurobiological stress response. As this is the first study to examine the effect of autonomy and relatedness on adolescents' neurobiological response to stress, replication is needed and will provide an important area for future research.

Surprisingly, autonomy and relatedness was associated with increased cortisol output but not increased systolic blood pressure output. Past research has generally found that parent–adolescent interaction tasks do not produce significant elevations in cortisol (Gunnar et al. 2009) but increased cardiovascular activity has been found in response to the conflict (Allen et al. 2012a; Chaplin et al. 2012). Consistent with previous research utilizing a parent–adolescent conflict task, we also did not find an overall cortisol response to the interaction. We did, however, uncover important individual differences in cortisol response utilizing AUCg. Gunnar and colleagues' review of stressor paradigms suggests that cortisol increases may only be found during parent–adolescent conflicts when parenting behaviors, such as negativity are taken into account. Furthermore, past research has suggested that when central goals to self are threatened, when stressors are uncontrollable, and when stressors present a threat to social self an increased HPA-axis response is more likely (Dickerson and Kemeny 2004). Arguably, adolescents whose mothers do not promote autonomy and relatedness within the task will experience the above outlined conditions providing a strong explanation for why we see increased cortisol response among youth. Again, this is the first study to demonstrate an association between cortisol and autonomy and relatedness and provides important preliminary evidence that autonomy and relatedness like parental negativity may possess key characteristics needed to elicit a cortisol response in youth.

Perceived Stress

The results support the hypothesis that adolescents who reported more perceived stress within the last month were more likely to evidence an increased stress response when observed autonomy and relatedness was low. Specifically, youth reporting higher perceived stress and problems with autonomy and relatedness evidenced an increased cardiovascular

response but youth lower in perceived stress and autonomy and relatedness did not evidence an increased cardiovascular response. A similar interaction was found for undermining relatedness. This finding is consistent with our hypothesis and previous research indicating that high amounts of daily stress may impact individuals' ability to cope with new stressors (Stawski et al. 2008). Unfortunately, previous research has not specifically examined the relationship between perceived stress and acute stressors impacting adolescents' stress response and thus replication is needed.

Perceived stress also moderated the association between autonomy and relatedness and cortisol output. These results, however, were more complex in the interpretation. The interpretation of the interaction suggested that for youth low in perceived stress, the amount of observed autonomy and relatedness (high or low) was not associated with increased cortisol output, meaning cortisol output looked relatively the same at each level of autonomy and relatedness. In contrast, for youth high in perceived stress, autonomy and relatedness had differential effects depending on whether mothers were promoting or undermining this behavior. Specifically, youth high in perceived stress and lower in autonomy and relatedness evidenced the highest cortisol output and those higher in perceived stress and higher in autonomy and relatedness evidenced the lowest cortisol output. To the extent that perceived stress may be indicative of a trait reactivity (Van Eck et al. 1998), these findings are consistent with theories that suggest that youth high in trait reactivity or in this case perceived stress are particularly sensitive to context and may evidence positive or negative outcomes depending on whether the context is supportive (e.g., promotes autonomy and relatedness) or adverse (undermines autonomy and relatedness; Ellis and Boyce 2008). This interpretation would run contrary to previous research demonstrating that perceived stress is associated with the actual number of stressful life events and thus you would expect that perceived stress only exacerbates the effect of new stressors encountered (Stawski et al. 2008). Future research should examine perceived stress, trait reactivity/temperament, and stressful life events as moderators of the association between autonomy and relatedness and adolescents' stress response to examine if the current findings look similar across these potentially different but related variables.

Limitations

Although this study examines an important but understudied topic, the study is not without limitations. The study used correlational data and thus we should not draw firm conclusions regarding the direction of effects. It is plausible that consistent with child-effects models that youth who evidence larger physiological output may engender a response in parents that involves the restriction of autonomy, potentially due to concerns that their child may not be able to handle increased self-regulatory responsibility. More longitudinal research is needed to evaluate the direction of effects. Also, autonomy and relatedness was only examined within the task and this measurement may differ from every day parent-adolescent interactions. The focus of this study was to examine how problems with autonomy and relatedness are related to adolescents' acute stress response when faced with an ecologically valid stressor of discussing conflict. Nevertheless, future research should consider examining self-report measures of autonomy and relatedness and the association with stress response. Furthermore, the current study only examined mother-adolescent interactions and did not

include fathers in the study. Fathers and mothers have different relationships with their children and different effects on their adjustment (Lamb and Lewis 2005; Laible and Carlo 2004) and future research should examine if similar results are found for fathers. Finally, the sample was predominately Caucasian and middle-class. Tangential research suggests that autonomy may be viewed differently and affect adolescent adjustment differently depending on ethnicity and SES (Avenevoli et al. 1999; Demo and Cox 2000). Thus, replication is needed with diverse samples.

Conclusion

This study's findings reveal associations between lower maternal autonomy and relatedness and adolescents' increased cortisol response. These findings build on previous research that has demonstrated an association between parent–adolescent relationships and adolescents' neurobiological response to stress (Byrd-Craven et al. 2012; Spies et al. 2011). Most importantly, our study is the first study to exclusively focus on autonomy and relatedness, a distinct construct from other parenting behaviors, that is critical for adolescents to become self-regulating autonomous adults and has been associated with lifelong positive development (Oudekerk et al. 2015). The findings also suggest that adolescents whose mothers undermine autonomy and relatedness and who report higher perceived stress evidence a heightened HPA-axis and cardiovascular response. This is the first study during adolescence to demonstrate that perceived stress in adolescents' daily lives may have an impact on the association between autonomy and relatedness (or other key developmental tasks) and adolescents' neurobiological stress response. In a recent review, Seiffge-Krenke (2011) called attention to the paucity of research on this general topic and the importance of conducting studies that examine the role of the appraisal process in the impact of interpersonal stressors on adolescents' coping. Our study directly contributes to that call by considering how the body physiologically copes with an interpersonal stressor during the critical time of adolescence. Taken together, these findings support the importance of examining individual differences in the association between important developmental tasks and adolescents' coping with those tasks. This research may be important to incorporate into parenting programs focused on educating families about normative changes that occur during adolescence and how to successfully negotiate these changes.

Acknowledgments

Support for this project was provided by an Institutional Development Award (IDeA) awarded to Emily Cook from the National Institute of General Medical Sciences of the National Institutes of Health under Grant Number 2 P20 GM103430. Special thanks to research assistants Amanda Welch, Kristen Wilkinson, and Kyle Fernandez and to all the families who participated.

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Fig. 1. Perceived stress, autonomy and relatedness and adolescents' adrenocortical and cardiovascular stress response. The *top graph* displays the interaction between autonomy and relatedness (AR) and perceived stress on SBP and the *bottom graph* displays the interaction between AR and perceived stress on cortisol. For interpretation of the interaction, models were estimated with no controls in the model

Fig. 2. Perceived stress, undermining relatedness and adolescents' cardiovascular stress response. This graph displays the interaction between undermining relatedness and perceived stress on SBP. For interpretation of the interaction, models were estimated with no controls in the model

Table 1

Means, standard deviations and correlations between study variables (N = 97)

Variables	1	2	3	4	5	6	7	8
1. Puberty	–							
2. Gender	–.62**	–						
3. Autonomy and relatedness	.01	.13	–					
4. Undermining autonomy	–.04	–.08	–.20*	–				
5. Undermining relatedness	–.04	–.05	–.34**	.25*	–			
6. Perceived stress	.18	–.36**	.10	–.04	–.09	–		
7. SBP AUCg	.07	.19*	–.05	.01	.05	.11	–	
8. Cortisol AUCg	.20*	.04	–.15	.02	–.12	.02	.07	–
<i>M</i>	3.34	–	10.87	2.48	.46	2.58	6868.09	424.47
<i>SD</i>	.48	–	2.13	1.81	.86	.68	597.15	241.62
Skewness	–.87	–	–.58	.52	3.19	–.06	.34	2.93

Gender is dummy coded with 0 = girls and 1 = boys

* $p < .05$;** $p < .01$

Table 2
The association of autonomy and relatedness with adolescents' adrenocortical and cardiovascular stress response

Variables	SBP—ground (N = 100)			Cort—ground (N = 97)		
	B	SE	Beta	B	SE	Beta
<i>Regression model—predictors undermining autonomy and undermining relatedness</i>						
Step 1						
Gender	584.56	171.22	.46**	122.42	70.57	.24
Puberty	386.71	157.20	.31**	167.71	65.84	.33*
Undermining Rel (UR)	28.51	73.18	.04	-26.52	30.34	-.09
Undermining Aut (UA)	17.767	33.44	.05	5.26	14.22	.04
Perceived Stress	200.76	92.17	.23**	6.19	38.82	.02
Step 2						
Undermining Rel	96.18	80.51	.14	-27.42	33.96	-.09
Undermining Aut	6.27	33.82	.02	5.49	14.67	.04
Perceived stress	231.41	92.96	.26**	6.12	39.77	.02
UR × stress	279.26	140.05	.23**	-3.24	59.34	-.01
UA × stress	-18.62	51.00	-.04	1.84	22.87	.08
<i>Regression model—predictor autonomy and relatedness</i>						
Step 1						
Gender	583.32	169.54	.46**	149.87	67.51	.29*
Puberty	382.25	155.25	.31*	179.02	62.92	.36**
Autonomy and relatedness (AR)	-24.12	26.58	-.09	-28.41	10.62	-.27**
Perceived stress	189.86	91.95	.22*	8.89	36.94	.03
Step 2						
Aut and Rel	-15.65	26.88	-.06	-23.77	10.60	-.22
Perceived stress	198.07	90.51	.23**	12.61	36.18	.04
AR × stress	-70.42	42.22	-.20*	-37.02	16.64	-.23**

Four separate hierarchical regression analyses were estimated: (1) regression of undermining autonomy and undermining relatedness on cortisol, (2) regression of undermining autonomy and undermining relatedness on SBP, (3) regression of autonomy and relatedness on cortisol, and (4) regression of autonomy and relatedness on SBP. For simplicity all models are presented in one table even though four separate regression analyses were estimated

$50' > d'$
**
 $101' > d'$
*

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