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Does Context Matter? A Multi-Method Assessment of Affect in Adolescent Depression Across Multiple Affective Interaction Contexts

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Abstract

This study utilized a multi-method approach (self-reported affect, observed behavior, and psychophysiology) to investigate differences between clinically depressed and non-depressed adolescents across three different affective interaction contexts with their parents. 152 adolescents (52 males, 14–18 y.o.), and their parents, participated in a laboratory session in which they discussed positive and negative aspects of their relationship, and reminisced on positive and negative memories. We found that across contexts depressed adolescents exhibited higher negative affect and behaviors, lower positive behaviors, and greater autonomic and sympathetic activity. Context specific findings indicated that depressed adolescents 1) exhibited greater persistence of negative affect and dysphoric behavior across the sequence of tasks, whereas these phenomena declined amongst their non-depressed peers, 2) depressed adolescents had greater increases in aggressive behaviors during negative interactions, and 3) depressed adolescents had greater parasympathetic withdrawal during negative interactions, while this response characterized the non-depressed group during positive interactions.

Introduction

Adolescence is a developmental period characterized by alterations in affective functioning during which individuals are at increased risk for the onset of depressive psychopathology (Allen & Sheeber, 2008; Zisook et al., 2007). Indeed, depression is often characterized as a disorder of *affect regulation*, a process that has been assessed at the level of self-reported affect, behavior, and physiology (e.g., Allen, Kuppens, & Sheeber, 2012; Byrne et al., 2010; Davidson, Pizzagalli, Nitschke, & Putnam, 2002; Gross & Jazaieri, 2014; Sheeber et al., 2012), with depression being associated with impairment at each level. Disturbances in affective behavior in depression are often observed in social contexts, and during adolescence, parent-adolescent interactions are a particularly important context given that behavior during these interactions has shown strong associations with adolescent mental health and functioning (Kuppens et al., 2012; Kuppens, Allen, & Sheeber, 2010; Schwartz et al., 2013; Schwartz, Sheeber, Dudgeon, & Allen, 2012; Sheeber et al., 2012). Notably, however, most studies only examine the impact of depression within a single context and do not simultaneously assess across self-reported affect, behavior, and physiology. Indeed, research has yet to fully specify the impact of different interactional contexts, designed to elicit different types of affect, on depressed and non-depressed adolescent self-reported

affect, behavior, and physiological responses. Additionally, research has yet to fully elucidate the experiential, behavioral, and psychophysiological differences between depressed and non-depressed adolescents during these interactional contexts. The present study addresses these gaps in the literature by utilizing a novel multi-method design to examine differences between depressed and non-depressed adolescents' experiential, behavioral, and psychophysiological responses across multiple emotionally evocative family interaction contexts.

Why Does Context Matter?

Contextual influences on research findings in the sciences has recently gained much attention, especially because of their relevance to scientific reproducibility (Bavel, Mendsiedlecki, Brady, & Reinero, 2016; Open Science Collaboration, 2015). Bavel et al. (2016) recently highlighted this issue by rating 100 studies from the Reproducibility Project (Open Science Collaboration, 2015) with regard to their "contextual sensitivity" (i.e., how likely the effect reported was to vary by context—defined broadly as time, culture, location, or population) and found that the greater contextual sensitivity of a study was associated with lower likelihood of replication, suggesting that contextual factors can be "hidden" moderators of effects, and that research should address phenomena both across (context independent) and between (context dependent) environments. As related to the current project, this is notable in that the vast majority of studies on parenting factors associated with adolescent depression examine parent-adolescent interactions in only one context, most typically a "problem solving task", which is then used to draw general conclusions about adolescent functioning. In the current study, we address this issue by investigating the impact of adolescent depression on affective functioning during various parent-adolescent interactions that vary in affective tone.

Affect, Behavior, and Psychophysiology of Depression

Emotion is often conceptualized as consisting of coordinated alterations at the level of experience, behavior, and psychophysiology (Mauss, Levenson, McCarter, Wilhelm, & Gross, 2005). Research has demonstrated that depression is characterized by alterations in emotion, which tend to negatively impact psychosocial functioning and adjustment (Allen & Badcock, 2003). Therefore, a greater understanding of emotional processes in depressed adolescents across multiple social interactional contexts requires measures in the domain of self-reported affect, observed behavior, and psychophysiology.

Self-Reported Affect in Depression—Individuals with depression tend to experience higher levels of negative affect and lower levels of positive affect as compared to their non-depressed peers (Watson, 2000), a finding that is especially true for depressed adolescent females (Forbes, Williamson, Ryan, & Dahl, 2004). Depressed adolescents also tend to have deficits in the regulation of affective states (Silk, Steinberg, & Morris, 2003). These mean level differences in emotional states appear to be associated with abnormal temporal dynamics of emotion in depression, whereby young adults with depression tend to experience "emotional inertia" - the tendency to have affective states that are self-sustaining rather than sensitive to environmental changes (Koval, Kuppens, Allen, & Sheeber, 2012; Koval & Kuppens, 2012), which is the antithesis of emotional flexibility, which has been

shown to be associated with resilience from adolescence throughout adulthood (Lougheed & Hollenstein, 2016; Waugh, Thompson, & Gotlib, 2011).

Psychosocial Behavior in Depression—Another measure of affective functioning in depression that provides further evidence of affective impairment is behavioral observation of social interactions. Depressed adolescents tend to experience interpersonal difficulties that result from reduced social activity and engagement, deficits in social skills, and rigid responses to environmental demands (Rottenberg, 2005; Stark et al., 2006). Adolescents experiencing depression tend to exhibit higher levels of negative behaviors (e.g., behavioral disengagement and self-blame; Horwitz, Hill, & King, 2011), including aggression (Knox, King, Hanna, Logan, & Ghaziuddin, 2000), anger (Sheeber et al., 2009), and dysphoria in interpersonal interactions (Puig-Antich et al., 1985; Sheeber et al., 2009; Sheeber et al., 2012), while also displaying decreased positive behaviors (Sheeber et al., 2009). Similarly to emotional inertia in self-reported affect described above, behavioral emotional inertia of both negative and positive behaviors predict the emergence of clinical depression (Kuppens et al., 2012). Also, we have previously shown increased behavioral reactivity to negative parental behavior and reduced reactivity to positive parental behavior amongst depressed adolescents (Sheeber, Allen, Davis, & Sorensen, 2000). However, the broader emotional and/or interpersonal context may play an important role in how depressed adolescents behaviorally respond to interactions with their parents. Indeed, the study of contextual effects in depressed adolescents, especially in studies using cross method analyses that include behavioral observation, is a matter that still requires further examination.

Psychophysiology in Depression—Physiological activity is another component of emotion that may differ between depressed and non-depressed adolescents. In comparison to other indices of emotion, it may be less subject to measurement biases and thus allow for a more objective measure of affect, though it needs to be noted that no psychophysiological index has been shown to directly map onto specific emotion states in a one-to-one fashion (Cacioppo & Tassinary, 1990). One potentially important physiological correlate of depression is the autonomic nervous system (ANS) stress response (Lahmeyer & Bellur, 1987; Light, Kothandapani, & Allen, 1998; Moser et al., 1998). The ANS is composed of both the energy expending sympathetic nervous system (SNS) and the energy conserving parasympathetic nervous system (PNS). ANS components are activated when an organism faces environmental threat and challenge as well as psychosocial stress. Unlike survival threat and physical exertion, which are often transient and acute in nature, ongoing psychosocial and relational stress characterized by conflict, low social support, and social threat, particularly when it occurs in the context of close relationships, may have more chronic impacts on both psychological and physical health over time (Kiecolt-Glaser, Gouin, & Hantsoo, 2010).

There are many methods of indexing overall ANS activity as well as specific components of the ANS response (i.e., SNS or PNS). Heart rate and blood pressure are two overall indices of ANS activity that are influenced by a combination of sympathetic and parasympathetic innervation with depression being associated with higher resting heart rate and hypertension (Byrne et al., 2010; Davidson et al., 2000). In contrast, finger pulse transit time (FPTT),

which is the time interval between the previous R-wave and the systolic upstroke of the peripheral pulse at the finger (i.e., time between the heart's contraction and the pulse reaching the end of a finger), is influenced by the force of heart contraction and blood vessel dispensability created by SNS activity (Kang & Gruber, 2013; Mauss et al., 2005). Similarly, pre-ejection period (PEP) or the time interval between depolarization of the heart's left ventricle and the subsequent ejection of blood through the aortic valve indicates sympathetic response (Light, Kothandapani, & Allen, 1998). Research demonstrates that increased sympathetic activity, as indexed by shorter PEP time intervals, has been associated with depressive symptomatology in women (e.g., Light et al., 1998).

Respiratory sinus arrhythmia (RSA), or respiratory coupled heart rate variability, on the other hand, is an index of PNS activity via vagal control that has been shown to have associations with various forms of psychopathology throughout the lifespan (Beauchaine, 2015; Beauchaine, Gatzke-Kopp, & Mead, 2007; Porges, 2007). In addition, a recent systematic meta-analysis found that clinically depressed adolescents displayed lower resting parasympathetic activity, but do not exhibit associations between depressive symptom severity and parasympathetic activity, which is found in adults (Koenig, Kemp, Beauchaine, Thayer, & Kaess, 2016). In particular, increasing RSA trajectory (i.e., greater parasympathetic tone) over adolescence is associated with lower risk for depression (Gentzler, Rottenberg, Kovacs, George, & Morey, 2012), while depression in adults has been associated with low parasympathetic activity (i.e., low cardiac vagal tone or deficits in cardiac control) as characterized by lower resting RSA as compared to healthy controls (Rottenberg, Clift, Bolden, & Salomon, 2007). Similar findings have also been reported for infants of depressed mothers (Field & Diego, 2008). Research also indicates that depression in adulthood as well as depression with childhood onset is associated with blunted RSA reactivity (Bylsma, Salomon, Taylor-Clift, Morris, & Rottenberg, 2014; Yaroslavsky, Bylsma, Rottenberg, & Kovacs, 2013; Yaroslavsky, Rottenberg, & Kovacs, 2013). By contrast, states of positive emotion (which are especially low in clinically depressed states; Watson, 2000) are associated with higher resting RSA in first year university students (Oveis et al., 2009).

Parent-Child Interactions in Depression

There are a small number of studies that have measured emotional, behavioral, and physiological responses in depressed adolescents during parent-child interactions with few, if any, investigating all measures simultaneously. Research has found that during interpersonal conflict with parents exhibiting aversiveness, depressed adolescents display increased dysregulation of both behaviors and physiology (RSA), while control peers displayed greater physiological (RSA) regulation (Crowell et al., 2014). Allen et al. (2012) found that non-depressed adolescents had deceleration in heart rate in response to maternal angry and dysphoric behaviors, which was not observed in depressed adolescence. In contrast, depressed adolescents had significant heart rate accelerations when father's displayed angry behavior and heart rate decelerations when father's displayed dysphoric behaviors, findings that were not displayed by non-depressed peers.

In adolescent-parent interactions devoid of adolescent depression, research has found that parent-adolescent conflict discussions are associated with increased physiological and emotional responses, such that negative parenting has been associated with higher blood pressure and angry responses among adolescents (Chaplin et al., 2012). Another study looking at child-parent interactions found that children had lower heart rate increases from baseline to non-threat tasks, than from baseline to threat (i.e., conflict, anxiety) tasks (Gonzalez, Moore, Garcia, Thienemann, & Huffman, 2011), indicating greater sympathetic activation to conflictual discussions with parents. Furthermore, aversive behavior among both adolescents and their mothers is associated with low RSA during interactions (Crowell et al., 2013). Similarly, negative maternal behavior is associated lower physiological regulation, maladaptive emotion regulation strategies, and noncompliant behaviors in toddlers (Calkins, Smith, Gill, & Johnson, 2001) and negative and controlling parental behaviors are associated with lower RSA, while lower parasympathetic activity (i.e., lower vagal tone) is associated with harsh parenting practices in young children (El-Sheikh & Erath, 2011; Kennedy, Rubin, Hastings, & Maisel, 2004). Other studies have reported shortened PEP and decreased RSA in families with higher reported child-parent conflict during reactivity tasks (Salomon, Matthews, & Allen, 2000), indicating greater SNS and lower PNS response in high family conflict environments. While many of these studies address associations between psychophysiology indices and emotion with reported family interaction behavior, many studies fail to simultaneously address self-reported affect, observed behavior, and psychophysiology during actual varying live parent-child interactions, or the variations of these effects associated with clinical depression.

The Current Study

While we have previously described the overall dynamics of affective experience and behavior, averaged across interaction contexts, in depressed adolescents in this sample (Sheeber et al., 2009), but here we add multiple psychophysiology indices and uniquely address not only *general* dynamics of affective experience, behavior, and physiology (i.e., those that are found across contexts), but also explicitly explore the pattern of these variables across various affectively charged interactional contexts, in order to elucidate how these components of emotion and their interaction with depressive states are influenced by contextual differences in affective interpersonal situations. As noted earlier, attention to contextual influences has potentially significant implications for the reproducibility of findings (Bavel et al., 2016). This study therefore uniquely expands our understanding of abnormalities of the different components of emotion in adolescent depression in two ways. First, it examines these processes in a highly ecologically relevant, emotion eliciting contexts – various affectively charged parent-child interactions. As noted, few studies have addressed differences in observed behavior as a function of different interactional contexts. Second, we examined multiple components of emotional responses – self-report, behavior, and physiology – during these interactions, allowing for a thorough assessment of differences in the components of emotion between depressed and non-depressed teenagers across different systems of response.

We hypothesized that in general (i.e., across contexts) depressed adolescents would show greater negative and less positive self-reported affect, greater frequency and duration of

aggressive and dysphoric behavior and less frequency and duration of happy behavior, greater overall ANS response (i.e., higher heart rate and blood pressure) as well as greater SNS activation (i.e., PEP and FPTT) and lower PNS activation (i.e., RSA), than their non-depressed peers. Moreover, variations in these responses across interpersonal contexts will be examined, to evaluate whether the patterns hypothesized above are general in nature, or vary as a function of the nature of the parent-adolescent interaction context. Due to research indicating greater negative affect and sympathetic response during negative contexts (Chaplin et al., 2012), we hypothesized that putatively negative interpersonal interactions (i.e., the Problem Solving Task; PSI, which pulls for negative affect) would elicit the greatest difference in negative affect, negative behavior, and sympathetic response between depressed vs non-depressed adolescents, followed by collaborative interactions (i.e., the Family Consensus Interaction; FCI, which pulls for a mix of affects), and positive interactions (i.e., Event Planning Task; EPI, which elicits more positive affect). By contrast, due to research indicating that depressed persons are less responsive to rewarding or positive stimuli (e.g., Bylsma, Morris, & Rottenberg, 2008), we hypothesized that deficits in positive affect, positive behavior, and parasympathetic response amongst depressed adolescents (when compared to non-depressed adolescents) would be greatest during the putatively positive task (i.e., EPI).

Methods

Participants

Participants were 152 adolescents (52 males), aged 14–18, and their parents, who were participating in a study of emotional processes associated with depressive disorder during parent-adolescent interactions (see Table 1 for participant demographics). Inclusion criteria required that adolescents had to live with at least one parent or permanent guardian, and fulfill research criteria for placement in one of two groups (depressed vs. non-depressed). Adolescents who were depressed met DSM IV (APA, 1994) diagnostic criteria for a current unipolar depressive disorder during a diagnostic interview. Consistent with guidelines for establishing the offset of depressive episodes, a diagnosis was considered current if it was ongoing or had an offset within two months preceding the diagnostic interview (APA, 1994). Non-depressed adolescents had no current or lifetime history of psychopathology, and no history of mental health treatment. Adolescents were excluded if they evidenced comorbid externalizing or substance dependence disorders, were taking medications with known cardiac effects, or reported regular nicotine use.

Recruitment, Assessment Measures, and Procedures

Families were recruited using a two-gate procedure consisting of an in-school screening and an in-home diagnostic interview. In order to facilitate recruitment of a representative sample of students, we used a combined passive parental consent and active student assent protocol for the school screening (Biglan & Ary, 1990; Severson & Ary, 1983). Active parent consent and adolescent assent for the full assessment were obtained prior to the diagnostic interview.

Gate 1: School Depression Screener—The Center for Epidemiological Studies-Depression Scale (CES-D; Radloff, 1977) was used as the initial gate of a two-stage

recruitment and screening procedure. The CES-D is a widely used, self-report measure of depressive symptoms that has acceptable psychometric properties for use with adolescents (e.g., Roberts, Andrews, Lewinsohn, & Hops, 1990) and has a well-established record of use as a screener for depressive symptoms in adolescent samples (e.g., Asarnow et al., 2005; Sheeber, Davis, Leve, Hops, & Tildesley, 2007).

Students from area high schools completed the CES-D and a demographic data form during class. Approximately 70% of enrolled students who were living with at least one parent or permanent guardian participated (4182 of 5975), 12% ($n = 695$) declined or had parents decline their participation, and 18% ($n=1098$) were absent or off campus on the day of the assessment. CES-D cut-off scores for selecting potential participants were based on the distribution of scores obtained in an earlier screening of high school students ($N = 4495$) in the same area (Sheeber et al., 2007). Relatively high scores (> 31 for males and > 38 for females) were selected to maximize the positive predictive power to identify adolescents experiencing depressive disorder. Approximately 8% ($n = 372$) of the students scored above these cut-offs. The pool for the healthy group was defined as students not more than 1/2 SD above the mean in the earlier sample (<21 for males and <24 for females).

Gate 2: Diagnostic Interview—As the second screening procedure, interviewers conducted the Schedule of Affective Disorders and Schizophrenia- Children's Version (K-SADS, Orvaschel and Puig-Antich, 1994) with adolescents who had elevated CES-D scores. The K-SADS interview was conducted with the adolescents to obtain current and lifetime diagnoses. Interviewers, who were bachelor-and masters-level research staff, participated in a rigorous training program and demonstrated agreement with a senior interviewer ($> .80$) on at least two interviews before conducting independent interviews. All interview-derived diagnoses were confirmed by supervisors who reviewed both item-endorsement and interviewers' notes. Questions regarding the accuracy of diagnoses were resolved based upon discussion with the interviewer and review of the audiotaped interview as needed. Reliability ratings were obtained on approximately 20% of the interviews, chosen at random. The average agreement was $= .94$.

Subsequent to the interviews, families of adolescents who met criteria for MDD were invited to participate in the lab-based assessment. After each adolescent in the depressed group completed the laboratory assessment, a healthy, demographically matched comparison participant was recruited from the pool of students who scored within the normal range on the CES-D.

Approximately 9% ($n = 52$) of families contacted by phone were not eligible to participate as per the criteria described above (e.g., due to medicine regimen; moved out of family home). Of families invited to participate, approximately 26% ($n = 131$) declined. Rates of decline did not vary as a function of pre-interview group status (i.e., elevated or healthy CES-D score), age, or race, though more males than females declined (31.6% versus 23%), ($1, n = 498$) = 4.57, $p < .05$. Of adolescents with elevated CES-D scores who participated in the interview, 38% ($n = 81$) met criteria for MDD. Of these, 13.9% ($n = 10$) had a comorbid anxiety disorder and were retained in the MDD group given the high rate of comorbidity between mood and anxiety disorders. Five individuals were excluded due to psychotic

diagnoses (mania or schizophrenia). Of adolescents with CES-D scores in the healthy range, approximately 76% ($n = 84$) met criteria for inclusion.

Lab assessment—Families who met criteria for the investigation after the diagnostic interview were invited to participate in the lab assessment. Approximately 4% ($n = 7$) of families declined. The decline rate did not vary as a function of group status, age, race, or gender. Additionally, 11 participants were excluded from this report due to missing physiological data. In approximately 93% of two-parent families, both parents participated in the assessments. The average time between the diagnostic assessment and the lab assessment was 33.2 days ($SD = 20.1$; no between group differences).

The lab assessment included three family interaction tasks. Each task lasted 18 min, evenly divided across two discussions. The first task consisted of two fun-focused interactions (EPI) in which families were asked to first plan a fun family activity and then to reminisce about a fun time they had in the past. The second task consisted of a problem-solving interaction (PSI) in which families were asked to discuss and resolve two areas of conflict. The third task, consisted of a family consensus interaction (FCI) in which families were asked to discuss two areas of family life; one focused on identifying and describing the best and most difficult years the adolescent had experienced, and the other focused on the most challenging and most rewarding aspects of parenting the adolescent. The EPI and PSI tasks have been shown to preferentially elicit positive and aggressive behavioral responses, respectively (Allen et al., 2012; Sheeber et al., 2012), yet each task has the capacity to elicit a wide range of affective behavior. The FCI was designed to equally elicit positive and negative behaviors. Including a positive, negative, and an emotionally mixed context is particularly important in order to cover the types of affective interactions in which adolescents and parents are likely to engage and to understand whether behavior within these diverse interactional contexts have implications for adolescent well-being. Interactions were video recorded for subsequent behavioral coding. Participants were instructed to abstain from alcohol and illicit drugs on the day of the assessment. Compliance with this instruction was confirmed on the day of the assessment via self-report.

Physiological Measures and Procedures—All data were acquired using software and equipment from the James Long Company (www.jameslong.net) except where otherwise noted. Electrocardiograph (ECG) was input to an isolated bioelectric amplifier custom built for research (“Bioamp”). Impedance cardiogram (ICG) signals were amplified and processed by a Hutchinson Impedance Cardiograph model HIC-2000 produced by Bio-Impedance Technology Inc. (Chapel Hill, NC). Blood pressure was monitored via a Portapres portable continuous blood pressure monitor produced by Finapres Medical Systems (Amsterdam, The Netherlands). The Portapres blood pressure monitor measured systolic and diastolic blood pressures, and over time calculated the mean blood pressure from the aggregate blood pressure waveform.

The ECG and ICG signals were recorded using Ag-AgCl electrodes. To record the ECG signal, we used a three-lead system to maximize the r-wave amplitude and minimize movement artifact and t-wave amplitude. The ECG signals were amplified with the Bioamp, with a gain of 250 and bandpass of frequencies between 0.1–1,000Hz. ICG signals were

produced using two current electrodes placed on the back at thoracic vertebra T9 and on the neck at cervical vertebra C4 (Bosch et al., 2009) through which a 2mA RMS current was passed. The basal thorax impedance (Z_0) was measured (in ohms) by two electrodes placed between the current electrodes between the shoulder blades and in the mid back, and the rate of change in impedance waveform (dZ/dt) was calculated.

The ECGRWAVE program from the James Long Company identified r-waves from the ECG signal with an automated, multiple-pass, self-scaling algorithm. These signals were then visually inspected to see if the program identified the morphology of the r-wave correctly and manually corrected for missed or misrepresented r-waves. Sections of movement, noise artifact or flat line artifact were removed. Overall, this accounted for only 0.5% (in seconds) of the total data that had to be marked and removed as artifact. Other physiological data such as blood pressure were visually inspected to ensure signal quality, and quantitative data were examined to ensure that values fell within a biologically plausible range (e.g. values of 0 in any signal were removed as artifact).

Mean heart rate values were derived for each one-second epoch, based on a weighted average of the heart rate values associated with each of the inter-beat intervals (IBI) to fall either fully or partially within the epoch, with each of these intervals being weighted according to the time proportion of the epoch that each IBI constituted.

RSA reflects the variation in heart rate due to changes in respiration. We calculated a “time-domain” RSA variable by measuring the difference in milliseconds between the maximum inter-beat interval (IBI, or r-r interval) during expiration and the minimum IBI during inspiration (peak-to-trough method; Goldston & Baillie, 2008). Because the RSA variable had a non-normal distribution, we transformed it to $\log(RSA)$. $\log(RSA)$ has been used as a time-domain measure of RSA in previous research (Lehofer et al., 1997; Moser et al., 1998).

Pre-ejection period (PEP) estimates the period of time commencing with onset of ventricular depolarization as represented by the ECG Q wave and ending with the onset of left ventricular ejection as indicated by the B point of the dZ/dt signal (Cacioppo, Uchino, & Berntson, 1994). The positions in time of the Q peak in the ECG and the B point in the dZ/dt signal were detected automatically and were subsequently checked visually and edited where the detection was incorrect.

Finger pulse transit time (FPTT) were derived from the systolic time interval (in msec) between the closest previous R-wave of the heart beat as measured by the ECG (reflecting the contraction of the heart), and the peripheral finger pulse as it was measured by the finger cuffs associated with the Portapres blood pressure monitor, averaged over each interaction type.

Prior to the interactions tasks a two-minute resting baseline measure of all psychophysiological variables were collected, during which adolescents were instructed to sit quietly and with minimal movement. These baseline measures were used as covariates for all analyses.

We considered RSA to be a measure of vagal tone, and therefore of PNS functioning. We used FPTT and PEP as indicators of SNS functioning. Lastly, we used heart rate and blood pressure as overall indicators of ANS functioning (Cacioppo et al., 1994).

Behavioral Observations—The Living in Family Environments coding system (LIFE; Hops, Biglan, Tolman, Arthur, Longoria, 1995) was used to code parent behavior during the video-recorded family interactions. The LIFE is an event-based, microanalytic coding system in which a new code is entered each time there is a change in a participant's verbal content or affective behavior. As such, duration of each behavior (i.e., the proportion of time spent engaging in this behavior across the task) can be calculated as the time between onset of one code and onset of the next code, for each person in the interaction. In addition, frequency of each behavior can be calculated as the rate per minute of each behavior across each interaction task. Each entry is comprised of several components which identify the: (a) target (i.e., whose behavior is being coded); (b) verbal content; and (c) nonverbal (or para-verbal) affect. These micro-level data are then combined into mutually exclusive constructs, which are operationalized as particular combinations of content and affect codes (Hops et al., 1995). Three binary constructs, angry, dysphoric, and happy were derived from individual affect and content codes (with 1 indicating presence of the behavior and 0 otherwise). The angry, dysphoric, and happy constructs were used in this report. Angry behavior included aggressive (e.g., raised voice; clenched teeth) or contemptuous (e.g., eye rolling; sneering) nonverbal behavior and cruel (e.g., mocking; insults; threats) or provoking (e.g., taunts; dares) statements. Dysphoric behavior was defined by sad nonverbal behavior (e.g., tearfulness, sighing) or complaining statements. Happy behavior was defined by happy nonverbal behavior (smiling; laughing) and humorous statements.

Extensively trained observers, with over a decade of experience, coded the adolescents' nonverbal affect and the content of verbal statements. These data were coded into frequency (i.e., rate per minute) and duration (i.e., the proportion of time spent engaging in this behavior across the task). Observers were blind to diagnostic status. Approximately 25% of the videos were coded by an additional observer for reliability. Kappas for adolescent angry, dysphoric, and happy behavior ranged from .72 to .84 (Average = .79) which reflect good agreement (Fleiss, 1981; Landis & Koch, 1977). The validity of the LIFE system as a measure of family processes has been established in numerous studies of adolescent depression (e.g., Katz & Hunter, 2007; Sheeber et al., 2007).

Self-Reported Affect—The Positive and Negative Affective Scale (PANAS; Watson, & Clark, 1994) was used to assess adolescents' self-reported affect both before and after each interaction task. The post-interaction assessment queried how the adolescent was feeling during the interaction. The measure has demonstrated acceptable psychometric properties in adolescent samples and all subscale scores demonstrated acceptable reliability (i.e., > .80). To assess positive and negative affect prior to the beginning of the first task, we used pre-positive and pre-negative PANAS scores. In order to examine emotional change during each task specifically (i.e., controlling for the effect of baseline affect before each task), we ran a series of regression analyses using the pre-task affect ratings to predict the post-task affect

ratings for each task (i.e., EPI, PSI, FCI) and then created unstandardized residual scores representing the change unique to each task period.

Data Analysis—The data reflect information on depressed or non-depressed adolescents' observed behavior, self-reported affect, and psychophysiology averaged across each of the three interaction tasks. Using SPSS Version 23, a series of repeated-measures analyses of variance (ANOVAs) were performed with independent variables reflecting a between-subjects group factor (i.e., depressed vs. non-depressed) and within-subjects factors reflecting the 3 interaction tasks/contexts (i.e., EPI, PSI, FCI). Dependent variables included measures of observed behavior, self-reported affect, and physiology (averaged within each condition). For physiological variables, measures of baseline individual differences in the resting values of the variables were included in analyses as covariates in order to control for the effect of baseline individual differences (i.e., heart rate, PEP, RSA, BP, FPTT). The self-reported affect measures were taken both immediately before and immediately after each interaction task, two sets of analyses. For post positive and negative scores, unstandardized residual change score between pre-positive to post-positive and pre-negative to post-negative were derived in order to index change in affect. The "outlier labeling rule" was used to assess outliers and biologically implausible values (Hoaglin, Iglewicz, & Tukey, 1986; Hoaglin & Iglewicz, 1987; Tukey, 1977).

Results

Adolescent Self Rated Affect

Main Effects of Group—As presented in Table 2, there was a significant main effect of group for both pre-task negative affect as well as during-task negative affect, such that depressed adolescents exhibited greater negative affect in anticipation of each interaction task and greater during-task negative affect when compared to their non-depressed peers ($p < .001$). There was also a significant main context effect for both positive affect and negative affect in anticipation of the specific interaction contexts. Specifically, there was significantly decreasing positive affect across all contexts ($p < .001$). In addition, there was the greatest negative affect prior to the PSI ($p < .001$), while there was no significant difference between these measure taken prior to the EPI and FCI.

Interaction Effects for Context—The second set of analyses for affect focused on interaction effects (see supplementary material for Figures 1a and 1b). Results indicated a significant interaction effect of Group by Context for pre-task negative affect, such that depressed adolescents exhibited greater pre-task negative affect. Contrasts showed that for depressed adolescents there was the greatest negative affect before the PSI as compared to the EPI ($p < .001$) and the FCI ($p < .01$), while there was no significant difference in pre-task context negative affect between the EPI and FCI. In addition, contrasts showed that for non-depressed adolescents there was greatest negative affect before the PSI compared to both the EPI ($p < .001$) and the FCI ($p < .01$), while there was also greater negative affect before the FCI compared to the EPI ($p < .05$). There were no significant effects for pre- or during- task positive affect by group, nor a significant effect for during-task negative affect by group.

Adolescent Affective Behavior

Main Effects for Group—As is presented in Table 3, there was a significant group effect for the frequency of aggressive and happy behavior ($p < .05$), such that across interaction contexts depressed participants showed higher frequency of aggressive behavior, lower frequency of happy behavior, and marginally higher dysphoric behavior than did the healthy controls. In contrast, when duration of behavior was examined, there was a group effect for duration of aggressive behavior ($p < .001$), but not for the duration of dysphoric or happy behavior. Specifically, depressed participants showed longer duration of aggressive behavior than did their non-depressed peers across interaction contexts. Next we examined the main effect of context on each of these affective behaviors and found a significant main effect of context for both the frequency and duration of aggressive, dysphoric, and happy behavior. Contrasts revealed that there was significantly increased *frequency* of aggressive behavior during the PSI as compared to the EPI and the FCI ($ps < .001$), but not between the EPI and the FCI. Similarly, contrasts revealed that there was increased *duration* of aggressive behavior during the PSI compared to the EPI and FCI ($ps < .001$) as well as greater *duration* of aggressive behavior during the FCI compared to the EPI ($p < .05$). In terms of dysphoric behavior, contrasts revealed differences in *frequency* and *duration* of dysphoric behavior across contexts, such that there was greater frequency and duration of dysphoric behavior during the PSI and FCI as compared to the EPI ($ps < .001$) and greater frequency and duration of dysphoric behavior during the FCI compared to the PSI ($p < .01$). In terms of happy behavior, contrast revealed greater *frequency* and *duration* of happy behavior during the EPI compared to the PSI and the FCI ($ps < .001$) and greater *frequency* and *duration* of happy behavior during the FCI compared to the PSI ($p < .05$ and $p < .001$, respectively).

Interaction Effects for Context—The second set of analyses focused on interaction effects (see supplementary material Figures 2a, 2b, 3a, 3b). Results indicated that there was a Group by Context interaction effect for the duration of aggressive and dysphoric, but not happy behavior. Contrasts showed that both depressed and non-depressed adolescents had greater duration of aggressive behavior during PSI compared to the EPI and FCI ($ps < .001$) with depressed adolescents exhibiting significantly greater duration of aggressive behavior during the PSI compared to non-depressed adolescents ($p < .001$). In addition, there were no differences in duration of aggressive behavior between the EPI and FCI. Similarly, contrasts showed that depressed adolescents, demonstrated differential duration of dysphoric behavior across the interaction tasks, such that there was greater duration of dysphoric behavior during the PSI compared to the EPI ($p < .001$), greater duration dysphoric behavior during the FCI compared to the PSI ($p < .01$), and greater duration of dysphoric during the FCI compared to the EPI ($p < .001$). In addition, for non-depressed adolescents, contrasts showed that there was greater duration of dysphoric behavior during the PSI and the FCI as compared to the EPI ($p < .001$) and there was no difference in duration of dysphoric behavior between the PSI and the FCI.

Adolescent Psychophysiology

Main Effects for Group—As presented in Table 4, when quiet baseline measures of psychophysiology were included as a covariate, there was a significant main group effect for PEP ($p < .05$), such that depressed adolescents had shorter PEP times, indicating greater

sympathetic activation, and a significant main group effect for BP ($p < .05$), such that depressed adolescents had higher BP than non-depressed peers. Interestingly, there were no main group effects for any other physiological variables (see Table 4). In addition, a significant main context effect emerged for PEP, such that PEP intervals were slower during the EPI compared to the FCI ($p < .05$). Lastly, there was a significant gender effect for FPTT, such that females had faster transit times (i.e., greater sympathetic activity) than males (there were no other gender effects for any other physiological variables).

Interaction Effects for Context—The second set of analyses focused on interaction effects (see supplementary material Figure 4 for RSA withdrawal during contexts from resting baseline). Interaction effects revealed a significant Group by Context interaction for RSA, with post hoc analyses revealing that despite this significant interaction effect, the main effect of context was not statistically significant within either the depressed or non-depressed groups when run separately. However, inspection of the pattern of means suggested that depressed adolescents had *greater* RSA withdrawal during the PSI than did non-depressed adolescents, whereas during the EPI depressed adolescents showed *less* RSA withdrawal than did the non-depressed adolescents. Finally, there was also a three-way interaction between Group, Context, and Gender for RSA. Post hoc analyses, run for each depression group separately showed that this effect was driven by the fact that depressed males showed significantly less RSA withdrawal during the EPI than did depressed females (there was no significant Context $\times$ Gender effect amongst the non-depressed participants).

Discussion

These findings demonstrate significant differences between clinically depressed and non-depressed adolescents in terms of both context independent and context specific effects on self-reported affect, observed behavior, and psychophysiology during various affectively charged parent-adolescent interactions.

Main Effects of Depression

Consistent with our hypotheses, across contexts depressed adolescents displayed greater negative affect in anticipation of and during interactional tasks, greater frequency and duration of aggressive behaviors, marginally greater dysphoric behaviors, and lower frequency of happy behaviors, along with shorter PEP (i.e., greater sympathetic activity) and higher BP (i.e., greater overall autonomic activity) as compared to their non-depressed peers. In contrast to our hypotheses, depressed adolescents did not differ from their non-depressed peers in terms of positive affect in anticipation of or during interaction tasks and showed no other overall autonomic or parasympathetic differences from their non-depressed peers.

These finding may have a few potential explanations. First, in terms of affect across tasks, depressed individuals, particularly depressed adolescent females, are known to demonstrate greater level of negative affect (Forbes, Williamson, Ryan, & Dahl, 2004; Watson, 2000), while there is a tendency among adults with depression for increased attentional biases resulting in greater emotional processing of negative appraisals of neutral stimuli or negative aspects of stimuli (Gotlib, Krasnoperova, Yue, & Joormann, 2004; Kan, Mimura, Kamijima, & Kawamura, 2004), and hyper-reactivity to emotional stimuli that is social in nature and

indicative of threat (Allen & Badcock, 2003; Price, Sloman, Gardner, Gilbert, & Rohde, 1994) - all of which may extend the length of negative emotional responses. In contrast to our hypotheses, there was no difference between depressed and non-depressed adolescents in terms of reported positive affect either prior to or during interaction tasks generally. This is particularly surprising given that those with depression demonstrate lower levels of positive affect in prior research (Forbes, Williamson, Ryan, & Dahl, 2004; Watson, 2000). Overall behavioral findings are consistent with some previous research indicating that those with depression tend to exhibit greater aggressive behaviors (Knox, King, Hanna, Logan, & Ghaziuddin, 2000), higher levels of negative behaviors (e.g., behavioral disengagement and self-blame; Horwitz, Hill, & King, 2011), and increased dysphoria during interpersonal interactions in prepubertal children (Puig-Antich et al., 1985). One interpretation of the strong findings for aggressive behavior in depressed adolescents is that they were experiencing more hostile parental behaviors than their non-depressed peers (as we have shown in previous research with this sample; Allen et al., 2012), as parental conflict has been shown to mediate the relationship between depression and aggression (Panak & Garber, 1992). In addition, the decreased frequency of happy behavior in depressed adolescents in this sample may be related to the previously mentioned emotion context insensitivity associated with depression. For example, depressed adolescents may be having less of an emotional reaction to positive stimuli, specifically to positive interpersonal experiences as has been shown in adults (i.e., emotional context insensitivity; Bylsma et al., 2008; Rottenberg, 2005), as well as exaggerated/chronic negative reactions to negative stimuli in adolescence through adults (Koval et al., 2012; Koval & Kuppens, 2012). This may indeed lead to the well-known interpersonal difficulties (e.g., social rejection) experienced by adolescents experiencing depression, as they may not be expressing appropriate positive behaviors, but rather expressing depressotypic behaviors (Slavich, O'Donovan, Epel, & Kemeny, 2010). Furthermore, given the core weight given to sadness in the diagnosis of depression, it is interesting to note that there was not a significant difference between depressed and non-depressed adolescence in terms of overall dysphoric behavior, although this finding was marginally significant.

Finally, group differences in psychophysiology are consistent with prior literature indicating greater sympathetic activity in those with depressive symptomatology in adolescents and adults (Byrne et al., 2010; Carney et al., 1995; Lahmeyer & Bellur, 1987; Light et al., 1998; Moser et al., 1998; Rottenberg et al., 2007) as well as greater incidence of hypertension in adults with depression (Davidson, Jonas, Dixon, & Markovitz, 2000; Jonas, Franks, & Ingram, 1997; Meng, Chen, Yang, Zheng, & Hui, 2012). It is important to note that in contrast to our hypotheses and prior research (see Koenig et al., 2016 discussing an overall effect of group on RSA, yet not all studies find effects) - there were null group effects for heart rate, RSA, and FPTT across all contexts. In terms of heart rate and RSA, the null finding may be explained by the fact that most prior research indicating higher heart rates and lower RSA in adolescents and adults with depression have used resting baseline heart rate measurements (Byrne et al., 2010; Moser et al., 1998), rather than heart rate reactivity to interpersonal contexts as we did in the present study. It is hard to interpret the null findings in regards to FPTT as there is a dearth of research looking at the association between depression and FPTT. In addition to the main effects found by group, it is important to note

that the varying interpersonal contexts strongly moderated affective, behavioral, and psychophysiological responses.

Context Specific Effects of Depression

In terms of affect experienced during interaction context and in accordance with our hypotheses, depressed adolescents displayed greater negative affect prior to each context as compared to their non-depressed peers. In addition, depressed adolescents displayed greater negative affect prior to the EPI and FCI contexts, while non-depressed adolescents displayed greater anticipatory negative affect prior to the EPI as compared to the other two contexts. These findings indicate that both depressed and non-depressed adolescents experience negative affect prior to entering a new context to begin with (i.e., the first interaction context), but while this negative affect diminishes for non-depressed adolescents after the initial context, it continues for depressed adolescents after they experience a negative interaction context. Specific to behavior, depressed and non-depressed adolescents showed similar increases in the duration of aggressive behavior during the PSI (negative) context as compared to the other two contexts, but depressed adolescents showed this pattern to a much larger degree. In other words, depressed adolescents displayed an exaggerated duration of aggressive behavior during the PSI (negative) context as compared to their non-depressed peers. Interestingly, while depressed and non-depressed adolescents did not differ in terms of dysphoric behavior in general, they did differ by context and across context. Specifically, depressed adolescents differed from non-depressed adolescents during the EPI (positive) context interactions during which they surprisingly showed shorter duration of dysphoric behaviors. This is an unanticipated finding, yet it reflects literature showing a “mood brightening effect” or exaggerated positive emotion reactivity to events in individuals with major depressive disorder (Bylsma, Taylor-Clift, & Rottenberg, 2011). Either way, this finding clearly requires replication before strong conclusions are drawn. In contrast, depressed adolescents differed from non-depressed adolescents in that their duration of dysphoric behavior linearly increased across all interaction contexts, while non-depressed adolescents’ dysphoric behavior plateaued in duration after the PSI (negative) interaction context. Finally, in terms of psychophysiological differences between depressed and non-depressed adolescents across contexts, interaction effects revealed a group and context interaction, such that depressed adolescents showed greater RSA withdrawal during the PSI, while non-depressed adolescents showed greater RSA withdrawal during the EPI, as was hypothesized. There was also a three-way interaction effect between Group, Context, and Gender for RSA, which was driven by the fact that depressed males showed significantly less RSA withdrawal during the EPI than did depressed females (there was no significant Context by Gender effect as amongst the non-depressed participants). In contrast to our hypotheses, there was no difference between depressed and non-depressed adolescents in terms of negative affect during, positive affect either prior to or during, and overall autonomic activity during each specific interaction context.

These findings have a number of possible explanations. First, depressed adolescents may have experienced a greater level of negative affect in anticipation of each task as compared to their non-depressed peers, because research indicates that depressed individuals experience greater overall level of negative affect (Davidson et al., 2002; Forbes,

Williamson, Ryan, & Dahl, 2004; Watson, 2000), but it remains unclear why this wouldn't be true for affect experienced during the interaction. Furthermore, non-depressed adolescents had the greatest anticipatory negative affect prior to the first context, which subsequently subsided for the remainder of the interactions, indicating emotional flexibility and resilience to context (Lougheed & Hollenstein, 2016; Waugh, Thompson, & Gotlib, 2011), while depressed adolescence had continued anticipatory negative affect prior to the FCI indicating potential emotional inertia and inflexibility due to the negative interaction of the PSI that carried over to the following task (Koval, Kuppens, Allen, & Sheeber, 2012; Kuppens et al., 2012; Kuppens, Allen, & Sheeber, 2010). The ever increasing duration of depressive behavior across tasks in depressed adolescents may also be understood as a form of behavioral inertia, given that previous research has indicated that those with depression have high temporal autocorrelations between negative emotional states over time (Koval & Kuppens, 2012), indicating less emotional flexibility and the propensity for negative behavioral spirals, specifically with dysphoric behavior during interpersonal interactions (Puig-Antich et al., 1985). Moreover, the autobiographical component of the final context, may have been more emotionally evocative for depressed than non-depressed adolescents (Williams et al., 2007). In contrast, their non-depressed peers may have had an adaptive increase in dysphoric behavior during the PSI, which stabilized and did not increase during the next consensus task context indicating a degree of behavioral flexibility, which is characteristic of resilience (Lougheed & Hollenstein, 2016; Waugh, Thompson, & Gotlib, 2011). In terms of aggressive behavior, which peaked for both depressed and non-depressed adolescents during the PSI (negative) task, depressed adolescents experienced this to a much greater degree than their non-depressed peers, which may be explained by the greater reactivity to emotional stimuli that is social in nature and indicative of threat (Allen & Badcock, 2003; Price et al., 1994) experienced by those with depression.

Finally, interpretation of the physiological effects observed depends to a certain extent on how one interprets the psychological significance of pattern of RSA findings. The data shows a dramatic reduction in RSA during all the interactions when compared to the resting baseline RSA, suggesting that the social interactions themselves prompt some type of vagal withdrawal. One parsimonious explanation for this is that the vagal withdrawal facilitates increased sympathetic control of the cardiac system, thus facilitating arousal in response to sympathetic activation. Therefore, one interpretation of these findings is that the relatively greater RSA withdrawal for non-depressed adolescents during the EPI (positive interaction) may indicate greater physiological engagement and positive sympathetic arousal, while the relatively greater RSA withdrawal exhibited by depressed adolescents during the PSI (negative interaction) may indicate the opposite (i.e., a greater interpretation of threat, mobilization of resources, and/or a lack of sympathetic regulatory ability) during the aversive context (Beauchaine et al., 2007). In this sense the findings may have some similarity to Schachter & Singer (1962) model which suggests that arousal can be variously interpreted or elicited depending on the affective context in which it occurs. In contrast, an alternative interpretation of these findings would be derived from the Polyvagal Theory (see Porges, 2007), which interprets RSA activation as supporting social communication and self-soothing. However, given the significant withdrawal of vagal activity during all of the interaction tasks when compared to the baseline measures, we consider the arousal

interpretation as more parsimonious. More generally, what can be understood is that there was a differing RSA response between depressed and non-depressed adolescents across the different affective interpersonal interactions, suggesting that interpersonal contexts can moderate these effects. In terms of the three way interaction between RSA, group, and gender, one reason for this gender difference may be that females tend to have lower autonomic responses than age-matched men due to the possible effect of estrogen on sympathoadrenal response (Kajantie & Phillips, 2006).

Limitations and Future Directions—Though this study had significant strengths in employing a multimethod assessment of differences between depressed and non-depressed adolescents in terms of self-reported affect, observed behavior, and psychophysiology across three affectively charged interpersonal contexts, it is important to note a number of limitations. First, the present study focused solely on adolescent self-reported affective, observed behavior, and psychophysiological processes. Though this focus on adolescent processes provides a refined description of the functioning of clinically depressed adolescents, it lacks the systemic view that could be gained by also addressing the role of parental self-reported affect, behavior, and psychophysiology. Future studies should address the role of parental processes in reactions of depressed adolescents and look at conditional responding between parents and adolescents across different tasks and groups. Previous research from our lab has addressed the importance of this systemic view, at least at the behavioral level (Hollenstein, Allen, & Sheeber, 2015). Second, the current study was limited to elucidating the impact of depression during adolescence on interactions within the context of parent-adolescent interactions. Future studies should examine the role of peer interactions in these contexts as research had elucidated that adolescence is a developmental period characterized by a “social reorientation” from parents to peers (Nelson, Leibenluft, McClure, & Pine, 2005). Third, research also indicates that depression is moderately heritable (Levinson, 2006) and therefore some of these adolescents’ parents may have had a diagnosis of depression themselves, which could affect relational interactions between adolescents and their parents. Future studies should address the role parental psychopathology plays in depressed and non-depressed adolescent responses to interaction contexts. We are currently conducting a study to examine family interactions across various emotional contexts in which the mother has a diagnosis of depression in order to see how maternal, rather than adolescent depression, influences relational, affective, behavioral, and physiological dynamics during parent-adolescent interactions. Fourth, the current study focused on adolescent psychophysiology, but future research would benefit from also examining parental psychophysiology. Psychophysiological attunement or coregulation (i.e., the bidirectional synchronization of physiology between two or more individuals across time; Nelson, Laurent, Bernstein, & Laurent, 2016) is a burgeoning area of research that may have implications for family interactions and adolescent outcomes (Timmons, Margolin, & Saxbe, 2015). As mentioned above, our lab is working on a new study to address the role of both adolescent and parental psychophysiology during interactions to elucidate the role depression plays in psychophysiological attunement in parent-adolescent dyads and how levels of attunement or lack thereof relate to adolescent mental health and adjustment. Fifth, interaction contexts were not randomized and therefore we cannot rule out priming or ordering effects. Future studies should randomize the presentation of interaction

contexts in order to control for these possible effects. Fifth, our study did not differentiate between adolescents with solely clinical depression and adolescents with co-occurring clinical depression and other disorders. Future research should address co-occurring disorders, which may have also explained the lack of many psychophysiology interaction effects in the current sample, as co-occurring disorders may have had moderating influences. Sixth, we did not have a self-report measure of discrete emotions that mapped onto the dimensions measured in the observational data (i.e., anger, dysphoria, happy). Future studies should include self-report scales that more closely conceptually map onto the dimensions of observational data. Sixth, this study cannot address whether affective, behavioral, and physiological factors are risk factors for depression or concomitants of depression. We suggest that future research focus on this topic to provide a better means of understanding the etiology and subsequent manifestations of depression. Finally, future studies should incorporate measures of physical health outcomes (i.e., inflammation, chronic disease, biological aging) as research is beginning to elucidate the connection between psychopathology, specifically depression, and physical disease. Measuring physiology would be the first step as research is elucidating the connection between autonomic alterations in depression that may lead to heart disease (Hare, Toukhsati, Johansson, & Jaarsma, 2014; Nemeroff & Goldschmidt-Clermont, 2012). The way adolescents interact with their parents during this transitional period to adulthood may be particularly important in buffering or exacerbating the physical health problems and outcomes associated with depression that may emerge in adulthood (Celano & Huffman, 2011; Pan, Sun, Okereke, Rexrode, & Hu, 2011; Valkanova, Ebmeier, & Allan, 2013; Wolkowitz et al., 2011).

Clinical Implications

Increased understanding of the ways in which context influences adolescent depression may help to provide multiple points of entry for treatment efforts to prevent the negative impacts in adulthood that are associated with adolescent depression (e.g., psychopathology, unemployment, interpersonal difficulties, and physical health problems; Bardone et al., 1998; Copeland, Shanahan, Costello, & Angold, 2009; Fergusson, Boden, & Horwood, 2007; Keenan-Miller, Hammen, & Brennan, 2007; Pine, Cohen, Cohen, & Brook, 1999).

Psychoeducation and Treatment—First, increased knowledge of how context influences the expression of depression in adolescence may also help in conceptualizing the treatment of adolescent depression. Our findings highlight that when working in mental health settings, context changes the way that psychopathology presents itself and, therefore, psychopathology may not be seen clearly in all contexts – emphasizing the importance of assessment behavior across as many contexts, and via as many observers, as possible. For example, while adolescents display greater negative affect before entering a new context, they may not be as distinguishable from non-depressed adolescents at the behavioral level during positive or emotionally mixed contexts. Similarly, parent-adolescent interventions that incorporate psychoeducation on how context influences the expression of depression may provide grounds for better parental understanding of adolescent experience. Second, this increased knowledge of both overall differences and context influences on the expression of depression in adolescence may also help in conceptualizing the treatment of adolescent depression. For example, with regards to affect, our findings indicate that

depressed adolescents may have particularly strong negative affect in anticipation of new interaction contexts. Creating treatments that incorporate the use of cognitive reappraisal (Ray, McRae, Ochsner, & Gross, 2010) and mindfulness (Keng, Smoski, & Robins, 2011) prior to entering new contexts (particularly after negative interaction contexts between adolescents and their parents) may provide for a quicker return to emotional and behavioral homeostasis. In addition, in terms of behavioral findings, the use of mindfulness (Keng et al., 2011) and relaxation techniques (Reinecke & Ginsburg, 2008) may assist in ameliorating some of the negative behavior and affect associated with negative adolescent-parent interactions as well as reduce physiological arousal, respectively. Lastly, in terms of physiology, our findings and others indicate that those with depression have greater RSA withdrawal during negative interactions, indicating greater sympathetic arousal, than their non-depressed peers. Incorporating RSA biofeedback (Karavidas et al., 2007) or vagal nerve stimulation (Sackeim et al., 2001) in the treatment of depression in adolescence may be particularly useful in upregulating parasympathetic control, which may be especially important for future negative interaction contexts. Further research is needed to fine tune these contextual differences and identify when and where to intervene in adolescent depression in order to prevent the recurrence and duration of depressive episodes, which are associated with future negative health and adjustment outcomes as well as intergenerational transmission of risk for depression to future offspring (Lieb, Isensee, Hofler, Pfister, & Wittchen, 2002).

Conclusion

The present study provides important insights into differences between clinically depressed and non-depressed adolescents by using a multimethod approach across multiple emotionally evocative interaction contexts. Overall, our findings suggest that depressed adolescents exhibit greater negative and lower positive behaviors, higher negative affect, greater overall autonomic and sympathetic activity, and lower parasympathetic activity, particularly during emotionally charged negative interpersonal interactions as compared to their non-depressed peers. More research is needed to help refine our understanding of how these levels of analysis interact both within and between adolescents and their parents in order to provide a more comprehensive understanding of the intrapersonal and interpersonal outcomes associated with depression in adolescence.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Participant Characteristics by Group

Variable	Depressed			Non-Depressed		
	N	Mean (SD)	Percentage	N	Mean (SD)	Percentage
Age	75	16.21 (1.11)		77	16.13 (1.05)	
Grade	75	10.15 (1.11)		77	9.94 (1.02)	
BMI	74	24.03 (4.69)		76	23.08 (4.09)	
PDS	75	3.51 (.53)		75	3.39 (.50)	
Sex						
Male	23		30.7	29	37.7	
Female	52		69.3	48	62.3	
Race						
White	61		81.3	64	83.1	
Black	2		2.7	2	2.6	
Asian	1		1.3	2	2.6	
Native	4		5.3	2	2.6	
American/Alaskan						
Hispanic	5		6.7	6	7.8	
Other	1		1.3	1	1.3	

Note: BMI = body mass index; PDS = pubertal development scale

Table 2

Self-Reported Affect

Affect	Group	Context (Task)	Gender	Group × Task	Group × Task × Gender
Pre-Positive Affect	2.491	53.913 ^{***}	1.607	.168	1.288
Pre-Negative Affect	17.235 ^{***}	23.764 ^{***}	.153	3.439 [*]	.670
Post-Positive Affect	2.180	.097	3.201 [†]	.788	.961
Post-Negative Affect	16.817 ^{***}	.076	.838	1.692	1.404

Note:

^{*} = $p < .05$,

^{**} = $p < .01$,

^{***} = $p < .001$,

[†] = $p < .10$.

Table 3

Observed Affective Behavior

Behavior	Type	Group	Task	Gender	Group × Task	Group × Task × Gender
Aggression	Frequency	5.783 *	25.070 ***	3.435 †	1.122	.581
	Duration	12.422 ***	40.535 ***	3.784 †	5.062 **	.311
Dysphonic	Frequency	3.798 †	16.080 ***	.123	.932	1.096
	Duration	.558	64.581 ***	.003	3.623 *	.154
Happy	Frequency	4.122 *	64.151 ***	.802	1.200	.714
	Duration	.384	93.337 ***	.002	.148	.114

Note:

* = $p < .05$,

** = $p < .01$,

*** = $p < .001$,

† = $p < .09$.

Table 4

Psychophysiology

Variable	Group	Task	Gender	Group × Task	Group × Task × Gender
HR	.012	.683	2.252	1.477	2.550 [†]
PEP	4.01 [*]	3.859 [*]	.503	.434	.040
RSA	.148	1.032	2.559	4.705 ^{**}	4.613 ^{**}
FPTT	.007	.427	12.006 ^{***}	1.545	2.795 [†]
BP	4.048 [*]	3.040 [†]	0.000	1.418	1.727

Note:

^{*} = $p < .05$,

^{**} = $p < .01$,

^{***} = $p < .001$,

[†] = $p < .09$.

HR = heart rate, PEP = pre-ejection period, RSA = respiratory sinus arrhythmia, FPTT = finger pulse transit time.