Physiological Reactivity to Stress and Parental Support: Comparison of Clinical and Non-Clinical Adolescents

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An Alarm Stress Task was developed to study affect regulation in the context of parent–child interactions in adolescents (mean age = 12.72, standard deviation = 2.06) with (n = 20) and without (n = 20) mental health problems. Changes in heart rate (HR), pre-ejection period (PEP) and respiratory sinus arrhythmia (RSA) were used as indicators of affect regulation. HR increased, and PEP and RSA decreased significantly in reaction to a suggested failure on a simple task, indicating that this procedure induced affective arousal in adolescents. During reunion with the parent, RSA increased significantly. Support seeking on reunion was associated with stronger parasympathetic reactivity during stress and reunion, consistent with the model that the parasympathetic system is involved when affect is regulated by social engagement. Quality of parent–adolescent interactive behaviour was overall lower in the clinical sample. Individual and relationship-based processes of affect regulation may be simultaneously assessed, highlighting the continuing importance of the parent–child relationship in adolescence for affect regulation and mental health. Copyright © 2008 John Wiley & Sons, Ltd.

Affect regulation has been proposed as a central developmental process, linking mental health developmentally to environmental factors (Bradley, 2000; Eisenberg et al., 2001; Southam-Gerow & Kendall, 2002). The attachment relationship between parents and children plays an important role in the development of affect regulation (Fox & Calkins, 2003; Schore, 2001). Human studies have mostly focused on relationships in infancy and preschool age. Less is known about linkages between parent–child relationships, regulation of affect and mental health in adolescence. In infancy, distress-alleviation is typically provided by direct proximity and interaction with the attachment figure (Oosterman & Schuengel, 2007a; Zelenko et al., 2005), but over the course of development, children and adolescents gradually increase their ability to regulate their distress by themselves (Thompson, 1994). Nonetheless, parents may continue to alleviate the distress of their adolescent children, when distress is too high or complex for adolescents to cope with by themselves. This might especially be important for adolescents with mental health problems (Rosenstein & Horowitz, 1996; Scott Brown & Wright, 2003). The aim of the current study is to investigate differences in affect regulation between adolescents referred for mental health services and

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non-referred adolescents. Specifically, we focused on physiological responses during a stressful situation, varying the availability of the parent for support.

Existing paradigms for studying affect regulation within the context of parent–child interactions may not be stressful beyond pre-school age (e.g., the Strange Situation Procedure; Ainsworth & Wittig, 1969; Oosterman & Schuengel, 2007b). Affect regulation studies in adolescence have used paradigms that are stressful, but which require activities that interfere with parent–child interaction, such as mental arithmetic tasks or the public speaking task (e.g., Salomon, Matthews, & Allen, 2000). Still other paradigms (e.g., cold pressure task; Mezzacappa, Kelsey, Katkin, & Sloan, 2001) elicit stress of which the participant is usually unaware and may not elicit interactive behaviour. Discussion tasks (Allen et al., 2003; Kobak, Cole, Ferenz-Gillies, Fleming, & Gamble, 1993) reveal important individual differences in parent–adolescent interaction, but may primarily be informative about stress emanating from the relationship itself, less about the role of the relationship in dealing with external stressors. For this study, the Alarm Stress Task was developed. The stressor was a simple task, which presumably all adolescents could succeed at (lying quietly on a bed), but for which they invariably were led to believe that they had failed. Irrespective of their actual movements, a computer alarm was set off twice, indicating that they did not lie quietly enough. However, no feedback was given about the movement they made. Disappointment paradigms have shown to elicit negative affect and regulation efforts in healthy and high-risk children, and compare to social experiences in adolescents' regular lives (Forbes, Fox, Cohn, Galles, & Kovacs, 2006). The experimental stressor, giving feedback to adolescents that they had failed on the task while they were led to believe that their peers usually succeed on it, was therefore assumed to be stressful (the feeling of inability to meet the demands of the situation), producing affective arousal in need of regulation. The ambiguity of the feedback made it extra difficult for adolescents to reappraise the situation on their own. In such a situation, seeking information and support from an attachment figure may be considered an adaptive emotional response. Whether adolescents and parents use these behaviours to adapt to the arousal, was assessed by reuniting the adolescents twice within the procedure with their attachment figure (the adolescent's mother or father).

PHYSIOLOGICAL REACTIVITY

When challenged by stress, the brain (i.e., amygdala and hippocampus) activates the autonomic nervous system (ANS), the involuntary system of nerves that controls and stimulates arousal (Kemeny, 2003). Responding to stress involves activity of the sympathetic and parasympathetic (vagal) branches of the ANS to regulate arousal (Johnson, Kamilaris, Chrousos, & Gold, 1992). The sympathetic nervous system is involved with energy expenditure and 'fight or flight' responses, while the parasympathetic nervous system is involved with energy conservation, and with the control of attention, emotion and behaviour (Myrtek, 2004; Porges, 2003b).

Adolescents with psychopathology show difficulties in regulating stress (Bradley, 2000; Eisenberg et al., 2001; Keenan, 2000; Southam-Gerow & Kendall, 2002). Inadequate strategies for self-regulation, such as rumination, prolong arousal, resulting in an increased risk for developing emotional and behavioural problems (Mikulincer, Shaver, & Pereg, 2003). During stress, parasympathetic withdrawal supports the metabolic requirements for mobilization and allows the sympathetic nervous system to facilitate fight or flight responses. Therefore, sympathetic increases and parasympathetic decreases may both be expected as a reaction to a stressor. Weak parasympathetic responses to stress have been related to psychopathology (Calkins, Graziano, & Keane, 2007; El Sheikh, 2001; El Sheikh & Whitson, 2006; Rottenberg, Salomon, Gross, & Gotlib, 2005). Therefore, the parasympathetic response in adolescents with mental health problems may be weaker than in adolescents without such problems.

PARENT–CHILD INTERACTIONS

The parent–child relationship is hypothesized to have regulatory effects on children's physiological arousal during stressful times (Schore, 2001). A review of studies in adolescents and adults shows that the presence of a supportive person, in particular an acquaintance, has suppressing effects on cardiovascular reactivity to acute psychological stress (Uchino, Cacioppo, & Kiecolt Glaser, 1996). Research with young children (4.5 years) has shown that reunion with the attachment figure, after a short period of separation, indeed resulted in physiological relaxation, as indicated by decreases

in heart rate (HR), and increases in parasympathetic activity (Stevenson-Hinde & Marshall, 1999). Thus, reunion with the parent after the occurrence of a stressor in the parent's absence would attenuate stress-induced ANS activity, as indicated by increases in sympathetic and parasympathetic activity. Increases in parasympathetic activity in particular may be expected after reunion, based on the theory that the vagal system facilitates social engagement to resolve stress (Porges, 2003a). However, in adolescents with mental health problems, parasympathetic increases during reunion may be weaker than in adolescents without such problems.

Not only the presence of the attachment figure might reduce physiological arousal, but the quality of parent–child interactions might also be indicative of attenuation of arousal (Cassidy, 1994; Diamond, 2001; Schore, 2001). Parental sensitive and responsive behaviours facilitate the development of adaptive self-regulation skills in children. In secure attachment relationships, children and their attachment figures are successfully cooperating in the service of regaining affective homeostasis when children are emotionally aroused (Main, 1990). Infants with an insecure avoidant attachment relationship with their parents showed impaired parasympathetic functioning 4 years later (Burgess, Marshall, Rubin, & Fox, 2003). Moreover, insecure attachment classifications in adults were related to impaired parasympathetic regulation (Maunder, Lancee, Nolan, Hunter, & Tannenbaum, 2006). Parasympathetic increases would therefore be associated with social engagement behaviours indicative of using the parent as a secure base.

It has been suggested that adolescents with psychopathology have parents who are less sensitive and responsive in their interaction with the adolescents (Sroufe, Carlson, Levy, & Egeland, 1999). Parents support their adolescents by serving as a secure base from which to explore and by monitoring the adolescent for signs of distress, providing comfort and reassurance when needed (Bender et al., 2007; Waters, Vaugn, Posada, & Kondo-Ikemura, 1995). When a parent is sensitive and comforting in stressful situations, distress remains within tolerable limits, enabling adolescents to develop regulation skills. Furthermore, when the stressful situation is too difficult to resolve using existing regulation skills, adolescents with sensitive parents will continue to show their distress to their parent, whereas other adolescents may start to hide their distress.

PURPOSE OF THE STUDY

In this study, we examined physiological reactivity of adolescents with and without psychopathology in the Alarm Stress Task. During the reunions, we rated secure base interaction of adolescent and parent. We expected that the feedback of failure on the simple task of lying quietly would lead to support-seeking behaviour because the stressor is too ambiguous to successfully resolve by self-regulation and too salient to be ignored. The aims of this study were, first, to determine the physiological reactivity to the stressor and to the reunion; second, to study the influence of secure base behaviour on this physiological reactivity; and third, to explore the degree to which physiological reactivity and secure base behaviour are related to psychopathology.

On the basis of the literature discussed above, we predicted that adolescents would experience physiological arousal assessed through sympathetic and parasympathetic indices. Second, we expected that reunion with the parent would attenuate arousal caused by the alarm, especially on the parasympathetic system. Furthermore, high secure base behaviour was expected to be related to better affect regulation as indicated by a stronger parasympathetic decrease during stress and a stronger parasympathetic increase during reunion. Adolescents with psychopathology and their parents were expected to display less secure base interaction. Adolescents with psychopathology were also expected to show a weaker parasympathetic decrease to the stressor and a weaker parasympathetic increase during reunion than adolescents without psychopathology.

METHOD

Participants

Forty adolescents in the age of 10 to 16 years old and their primary caregiver (two fathers) participated in the study. The sample included 20 adolescents (the clinical sample) from an outpatient clinic of an academic centre for child and adolescent psychiatry, and 20 adolescents (the non-clinical sample) from the community.

The clinical sample (13 boys, age mean (M) = 12.80, standard deviation (SD) = 2.05) was selected on four criteria: no intellectual disability (IQ above 70), aged between 10 and 16 years, living at home, without any diagnosis in the autistic spectrum. The non-clinical sample (10 boys, age M = 12.64,

SD = 2.07) was selected on the same criteria, requiring in addition that these adolescents had no history of any mental illness or psychiatric counseling in the last 4 years. The clinical sample included 10 children with internalizing problems (Anxiety Disorder, Obsessive Compulsive Disorder (OCD) and Depression) and 10 children with externalizing problems (Attention Deficit Hyperactivity Disorder (ADHD) and Oppositional Defiant Disorder (ODD)).

Procedure

Permission for this research was granted by the Central Committee on Research Involving Human Subjects and the university's Medical Ethical Commission. All families were informed about the research project called 'Stress and Heart Rate' with an information folder. The families were contacted by phone to ask their participation. Data were collected during home visits in the afternoon between 2:00 and 5:00 p.m. At the end of the home visit, the researcher debriefed both the parent and adolescent and answered all the questions they had. In addition, the researcher asked how they perceived their participation and if they had any objections or comments. None of the adolescents or parents had any complaints about the procedure, and no one would have withdrawn their participation if they had known that they would be deceived. The adolescents received €20 for their participation.

Instruments

Alarm Stress Task (AST)

The AST is a paradigm in which adolescents lie on their beds, while their physiological arousal is measured by an ambulatory monitoring system (see below). Adolescents were instructed to lie quietly during 20 minutes (Figure 1). The experimenter suggested that any movement could spoil the measurement and would therefore set off an alarm signal. However, independent of movement, the alarm signal was given twice during the absence of the parent. Following both alarms there was a 3-minute reunion with the parent. The whole procedure was recorded using a fixed video camera placed with the adolescents in their bedroom. Both the adolescent and the parent were not informed beforehand that the alarm was programmed.

All distracting objects in the bedroom were turned off (e.g., television, computer, mobile phone and watch). Electrodes were placed on the body and connected to a laptop near the bed. The laptop showed a programmed PowerPoint slideshow. The researcher explained the task to both the parent and adolescent, accompanied by showing slides on the laptop. The researcher gave the following instruction:

Soon you will have to lie very quietly on your bed for 20 minutes. If you make any movement, the computer will give an alarm. This means that your HR cannot be measured well and that you have failed the task. Your father/mother will visit you three times to have a little chat with you. You may talk about all kinds of subjects, but try to behave as you normally do. Do not start moving until I visit you at the end of the task.

The researcher showed a slide with a circle diagram suggesting that 75% of adolescents succeeded in having no alarm (the green group), 15% had one alarm (the yellow group), and 10% had two alarms (red group). The adolescents were asked to try to belong to the green group. The researcher started the slide show with a blue slide showing an overview of all episodes of the task and left the adolescent alone. The researcher and the parent waited in another room. After 5 minutes, the parent visited the adolescent for 3 minutes. At 9.5 and 15.5 minutes after the start of the task, a white slide with the text 'Alarm. Try to lie quietly!' in red letters was shown for 30 seconds. A soft acoustic alarm signal accompanied this slide. At 1.5 minutes after each alarm, the

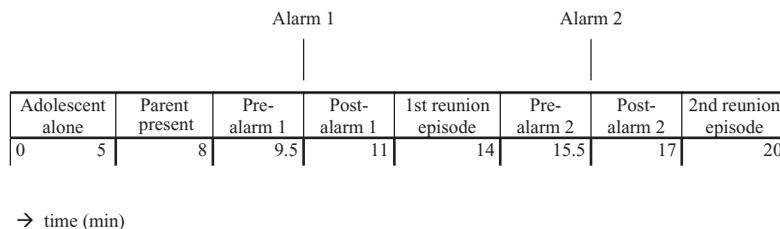|		Alarm 1			Alarm 2		
Adolescent alone	Parent present	Pre-alarm 1	Post-alarm 1	1st reunion episode	Pre-alarm 2	Post-alarm 2	2nd reunion episode
0 5	8	9.5	11	14	15.5	17	20

→ time (min)

Figure 1. Procedure Alarm Stress Task

parent was instructed to visit the adolescent for 3 minutes. A small hourglass reminded the parent to leave the bedroom. After the third parental visit, when the parent had left the room, the researcher came in, evaluated the task with the adolescent, and removed the electrodes.

Physiological Measures

During the 20 minutes of the task, physiological activity was recorded by the Vrije Universiteit-Ambulatory Monitoring System (VU-AMS; De Geus & Van Doornen, 1996). Indices of sympathetic and parasympathetic drive were derived by analysis of Electro cardiogram (ECG) and thoracic impedance signals. The ECG and Impedance cardiogram (ICG) complexes were averaged across 15-second periods. Heart Rate (HR) is the average of the number of beats per minute in the 15-second period. Pre-Ejection Period (PEP) is defined as the time interval in milliseconds between the onset of ventricular depolarization (Q-wave onset in ECG) and the onset of ventricular ejection (B-point in ICG), and shortens in reaction to sympathetic activation. Respiratory sinus arrhythmia (RSA), referring to the variability in HR that occurs at the frequency of breathing, decreases as a result of parasympathetic withdrawal. RSA was computed using the peak-to-trough method (Grossman, Van Beek, & Wientjes, 1990). This method combines the respiratory time intervals and inter-beat intervals to obtain the shortest inter-beat interval in milliseconds during HR acceleration in the inspiration phase, and the longest inter-beat interval during deceleration in the expiration phase. The difference between these intervals is used as an index of RSA. RSA has been identified as suitable for the study of physiological links to multiple dimensions of emotional and behavioural functioning in children (Boomsma, Van Baal, & Orlebeke, 1990; Huffman et al., 1998; Stifter & Fox, 1990). Reliability and validity of the VU-AMS device have been proven (De Geus & Van Doornen, 1996; Willemsen, De Geus, Klaver, Van Doornen, & Carroll, 1996).

Secure Base Behaviour

Analogous to individual differences in attachment behaviour of infants during the Strange Situation Procedure (Ainsworth, Blehar, Waters, & Wall, 1978), individual differences in secure base interactions during the AST might be indicative of the quality of the attachment relationship between adolescents and parents. The Secure Base Scoring System (SBSS; Crowell, J.A., Pan, H., Gao, Y., Treboux, D., O'Connor, E., & Waters, E, unpublished manuscript, 1998) is an observation-based scoring manual to measure secure base interaction. Although originally developed to study interaction between adult romantic partners, the scales of the SBSS tap behavioural dimensions of attachment relationships, which also apply to parent–adolescent relationships. The SBSS was validated by demonstrating associations with representations of attachment Adult Attachment Interview (AAI), characteristics of the relationship (happiness, discord and aggression) and communication behaviour (Crowell et al., 2002). Security of the attachment representation was related to more effective secure base use and support. Coherence in the description of early experiences was significantly and uniquely related to secure base behaviour even taking into account other possible factors. In addition, secure base behaviour proved to predict relationship quality beyond communication characteristics. Because the SBSS was originally developed for a discussion task, minor adaptations were made to the scale-point descriptions for using it in the AST with parents and adolescents. For example, descriptions about physical contact were removed because the behaviour of the adolescents was constrained by the instruction to lie quietly.

There were five rating scales for observing adolescent behaviour. *Strength and clarity* of the distress signal refers to the intensity and clarity of the adolescent's request to the parent that something is bothering him. *Maintenance* of distress is the activity and persistency of the adolescent in maintaining a clear distress signal. *Approach* to the attachment figure refers to a clear and direct expression in behaviour, words and affect of the desire and need for the support and help of the parent. The *ability to be comforted* refers to markedly diminished behavioural distress in the adolescent in reaction to comforting behaviour of the parent. The *Summary scale* is the observer's overall impression of the secure base use of the adolescent. Also, five rating scales described the secure base behaviour of the parent. *Interest in distress* is the willingness and ability of the parent to be a good listener and a catalyst in encouraging the adolescent to express his feelings and thoughts. *Recognition* represents the immediate awareness of the distress as soon as the adolescent expresses his concern. *Interpretation* is the correctness in understanding the adolescent's concern. *Responsiveness* represents the readiness, flexibility and effectiveness of the parent in supporting the adolescent. The *Summary scale* is the observer's overall impression of the secure base support of the parent. All scales were

rated on a seven-point scale. Higher scores indicated higher quality of secure base behaviour.

During the reunion episodes, all adolescents raised the topic of the alarm. Two observers independently scored adolescent's and parent's secure base behaviour during the first and second reunion of the AST. The observers were blind to the diagnosis of the adolescent and the physiological reaction of the adolescent to the stressor. Because of adequate interrater reliability (ICC = 0.81, range 0.72–0.94), the scores of the two observers were averaged. Secure base scores in the first and second reunion were significantly correlated for adolescent (mean $r_{(39)} = 0.65$, $p < 0.01$, range 0.56–0.74) and parent (mean $r_{(39)} = 0.70$, $p < 0.01$, range 0.56–0.79). The scores on the five adolescent secure base scales (mean alpha = 0.96) were strongly intercorrelated (mean $r = 0.50$, $p < 0.01$) and principal component analyses pointed to one underlying factor (factor loadings 0.70–0.95). Therefore, the scores on the five scales were averaged to indicate secure base support of the adolescent. The five parent secure base scales were also averaged to one secure base score (mean alpha = 0.89; mean $r = 0.64$, $p < 0.01$; factor loadings 0.83–0.98). For one adolescent in the clinical sample, scores of secure base behaviour in the first reunion were missing because of technical problems with the video equipment.

Data Reduction

Time-stamped information from the videotapes was combined with the physiological data, to accurately indicate the start and end-times of the pre- and post-episodes of both alarms and reunions. The exact time of the alarm distinguished the pre- and post-alarm episodes, while opening the door by the parent distinguished the pre- and post-reunion episodes. Although the Q-wave onset in ECG (onset of ventricular depolarization) and the B-point in the impedance waveform (onset of ventricular ejection) are automated by computer software (VU-AMS software), all complexes were inspected by hand. When B-points suggested by automated scoring were not morphologically consistent across the entire recording, a new B-point was set manually. This procedure has been proved to be reliable and valid (Riese et al., 2003). Reliability in indicating the B-point was determined among three independent observers, who were blind to the other ratings, and scored the ICG complexes of 30 children (from different studies) on the base of a scoring manual. The ICC was 0.94 (95% confidence interval: 0.93 to 0.94).

The subtraction of RSA from the respiration and electrocar-diogram recordings was automated by the program AMSRES (VU-AMS software). Respiration data were prepared by checking for unrealistic breathings and spikes in inter-beat intervals were removed by hand.

RESULTS

Descriptives

The clinical and non-clinical sample did not differ in gender composition ($\chi^2_{(1,N=40)} = 0.92$, $p = 0.34$) or age ($F_{(1,39)} = 0.06$; $p = 0.81$). Analyses of the physiological data revealed no significant gender or age differences ($p > 0.05$). In addition, there were no significant gender effects on the secure base data, however, age was related to less secure base behaviour of the parent in the first ($r = -0.44$, $p < 0.01$) and second reunion ($r = -0.38$, $p < 0.05$). Because of these significant age effects, adolescent age was included in further analyses when appropriate.

Physiological Reactivity after the Alarm and During Reunion

To determine the effects of both alarms and reunions on change in the physiological measures, repeated measures analyses of variance (ANOVAs) were performed for HR, PEP and RSA, separately. In separate analyses, the change in HRA, PEP and RSA from pre- to post-episodes of the alarm and reunion were examined. Table 1 shows the descriptives in the pre- and post-episodes of alarm and reunion for all 40 subjects. As shown, the first alarm elicited significant increases in HR and decreases in PEP and RSA. The second alarm elicited significant increases in HR and decreases in PEP. RSA showed a non-significant decrease after the second alarm. For reunion, we found a significant increase in RSA during the first and second reunion (Table 1). HR and PEP showed a non-significant increase during the first and second reunion.

Secure Base Behaviour and Physiological Reactivity

Pearson correlation analyses were performed to examine if the quality of secure base behaviour of parent and adolescent during reunions was related to changes in HR, PEP and RSA after the stressor

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Table 1.   Means and standard deviations (SD) for heart rate (HR), pre-ejection period (PEP) and respiratory sinus arrhythmia (RSA) in the pre- and post-episodes of both alarms and reunions

	Mean pre-episode	SD	Mean post-episode	SD	df	F	η
First alarm							
HR (b/min)	76.98	11.04	79.72	16.14	1	4.46*	0.33
PEP (msec)	91.32	13.08	89.52	12.86	1	4.49*	0.32
RSA (msec)	96.85	45.50	79.84	38.78	1	14.69*	0.53
First reunion							
HR	79.72	16.14	80.44	14.39	1	1.00	0.17
PEP	89.52	12.86	90.43	12.91	1	2.66	0.24
RSA	79.84	38.78	97.43	48.81	1	9.67*	0.45
Second alarm							
HR	77.83	12.54	79.46	15.16	1	5.55*	0.36
PEP	92.00	13.49	90.49	13.58	1	11.36*	0.48
RSA	90.62	44.60	85.80	39.05	1	0.92	0.14
Second reunion							
HR	79.46	15.16	80.65	13.31	1	2.29	0.26
PEP	90.49	13.58	91.31	13.35	1	1.29	0.24
RSA	85.80	39.05	94.05	39.48	1	5.04*	0.35

*p < 0.05.
df = degrees of freedom.

Table 2.   Pearson bivariate correlations between respiratory sinus arrhythmia (RSA) reactivity (change scores) and secure base behaviour of adolescent and parent

RSA reactivity (ms)	Secure base behaviour of adolescent		Secure base behaviour of parent	
	First reunion	Second reunion	First reunion	Second reunion
First alarm	−0.39*	−0.09	−0.25	−0.28**
First reunion	0.33*	0.17	0.28**	0.23
Second alarm	−0.40*	−0.05	−0.04	−0.23
Second reunion	0.28**	0.12	0.17	0.28**

*p < 0.05. **p < 0.10.

and reunion. Therefore, change scores were computed by subtracting the pre-alarm and pre-reunion episodes from the post-alarm and post-reunion episodes so that positive change scores indicate increases in HR, PEP and RSA. Secure base behaviours of both the parent and adolescent were not significantly associated with HR and PEP reactivity during stress and reunion ($p > 0.05$). However, as shown in Table 2, correlations with RSA reactivity were significant. Higher quality of secure base behaviour of the adolescent during the first reunion was associated with stronger RSA withdrawal after both alarms and with stronger RSA increases during the first reunion. Secure base behaviour of the adolescent in the second reunion and secure base behaviour of the parent were not significantly associated with RSA, although each of the effects was in the expected direction.

Physiological Reactivity in the Clinical and Non-Clinical Sample

Figure 2 shows the change in HR, PEP and RSA for the clinical and non-clinical adolescents. To identify differences between the clinical and non-clinical samples in physiological reactivity to the alarm and reunion, repeated measure analyses were conducted with sample included as a between-subjects factor. These analyses revealed no significant differences in reactivity on HR, PEP and RSA to the alarms and reunions between clinical and non-clinical adolescents ($p > 0.05$).

Secure Base Behaviour in the Clinical and Non-Clinical Sample

To examine whether secure base behaviour was different in the clinical and non-clinical sample, four
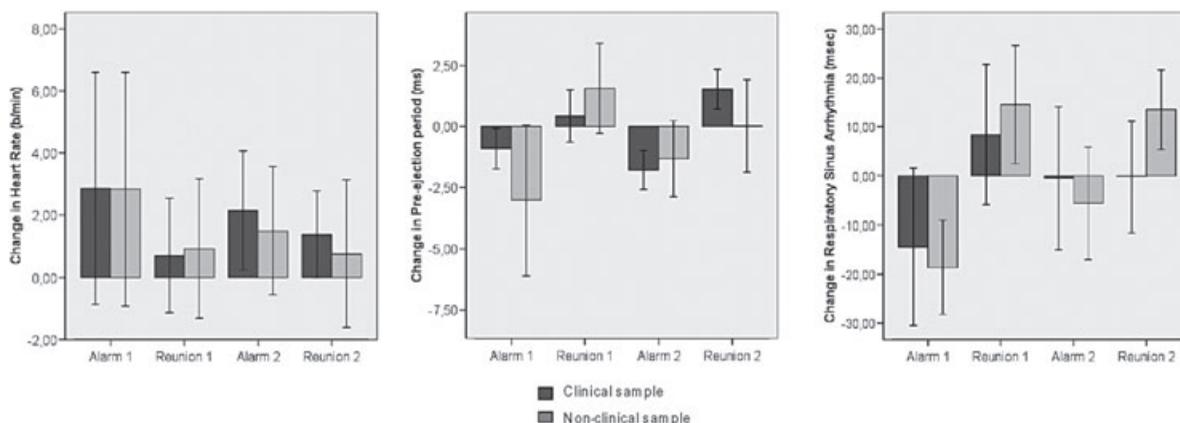
Figure 2. Change in heart rate, pre-ejection period, and respiratory sinus arrhythmia after the alarm and during reunion in the clinical and non-clinical sample. Error bars depict +/− 2.00 SE

Table 3. Means and standard deviations of secure base behaviour of adolescent and parent in the clinical and non-clinical sample

	Non-clinical sample		Clinical sample				
	Mean	SD	Mean	SD	df	F	η
Adolescent secure base scales							
Strength and clarity of signal	5.39	0.68	5.23	1.39	1	0.17	0.08
Maintenance of distress signal	5.43	1.20	5.08	1.65	1	0.50	0.12
Approach to attachment figure	4.89	1.18	3.98	1.07	1	6.43*	0.38
Ability to be comforted	4.48	1.18	3.76	0.99	1	4.24*	0.32
Summary scale	4.85	1.06	3.89	0.93	1	8.93*	0.44
Parent secure base scales							
Interest in distress	5.01	1.21	4.54	0.72	1	2.32	0.24
Recognition of distress	4.89	1.38	4.78	1.08	1	0.03	0.04
Interpretation of distress	4.63	1.39	3.83	0.98	1	4.88*	0.33
Responsiveness to distress	4.83	1.41	4.09	0.81	1	4.26*	0.31
Summary scale	4.83	1.34	3.88	0.89	1	7.48*	0.39

*$p < 0.05$.
SD = standard deviation. df = degrees of freedom.

ANOVAs were conducted on secure behaviour of parent and adolescent in the first and second reunion. After controlling for age, we found less secure base behaviour in the clinical than in the non-clinical sample for adolescents ($F_{(1,37)} = 4.19$, $p < 0.05$, $η = 0.32$) and parents ($F_{(1,37)} = 5.17$, $p < 0.05$, $η = 0.35$) in the second reunion, but not in the first reunion ($p > 0.05$). To indicate which behaviours were important, multivariate analyses of variance were performed with the five subscales of secure base behaviour. Adolescents from the non-clinical sample had significantly higher scores than

adolescents from the clinical sample on: Approach, Ability to be comforted, and the Sum scale (Table 3). Moreover, parents from the non-clinical sample had significantly higher scores on: Interpretation, Responsiveness, and the Sum scale.

DISCUSSION

The Alarm Stress Task enables simultaneous observation of physiological and behavioural indices of affect regulation within the context of the

parent–adolescent relationship. The message to adolescents that they failed in the simple task of lying quietly elicited significant physiological reactivity in adolescents indicated by HR increases, and PEP and RSA decreases. When adolescents were reunited with their parents after the alarm and approached their parents for support, RSA increased, supporting the association between social engagement and the parasympathetic system (Porges, 2003a). Adolescents who used their parents as a secure base showed stronger reactivity of the parasympathetic system during stress and reunion, suggesting that relationships with parents may continue to fulfill their homeostatic function as an attachment relationship for adolescents. Clinical and non-clinical adolescents did not significantly differ in their physiological reactivity to the stressor nor in their recovery during reunion. However, consistent with expectations, adolescents with psychopathology and their parents showed less secure base behaviour.

The stressor in the AST challenged both the sympathetic and parasympathetic systems, indicating that parasympathetic withdrawal in reaction to the stressor alone was not sufficient to regulate the stressor. Sympathetic activation and parasympathetic withdrawal are also shown by adolescents in arithmetic (Berntson, Cacioppo, & Fieldstone, 1996) and reaction time tasks (Salomon et al., 2000). Forbes et al. (2006) also found parasympathetic withdrawal in reaction to disappointment. The significant increases in RSA during reunion corresponds with studies that found parasympathetic increases in infants during reunion with the attachment figure (Stevenson-Hinde & Marshall, 1999; Willemsen-Swinkels, Bakermans-Kranenburg, Buitelaar, Van IJzendoorn, & Van Engeland, 2000).

The association between secure base behaviour of the adolescent and stronger increases in RSA during reunion indicates that sharing distress with the parent is supported by increases in the parasympathetic system after stress, facilitating a state of calm behaviour. Secure base behaviour of the adolescent was also associated with stronger parasympathetic decreases during the alarm, when the parent was not available. Secure base behaviour of the parent was not significantly associated with parasympathetic reactivity, although the results were in the expected direction. These results correspond to studies with young children and adults that found that attachment security was related to increased parasympathetic reactivity (Burgess et al., 2003; Maunder et al., 2006). It was

remarkable that secure base behaviour during the first reunion was also associated with preceding parasympathetic reactivity during the first alarm. This may indicate that the greater the severity of stress experienced during the alarm, the more adolescents mobilized secure base behaviour to regulate their arousal. Moreover, significant associations with increased parasympathetic, rather than the sympathetic reactivity, during the preceding alarm may support the hypothesis that inner working models of attachment in adolescents control the physiological regulation of stress (Spangler & Zimmermann, 1999). The results were limited to secure base behaviour of the adolescent in the first reunion, probably because adolescents who regulated the first stressor adaptively, and were supported effectively, were less aroused by the second stressor and showed less parasympathetic decreases, although they continued to display their distress to their parent. In future studies, it would be interesting to examine whether clinical adolescents would differ from non-clinical adolescents in the way secure base behaviour is related to parasympathetic functioning.

We did not find evidence for the hypothesis that adolescents with and without mental health problems would differ in their physiological reaction to the stressor (e.g., Calkins et al., 2007; Rottenberg et al., 2005). However, we found an indirect effect via secure base behaviour. Clinical adolescents showed less secure base behaviour, which was associated with impaired vagal regulation. An explanation for the non-significant relation between psychopathology and physiological reactivity might be the heterogeneity of the type of psychopathology in the clinical group. Unfortunately, the small sample size limited the statistical power to differentiate between adolescents with internalizing and externalizing problems (Calkins et al., 2007; Dietrich et al., 2007). Another explanation might be that other factors moderate the relation between psychopathology and physiological reactivity, such as environmental stress. Future research with larger samples might focus on differences between internalizing and externalizing problems, and on moderators of the relation between psychopathology and the physiological regulation of stress.

Limitations and Future Research

This study was limited in several ways. First, the sample size was small and the clinical sample was

heterogeneous. Second, secure base behaviour of the adolescent might be limited to verbal contact due to the instruction to lie quietly. However, physical contact may be less important for adolescents than for younger children. In addition, there may be other factors that caused the increase in RSA during reunion, such as talking. Moreover, the increase in RSA might be the effect of recovery after the stressor, which also would have taken place without the parent. However, the associations between the quality of secure base interactions and parasympathetic reactivity, even in absence of the parent, emphasize that secure base behaviour is associated with the regulation of stress.

A unique finding of this study is that vagal regulation in adolescents is improved when adolescents openly shared their distress with their parent, which was clearly more visible in nonclinical than clinical adolescents. Therefore, we may conclude that attachment relationships continue to be important for adolescents and the regulation of stress. Less secure base interaction was observed in adolescents with psychopathology, suggesting a possible reason for deficits in stress regulation in adolescents with mental health problems (Bradley, 2000; Southam-Gerow & Kendall, 2002). However, in this study, we did not find evidence for the association between psychopathology and the regulation of physiological arousal. Future research should therefore consider the heterogeneity of the type of psychopathology. The Alarm Stress Task has shown to provide the opportunity to assess individual and relationship-based processes of affect regulation in adolescents simultaneously.

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