INTRODUCTION

Narratives, the stories constructed by individuals to convey their memories, thoughts, and feelings, are thought to serve an important regulatory function (e.g., Bruner, 1990; Oppenheim & Waters, 1995; Pennebaker & Seagal, 1999; Shields, Ryan, & Cicchetti, 2001). Children and adults make sense of their experiences and their environment by placing them in an explanatory narrative context. Specifically, narratives provide people a causal structure to life events that is emotionally meaningful and that provides both temporal and evaluative cohesion to one’s personal experience (Fivush, 1994, 1995; Omer & Alon, 1997).

Both the form and content of narratives are postulated to reflect important elements in social communication and in the manner in which children process emotion. The analysis of narrative form and content offers a window into the representation of the self in relation to conflicts, relationships, and emotionally salient events from immediate or past experience (Buchsbaum, Toth, Clyman, Cicchetti, & Emde, 1992; Main, 1996; Oppenheim, Nir, Warren, & Emde, 1997). Clinical literature suggests that the processing of emotional experience through both play and verbal communication assists children in regulating their emotions. For example, Slade (1994) noted that much of child therapy involves the construction of emotionally coherent narratives from children’s past negative experiences. When such narratives are established, children are better able to regulate their emotions and behavior.
Empirically, characteristics of children’s narratives have been found to correlate with several psychological domains that are closely associated with the processing of emotion. For example, Mize and Ladd (1988) reported an association between preschoolers’ narration to hypothetical social dilemmas and peer behavior and status. Kochanska, Padavic, and Koenig (1996) found meaningful links between children’s narrative themes and observed and maternal report of their sense of right and wrong. Warren, Oppenheim, and Emde (1996) found that higher levels of externalizing behavior problems were linked to increased frequencies of both distress and destructive narrative content themes, and Oppenheim, Emde, and Warren (1997) established that children who had more positive and disciplinary narrative representations of mother exhibited fewer behavior problems. Similarly, Oppenheim, Nir, et al. (1997) reported that children who were more emotionally coherent in a co-construction narrative task with their mothers evidenced fewer behavior problems.

Studies with clinical populations have shown that maltreated children’s negative narrative representations of their mothers and fathers were associated with emotion dysregulation, aggression, and peer rejection whereas positive and coherent representations were related to prosocial behavior and peer preference (Shields et al., 2001). In addition, narratives of maltreated children contained more negative maternal representations and more negative self-representations than the narratives of nonmaltreated children (MacFie et al., 1999; Toth, Cicchetti, MacFie, & Emde, 1997; Toth, Cicchetti, MacFie, Maughan, & VanMeenen, 2000). Finally, 5-year-olds’ narrative themes of negative expectations significantly predicted mother, father, and teacher reports of child internalizing and anxiety symptoms at 6 years of age (Warren, Emde, & Stroufe, 2000).

A further stage in understanding the regulatory role of narratives may be reached by examining physiological responses during narrative processing and production. Emotional responses during narrative production may vary as a function of the theme of the narrative, and such variations in emotion may be mirrored by specific patterns of physiological activation. The core motivation for the present study was to investigate the relations between narrative processing, narrative production, and cardiovascular measures known to be sensitive to emotional processing and cognitive effort. In addition, associations between individual differences in cardiac activity and variation in children’s narrative features were examined.

In the present investigation, we focused on the specific cardiovascular measures of heart period (HP; the interval between successive heartbeats is inversely related to heart rate) and vagal tone (VT; which reflects parasympathetically mediated oscillations in HP). HP and VT are regulated by a set of brainstem nuclei that continuously control the dynamics of the heart in response to physiological and psychological demands. These autonomic brainstem nuclei are influenced by higher structures known to be important in mediating emotional responses, such as the hypothalamus and the amygdala (Spyer, 1989). Typically, HP and VT are highly correlated; however, it is important to note that HP is the result of multiple factors including sympathetic, parasympathetic, and homeostatic influences whereas VT is exclusively a result of parasympathetic influence on the heart.

Under conditions of emotional processing or cognitive effort, HP often becomes shorter. Some researchers have maintained that such a decrease in HP in response to a stressor may simply be due to an increase in concurrent metabolic demand (see Obrist, Webb, Sutterer, & Howard, 1970). However, cardiac adjustments to psychological stress may exceed metabolic requirements (Turner & Carroll, 1985). Such a “suprametabolic” HP decrease is regarded as an adaptive anticipatory response (Sherwood & Turner, 1992) that has obvious functional significance. The need for efficient systems to mobilize and organize disparate physiological systems has shaped the evolution of our emotional responses (Levenson, 1988). In this sense, cardiovascular reactivity may be seen as an index of stress and physiological mobilization toward coping with potentially distressing stimuli. There are a variety of methods for investigating cardiovascular responses in the laboratory (see Krantz, Manuck, & Wing, 1986), including speech tasks (e.g., McCann et al., 1993), but these tasks have rarely involved the specific examination of individual narratives.

With regard to VT, Porges (1998) proposed that individuals with high VT and adaptive cardiac reactivity to challenges would show adaptive behavioral and emotional responses to stimulation. Most of the work examining VT in the child-development literature has focused on between-subjects variation in baseline VT and has generally provided support for Porges’ (1998) suggestion. For example, Fox (1989) found that infants with high VT were more reactive to both positive and negative events at 5 months and more sociable at 14 months. In a different study, 5-month-old infants with greater baseline VT displayed more interest and joy behaviors toward a stranger in a laboratory session (Stifter, Fox, & Porges, 1989). Similarly, infants who responded negatively to frustration but also displayed more regulatory behavior were found to have higher VT (Stifter & Jain, 1996). Observing 2- and 3-year-olds in the laboratory, Calkins (1997) found that baseline VT was positively related to positive temperamental reactivity and negatively related to negative temperamental reactivity. Likewise, observing older children’s adaptation to preschool entry, Fox and Field (1989) showed that young
children with high baseline VT showed a greater decrease in solitary play behavior and a greater increase in interactive play behavior over the first 6 weeks of preschool.

Only a small number of studies have assessed dynamic changes in VT within epochs of a task. Porges (1991, 1996; also see Porges, Doussard-Roosevelt, Portales, & Greenspan, 1996) suggested that during periods of challenge or stress, the vagus may function as a break to regulate cardiac output. Such action of the vagal “break” may be measured as decreases in VT in response to environmental challenges. Porges (1996) further offered that such reactive suppression of VT may act to increase an individual’s orientation to external stimuli, thereby increasing his or her ability to regulate and coordinate more complex emotional and behavioral responses. Along these lines, Stifter and Corey (2001) demonstrated that 1-year-olds’ ability to suppress cardiac VT during a cognitive challenge was related to increased frequency of positive social behavior. Calkins (1997) reported decreases in VT from baseline to episodes designed to elicit both positive and negative emotional reactivity and regulation, and Calkins and Dedmon (2000) found that children at high risk for externalizing behavior problems displayed lower respiratory sinus arrhythmia (RSA) suppression during challenging situations than did children with low risk for such problems. Although these studies have generally shown VT to be sensitive to attentional and cognitive demands, the findings of these studies also invite the suggestion that VT is somewhat less sensitive than HP to contextual emotional demands (e.g., Bornstein & Suess, 2000; Marshall & Stevenson-Hinde, 1998; Suess, Porges, & Plude, 1994).

Very few published studies have assessed associations between autonomic activity and narrative regulatory processes. Some studies have shown increases in autonomic responses (e.g., skin conductance, heart rate, palmar sweating) to the presentation of anxiety-provoking narratives in adults (e.g., Lazarus & Alfert, 1964) and children (e.g., Lore, 1966). However, the primary focus of such studies was on the processing of narrative information rather than the physiological correlates of narrative processing and production.

Perhaps the most relevant example of the interplay between narrative production and autonomic physiology is a study of adults by Dozier and Kobak (1992), who found that certain participants showed an increase in skin conductance when presented with attachment-related topics. The narratives of these participants were characterized by a restricted awareness and acknowledgment of negative affect and a limited recall of distressing attachment-related memories. This finding was interpreted as evidence supporting the hypothesis that deactivating narrative strategies reflect active attempts to divert attention from attachment-related issues, given that these strategies are associated with physiological patterns indicative of stress.

The goal of the current research was to examine the relations between HP, VT, and narrative processing and production. We had three main hypotheses concerning these associations: First, we expected that the presentation of emotionally laden story-stems by an experimenter would have an impact on children’s cardiac activity. Specifically, we expected the emotional impact of the presentation of the story-stems and children’s cognitive effort involved in processing them to be manifested in greater decreases in HP and VT during story-stem presentation as compared with a resting baseline condition (both conditions do not involve vocalization on the part of the children). Second, we expected differences in children’s cardiac activity during their narration to a neutral “warm-up” story-stem compared with their narration to emotionally laden story-stems. Note that vocalization may have an impact on cardiac activity, particularly on VT (e.g., Sloan, Korten, & Myers, 1991); however, contrasting HP and VT during children’s narration to a neutral warm-up story-stem and their HP and VT during narration to emotionally laden story-stems (both conditions involving child vocalization) allow for this comparison. We hypothesized that narration to the emotionally laden story-stems would produce greater decreases in HP and VT than narration to the neutral stem, given the greater stress and regulatory effort required by the emotional themes. Furthermore, because themes involving separation and reunion have been implicated as being particularly stressful for young children (e.g., Bowlby, 1973), we expected children’s narration to the first day in school, separation, and reunion story-stems to be less coherent, to invoke more negative and anxious contents, and to be associated with lower HP and lower VT as compared with the hot gravy and ball conflict story-stems, which do not involve such themes. Finally, we tested for associations between individual differences in HP and VT and individual differences in children’s narrative responses. Specifically, baseline HP and VT were expected to link to individual differences in narrative form and content. Although the mainstream of this literature assumes an association between high baseline HP and VT and more regulated behavior, there is apparent discontinuity in the literature regarding these associations. For example, Fox (1989) found greater reactivity to negative events in high baseline VT infants whereas Calkins (1997) found lower temperamental reactivity in children with high VT. We expected the present study to shed further light on this issue in older children.

As well as examining tonic levels of VT, we also expected children’s capacity for a dynamic suppression of VT in response to emotion-laden story-stems to be associated with more efficient regulatory narrative responses.
More specifically, children who suppressed VT in this context were expected to display increased story coherence and reduced narrative inhibition and negative/anxiety-related content and behavior as compared with children who do not display such VT suppression. This hypothesis is based on Porges’ (1996) “vagal brake” theory and Calkins’ (1997) and Stifter and Corey’s (2001) findings that showed an association between VT suppression and better emotion-regulation capabilities or improved social outcomes.

It was our hope that testing these hypotheses would increase our understanding of the psychological and physiological processes associated with the assimilation of emotionally charged information in children and with the production of narratives related to this information.

METHODS

Participants

A total of 58 children (29 males, 29 females) were seen in the laboratory at the age of 7 years (M = 7.17, SD = .21). These children were recruited as part of a larger longitudinal study of social and emotional development (for details, see Fox, Henderson, Rubin, Calkins, & Schmidt, 2001). Children were primarily of middle-class background, living with their families in and around the Washington, DC area. All children were Caucasian.

Procedure

Upon arrival at the laboratory and after informed consent was obtained from the parents, children were ushered into a testing room; parents were escorted to an adjacent waiting room, where they remained during the application of the ECG electrodes and the administration of the story-stems. Three minutes of resting baseline ECG data were collected while the children were alert and sitting quietly. The ECG signal was then continuously collected while the children completed a selected set of story-stems from the MacArthur Story-Stem Battery (MSSB; Bretherton, Oppehime, Buchsbaum, Emde, & the MacArthur Narrative Group, 1990) and two additional story-stems that were especially created for the present study (see Appendix A).

The experimenter told the child that they were going to play together and that the experimenter would tell him or her beginnings of some stories and that the child should complete them. Story-stems were presented and played out with dolls. Standard names were given to each doll, and the gender of the child in the story-stem matched the gender of the participant. The examiner presented the story-stems in a vivid and dramatic tone, and ended each with the request: “Show me and tell me what happens now.”

The examiner moved from one story-stem to the next after children addressed the main issue in the stem and brought the narrative to an end. Nondirective comments such as “Does anything else happen in the story?” or “What are they doing now that the parents have returned home?” were used to facilitate children’s narratives (for further details on procedure, see Oppenheim, Emde, et al., 1997; Oppenheim, Nir, et al., 1997). Each session was videotaped in its entirety. Finally, we administered the vocabulary subscale of the Wechsler Intelligence Scale for Children–Third Edition (WISC-III; Wechsler, 1991).

Measures

Children’s Narratives: The MacArthur Story-Stem Battery (MSSB). Children completed four story-stems (“warm-up birthday party;” “hot gravy;” “separation,” and “reunion”) from the original MSSB. Two additional story-stems (“first day in school” and “ball conflict”) were created for the present study in a style consistent with that of the MSSB. The warm-up birthday story-stem is typically regarded as an emotionally neutral stem. The rest of the selected story-stems as well as the newly created story-stems were designed to evoke distress responses, and included themes of self-injury, social play with unfamiliar peers, peer acceptance, altercation, and separation and reunion with parents.

Narrative responses were coded using a slightly modified version of the protocol developed by Robinson, Mantz-Simmons, MacFie, and the MacArthur Narrative Working Group (1996). Global ratings were made on certain general characteristics of each of the narratives, which also were coded for the degree to which specific themes were expressed. To highlight the expected associations between narratives reflecting emotional distress and cardiac activity, the content themes of “Anxiety/Wariness” (acts or verbalizations indicating that a character is feeling anxious or wary of a situation or person), “Negative Emotions” (characters appear to experience negative emotions such as feelings of anger, sadness, distress, concern, disappointment), and “Tired” (verbalization denoting tiredness, needing to rest, going to bed, or going to sleep as an index of depressed mood) were selected for further analyses. These content themes were coded as either present or absent. Because a child’s narrative could contain several different themes presented sequentially, it was possible to assign more than one content theme to one narrative. In addition to the aforementioned content themes, the global narrative scales of “Story Coherence,” “Narrative Inhibition,” and “Anxiety Behavior” also were analyzed.

Story Coherence of children’s narrative to each of the story-stems was coded on a 5-point scale that determined the connectedness, clarity, and intelligibility of the child’s narration. Scale points were 0 (child was unable to tell a story), 1 (highly incoherent story with fragmented shifts in story line), 2 (somewhat incoherent, story takes more than two incoherent shifts), 3 (somewhat coherent, story takes only one or two incoherent shifts or no shifts at all), and 4 (a story that is very coherent, logical, and includes a sequential series of events that is related to the story-stem). Narrative Inhibition was coded on a 3-point scale that refers to the flow of narration and the ease with which the child responded to the challenges presented in the story-stems. A score of 0 was assigned to “noninhibited,” smooth delivery of a story without any delays or pauses. A score of 1 (somewhat inhibited) was assigned to narratives that contained some periods of
silence, the child may have required extra prompting from the experimenter, or when the child seemed to avoid the dilemmas presented in the story-stems. A score of 2 reflected a highly inhibited narrative with long periods of silence; children receiving this code required a good deal of prompting from the experimenter to deliver the story, did not touch the dolls and props, and/or produced very short stories.

Child Anxiety Behavior (i.e., physical movements that indicate a sense of discomfort or apprehension such as rocking, thumb sucking, fidgeting, chewing on objects/self, stuttering, or anxious speech) was scored as either present or absent during each story-stem completion.

Intercoder reliability was calculated using 20% of the sample. Across the total variable matrix, agreement ranged from 87 to 100% (κ = .78–1.0). Discrepancies in coding were discussed and resolved by consensus.

**ECG Data Collection and Measures.** ECG data were collected during a resting baseline condition and throughout the whole narrative task using three disposable, self-adhesive electrodes (Kendall Hydro-Snap) placed on the upper and opposite lower portions of the child’s torso, with the ground electrode being placed on the back of his or her neck. Throughout the narrative procedure, digital event marks that were synchronous with the ECG collection were placed at the beginning of each presentation of a story-stem and at the end of the presentation epoch after the experimenter requested the child to “Show her and tell her what happens now.” These latter event marks also indicated the beginning of the child’s narration epochs. Finally, event marks were placed at the end of the child’s telling of each of his or her stories. The event marks were placed via a button press from the experimenter that inserted an event mark on a specific channel in the digitized physiological record. For 27 children, the ECG signals were amplified by a Grass bioamplifier (Model 7DAG), and the signal was digitized using Snapshot-Snostream acquisition software from HEM Data Corp. (Southfield, MI). The ECG data from the remaining 34 children were collected with a custom bioamplifier from SA Instruments (San Diego, CA), and the signal was digitized with the Snap-Master Data Acquisition System (HEM Data Corp.). For all children, the sampling rate was 512 Hz, and processing of the ECG signal was carried out using the IBI Analysis System from James Long Company (Caroga Lake, NY).

R-wave detection was carried out offline using a four-pass self-scaling peak-detection algorithm. This gave a data file containing the onset times of each detected R-wave in the physiological record. For artifact editing, the sampled ECG signal was viewed graphically alongside tick marks representing the times of software-detected R-waves. In the rare case of an undetected R-wave that was not detected by the software, a tick mark was inserted into the graphical ECG record. If the undetected R-wave was visible in the ECG, it was marked manually. If the R-wave was not visible, the tick mark was placed based on specific editing rules (Byrne & Porges, 1993). The edited R-wave series was converted to a prorated heart period series with a sampling interval of 250 ms. Heart periods spanning two sampling intervals were prorated between these two intervals using a weighted-mean algorithm. For each story, mean HP and VT were calculated for the presentation and narration epochs. VT was calculated using a time-domain method as follows: A third-order 21-point moving polynomial was passed over the entire prorated HP series to filter out low-frequency variability and slow trends from the data. For a discussion of the methodological issues associated with the application of moving polynomial filters to heart period data, see Porges and Bohrer (1990). VT was taken as the natural logarithm of the residual variability remaining in the HP series after application of the moving polynomial. Specifically, the natural logarithm was taken of the variance of the mean of the filtered HP series to give VT values in units of ln ms^2.

**WISC-III: Vocabulary.** Children’s vocabulary, as an index of language development, was individually assessed using the vocabulary subtest of the WISC-III. This subscale contains 30 words ranked in an ascending degree of difficulty. An experimenter presented words from this standard list, and children were asked to orally define them. In that sense, the scale touches upon both receptive and expressive capabilities in children’s language development. Children’s definitions were scored on a scale of 0 (the response is a wrong answer or shows poverty of thought) to 2 (the response indicates good understanding of the word). Words were presented until the child received a score of zero points on four consecutive words. Normalized scores were then computed for each child.

**RESULTS**

**Preliminary Analyses: Age and Vocabulary in Relation to Narrative and Cardiac Indices**

To assess whether cardiac patterns were associated with children’s age or language competence, Pearson correlations were computed between children’s age or WISC-III Vocabulary score and HP or VT during baseline, story-stem presentations, and children’s narrations. None of these correlations yielded statistically significant findings. To further assess whether children’s scores on the different narrative indices were associated with age or language competence, separate sets of correlations between children’s age and narrative scale scores, frequency of narrative content themes, and behavior performance scores were computed. Neither of these correlations yielded statistically significant findings. Therefore, age and the WISC-III Vocabulary scale were not included in subsequent analyses.

**Differences in HP and VT between Resting Baseline and Story-Stem Presentations**

To assess whether the presentation of the story-stems by the experimenter had an impact on children’s cardiac
activity, two repeated measures MANOVAs (one for HP and one for VT) were computed, with HP or VT during the resting baseline condition and during each of the story-stem presentation epochs as the within-subjects variables and gender as a between-subjects variable.1

Table 1 shows means and SDs of HP and VT during baseline and during presentation of the story-stems by the experimenter. In the MANOVAs, significant epoch effects were found for both HP, $F(6, 46) = 3.82, p < .01$, and VT, $F(6, 46) = 2.97, p < .05$. No significant main effects of gender or Gender $\times$ Epoch interaction effects were found. Follow-up least significant difference (LSD) comparisons contrasting HP or VT during the epoch in which children narrated their response to the neutral warm-up story-stem and epochs during which they narrated to the emotionally laden story-stems (Table 2) showed that HP was significantly shorter during children’s narratives to the first day at school, departure, and reunion stories compared with HP during their narration to the neutral warm-up story-stem. Vagal tone was significantly lower during children’s narration to the hot gravy, first day at school, departure, and reunion stories compared with VT during their narration to the neutral warm-up story-stem. HP and VT did not differ between children’s narration to the ball conflict story-stem and narration to the warm-up story-stem.

### Differences in HP and VT between Children’s Narration to a Neutral Warm-Up Story-Stem and Narration to Emotionally Laden Story-Stems

To assess differences in children’s cardiac activity when narrating to a neutral story-stem versus emotionally laden story-stems, two repeated measures MANOVAs (one for HP and one for VT) were computed, with HP or VT during children’s narration to each of the story-stems as the within-subjects variables and gender as a between-subjects variable. As reported in Footnote 1, 2 participants had missing ECG data during certain narrative production epochs, giving a sample size of 56 children for these analyses.

Table 2 presents means and SDs of HP and VT during children’s narration to each of the story-stems. In the MANOVAs, significant epoch effects were found for both HP, $F(5, 50) = 5.06, p < .001$, and VT, $F(5, 50) = 3.51, p < .01$. No significant main effects of gender or Gender $\times$ Epoch interaction effects were found. Follow-up LSD comparisons contrasting HP or VT during the epoch in which children narrated their response to the neutral warm-up story-stem and epochs during which they narrated to the emotionally laden story-stems (Table 2) showed that HP was significantly shorter during children’s narratives to the first day at school, departure, and reunion stories compared with HP during their narration to the neutral warm-up story-stem. Vagal tone was significantly lower during children’s narration to the hot gravy, first day at school, departure, and reunion stories compared with VT during their narration to the neutral warm-up story-stem. HP and VT did not differ between children’s narration to the ball conflict story-stem and narration to the warm-up story-stem.

### Differences in HP, VT, and Narrative Characteristics between Children’s Narration to Story-Stems Involving Separation–Reunion Themes and Story-Stems that Do Not

Mean HP and VT for stories involving separation–reunion themes (i.e., first day at school, separation, and reunion) were contrasted with mean HP and VT of stories that do not contain these themes (i.e., hot gravy and ball conflict; see Table 3). For both story-stem presentation and child-narration epochs, stories containing separation–reunion themes were characterized by significantly lower HP (faster heart rate) compared with stories that did not involve such themes. Vagal tone was significantly lower during children’s narration to separation–reunion themes as compared with their narration to the other stories. Such differences in VT were not found during the story-stem presentation epoch.

In addition, narration to separation–reunion stems was less coherent and contained higher frequency of tired

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1There are 53 participants included in these analyses: Due to technical problems, 3 participants did not have baseline ECG, and 2 additional participants had missing ECG data during certain narrative-production epochs.
content themes compared with narration to stems without separation–reunion themes. The two classes of stems did not differ on anxiety/wariness, negative emotions, narrative inhibition, and anxiety behavior.

**Associations between HP and VT and Children’s Narrative Responses**

To assess whether individual differences in baseline HP or VT are related to individual differences in negative and anxious narrative responses, Pearson correlations were computed between children’s baseline HP and VT and the narrative indices of anxiety/wariness, negative emotions, tired, story coherence, narrative inhibition, and anxiety behavior (each averaged across story-stems). A significant correlation was found between baseline HP and the negative emotions content theme such that longer HP was associated with increased verbalization of negative emotions \( r = .28, p < .05 \). None of the other correlations concerning HP or VT and narrative indices revealed significant findings.

To investigate the associations between individual differences in children’s VT suppression and narrative characteristics, children were assigned to one of two groups based on their VT suppression scores from the epoch of listening to a neutral story-stem to the average VT of epochs of listening to emotion-laden story-stems. \(^2\)

Children who displayed a decrease in VT (i.e., VT difference score greater than zero) to the emotion-laden story-stems were assigned into the “suppressors” group \((n = 28; 15 \text{ girls})\). Children who displayed an increase in VT to the emotion-laden story-stems (i.e., VT difference score smaller than zero) were assigned into the “augmenters” group \((n = 30; 14 \text{ girls})\). Table 4 presents the means and SDs of narrative indices by groups of VT suppressors and augmenters.

Between-group contrasts revealed that compared with children who displayed augmentation of VT to the emotion-laden story-stems, children who reacted to the presentation of the emotion-laden story-stems with VT suppression constructed more coherent narratives that contained lower frequency of anxiety and negative emotions contents. Interestingly, children in the suppressors group also displayed greater frequency of the tired content theme compared with children in the augmenters group. No between-group differences were found on the behavioral indices of anxiety and narrative inhibition.

**DISCUSSION**

The findings from this study indicate that the concurrent measurement of children’s narrative qualities and cardiovascular activity may provide a window into the emotional processes taking place during narrative processing and construction.

As expected, significant changes in HP and VT were observed between a resting baseline and epochs of story-stem presentation by the experimenter. The decreases in VT from baseline to each of the story-stem presentations (including the neutral warm-up story-stem) probably reflect a general effect of attention on VT. Attention-demanding tasks are associated with decreases in heart rate variability compared with baseline levels in both adults (e.g., Cacioppo, Uchino, & Berntson, 1994; Porges & Raskin, 1969; Walter & Porges, 1976) and children (e.g., Suess et al., 1994; Weber, van der Molen, & Molenaar, 1994; for review and discussion, see Porges, 1974).

While significant decreases in VT from baseline were found for the presentation of all story-stems, there were only significant decreases in HP for the presentation of the first day at school, departure, and reunion story-stems. Although usually highly correlated, HP and VT tap different psychophysiological processes: HP is the result of multiple factors including sympathetic, parasympathetic, and homeostatic influences whereas VT is exclusively a result of parasympathetic influence on the heart. Partly for these reasons, HP may be less sensitive than VT to the attentional demands of a task and more sensitive to the emotional context. The significant

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\(^2\)Vagal tone during presentation of the neutral story-stem was selected as a “baseline” from which to subtract VT to the presentation of emotion-laden stems because it provides a cleaner estimate of VT suppression to emotion-laden narratives as compared with a simple resting baseline that requires no cognitive processing. Calculations of VT suppression scores of epochs during which children verbally responded were omitted because of the potential confounding effects of vocalization on VT.

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**Table 2. Means and SDs of HP (ms) and VT (ln ms\(^2\)) during Children’s Narration to Story-Stems, and the Results of Post Hoc LSD Contrasts between HP or VT during Narration to a Neutral “Warm-Up” Story-Stem and during Narration to Emotionally Laden Story-Stems**

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<tr>
<td>HP</td>
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<tr>
<td>Warm-Up</td>
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<td>606.86</td>
<td>58.95</td>
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<td>603.19</td>
<td>56.23</td>
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<td>609.34</td>
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</tr>
<tr>
<td>Departure</td>
<td>605.36</td>
<td>59.67</td>
<td>.05</td>
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<tr>
<td>Reunion</td>
<td>598.14</td>
<td>57.13</td>
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<td>VT</td>
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<td>.01</td>
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decreases in HP from baseline for these three particular stories may thus reflect their more stressful emotional content compared with the other warm-up, hot gravy, and ball conflict story-stems. Furthermore, the three story-stems characterized by shorter HP involve themes of separation and reunion, which have been implicated as being particularly stressful themes for children (e.g., Ainsworth, Blehar, Waters, & Wall, 1978; Bowlby, 1969).

In addition to the differences in cardiac patterns found between the resting baseline and epochs during which children passively listened to emotion-laden story-stems, HP was shorter and VT was lower during children’s active narrative production to the emotion-laden stories compared with narrative production to a neutral story-stem. These findings suggest that children’s dealings with the conflicts presented in the story-stems through narrative production are mirrored by autonomic changes reflecting the degree and quality to which they elicit emotional and cognitive processing.

More refined contrasts between children’s reactions to story-stems that did or did not contain separation–reunion themes show that listening and narrating to separation–reunion stems are associated with lower HP compared with stories that did not involve such themes. Vagal tone was lower during children’s narration to separation–reunion stems compared with the rest of the stories. In concert with these cardiac patterns, narration to separation–reunion stems was less coherent and contained a higher frequency of tired content themes compared with narration to stems without separation–reunion themes. Taken together, these findings suggest that story-stems with themes of separation from and reunion with parents may be more emotionally potent or stressful than other story-stems dealing with neutral, parent–child conflict or peer altercation situations; however, note that the narrative indices of anxiety and negative emotionality did not show similar sensitivity to story-stem content type, rendering further research into this issue necessary.

| Table 3. Means and SDs of HP (ms) and VT (ln ms²) during Story-Stem Presentation and during Children’s Narration to Story-Stems Involving Separation–Reunion Themes Versus Story-Stems that Do Not Involve Such Themes. Also Presented Are Means and SDs of Narrative Indices for the Two Group Types of Stories |
|---|---|---|---|---|---|
|  | Separation–Reunion | Other |  |  |  |
|  | M | SD | M | SD | t (57) | p |
| Stem Presentation |  |  |  |  |  |  |
| HP | 631.18 | 61.73 | 644.58 | 72.38 | 4.06 | .001 |
| VT | 6.20 | 1.07 | 6.17 | 1.09 | .49 | n.s. |
| Child Narration |  |  |  |  |  |  |
| HP | 600.53 | 56.61 | 606.25 | 59.03 | 3.40 | .001 |
| VT | 5.63 | .98 | 5.77 | .99 | 2.44 | .05 |
| Narrative Indices |  |  |  |  |  |  |
| Story Coherence | 3.28 | .81 | 3.42 | .69 | 2.05 | .05 |
| Narrative Inhibition | .36 | .52 | .40 | .54 | 1.19 | n.s. |
| Anxiety Behavior | .28 | .37 | .26 | .35 | .76 | n.s. |
| Anxiety/Wariness | .11 | .22 | .10 | .20 | .19 | n.s. |
| Negative Emotions | .30 | .27 | .35 | .40 | 1.07 | n.s. |
| Tired | .23 | .26 | .07 | .17 | 4.93 | .001 |

| Table 4. Means and SDs of Narrative Indices by Groups of VT (ln ms²) Suppressors and Augmenters from an Epoch of Listening to a Neutral Story-Stem to Epochs of Listening to Emotion-Laden Story-Stems |
|---|---|---|---|---|---|
|  | Suppressors (n = 28) | Augmenters (n = 30) |  |  |  |
|  | M | SD | M | SD | t (56) | p |
| Story Coherence | 3.51 | .45 | 3.14 | .88 | 2.01 | .05 |
| Narrative Inhibition | .31 | .41 | .37 | .54 | .52 | n.s. |
| Anxiety Behavior | .29 | .35 | .22 | .31 | .68 | n.s. |
| Anxiety/Wariness | .05 | .12 | .15 | .21 | 2.25 | .05 |
| Negative Emotions | .23 | .28 | .41 | .36 | 2.15 | .05 |
| Tired | .24 | .22 | .09 | .13 | 3.20 | .01 |
The finding that not all story-stems evoke similar cardiac responses and may therefore importantly differ in the cognitive and emotional efforts they require is of particular importance. A common practice in children’s narrative research is to sum or average narrative indices across a set of story-stems without special consideration of the potential differences in the contribution of specific story-stems to the aggregated index (cf. von Klitzing, Kelsay, & Emde, 2003). The findings from the present study call into attention the potential limitations of such an approach, suggesting that story-stems should be carefully selected to reflect children’s reactions to more specifically defined contexts of interest; however, note that the inferences of the present study also are somewhat limited due to the potential order effects of story-stem presentation, in which presentation of the warm-up story was not counterbalanced with the other story-stems.

With regard to associations between individual differences in baseline HP and VT and individual variations in narrative processing and production, the present findings indicate that longer HP is associated with an increased frequency of verbalized negative emotions. The ability to openly verbalize negative emotions may be associated with an autonomic activation pattern that is supportive of the ability to perceive and attend to social signals as well as initiate productive social interaction (Porges, 1995, 1998). Somewhat congruent with this assumption are the findings of Main, Kaplan, and Cassidy (1985), which showed that the ability to openly discuss negative emotions at 6 years of age positively correlated with secure attachment both concurrently and in infancy.

In more general terms, however, and in contrast with previously reported associations between baseline HP or VT and infant’s and young children’s behavior regulation/temperamental characteristics, the data from the present study did not yield strong support for the hypotheses concerning associations between individual differences in baseline cardiac patterns and individual differences in narrative response. These departures from the result patterns of other studies may be uniquely associated with the different nature of the behavior tasks involved. Specifically, the narrative processing and production tasks of the present study seem to require greater attentional and mental processing resources compared with previously used episodes designed to elicit temperamental reactivity and simpler forms of behavior regulation. It may be the case that the greater cognitive demands imposed by the narrative tasks induce a ceiling effect on cardiac output that obscures potential individual differences in baseline patterns. In addition, the participants of the present study were older than the infants and toddlers usually studied when associations between baseline cardiac indices and behavior regulation were found (e.g., Fox, 1989; Stifter & Jain, 1996). It may therefore be of further interest to explore the developmental course of the associations between baseline cardiac measures and behavior and emotion regulation.

In contrast to the relatively modest associations between baseline cardiac measures and children’s narrative features, children’s ability to dynamically suppress VT during the processing of emotionally laden story-stems was associated with increased narrative coherence, reduced frequency of anxiety and negative-emotion contents, and increased content themes of tiredness. These findings highlight the interplay between the cognitive-regulatory function of narrative processing and production and VT suppression as an index of autonomic processes that may be supporting such regulation. These results also are in line with Porges et al.’s (1996) vagal brake theory. Faced with the cognitive-emotional challenge posed by the narrative tasks, children who showed appropriate physiological regulation also showed increased emotional regulation as indexed by the characteristics of their subsequent responses to the narratives. From this perspective, the findings from the present study are consistent with previous findings regarding the association between VT suppression and behavioral regulation in infants and younger children (e.g., Bornstein, & Suess, 2000; Calkins, 1997; Stifter & Corey, 2001). These findings also are consistent with those of Dozier and Kobak (1992), who found that college students employing deactivating strategies during attachment interviews show marked increases in skin-conductance levels from baseline to questions asking them to recall experiences of separation, rejection, and threat from parents.

One intervening factor that may have had an impact on the cardiac activity recorded in the present study is vocalization (e.g., Johnson & Campos, 1967; Porter, Porges, & Marshall, 1988; Sloan et al., 1991). Specifically, speaking may interfere with respiratory patterns which in turn may interfere with the quantification of VT. Although Sloan et al. (1991) showed that changes in VT during stressful and neutral tasks (both involving speaking) were not masked by respiratory rate changes, it is still possible that speaking may interfere with the quantification of VT. Interference of vocalization with VT quantification may have precluded our ability to reveal some of the expected changes in VT for this study; however, it should be stressed that to avoid possible interpretation difficulties due to vocalization effects on VT, the present study restricted comparisons of cardiac activity to either within both speaking or both nonspeaking epochs.

Given that physiological responses are a key part of major theories of emotion and cognition, a further stage in understanding can be reached if these expressive and regulatory processes are explored at the physiological as
well as the behavioral level. Indeed, the semistructured nature of the story-stem procedure lends itself to the concurrent monitoring of autonomic measures. In the current study, the measurement of HP and VT provided a window into the physiological processes associated with the cognitive and emotional effort of listening to the story-stems and narrating responses to them. Examination of the cardiovascular responses to stories and narratives with a variety of emotional contexts allowed us to draw novel inferences about the nature of children’s narratives and of emotion processing of these themes. Blair (2002) argued that a central question in the development of self-regulation in children is how emotional information influences cognition and cognitive development. He further suggested a central role for psychophysiological processes in the relation of emotionality, emotion regulation, and cognition. Further studies using the story-stem paradigm in combination with the measurement of psychophysiological variables would be useful in continuing to clarify the complex relations between behavior, physiology, and cognition.

APPENDIX A: STORY-STEM BATTERY

These story-stems are described for boys. The names and gender of child characters are female when participants are girls.

Warm-Up (Birthday Party)

Story Theme: Introduction, modeling of narration with family figures
Characters: Mom, Dad, Grandma, Child 1, Child 2
Props: table, birthday cake
Experimenter: “You know what? It’s Mark’s birthday and Mom made him this beautiful birthday cake. It’s time for the party.”
Mother: “Come on Grandma, Dad, and George. It’s time to celebrate Mark’s birthday.”
Experimenter: “Can you get the family ready at the table?”

Hot Gravy

Story Theme: Disobedience/parental empathy versus authority
Characters: Mom, Dad, Child 1, Child 2
Props: stove, pan, table
Mother: “We’re going to have a good supper, but it’s not ready yet. Don’t get too close to the stove.”
Child: “Mmm, that looks good. I don’t want to wait. I want some now!” (Child character reaches over and spills the hot pot.)
Child: “Ow, I burned my hand, it hurts.”

First Day at School

Story Theme: Social approach/withdrawal, novel situation
Characters: Child 1, Child 3 (same sex as Child 1), Child 4 (opposite sex as Child 1), Teacher
Props: grass
Experimenter: “It’s the child’s very first day at school. He and the other children are sitting in the classroom.”
Teacher: “O.K. kids, it’s time for recess. Let’s go out on the playground now.”

Ball Conflict

Story Theme: Social conflict with peer
Characters: Child 1, Child 3 (same sex as Child 1), Teacher
Props: Ball, grass
Child 1: “This is my brand new ball. I can kick it really high, watch me!”
Child 2: “I want to play with the ball too! Let me have it!” (Child 2 pushes Child 1 down.)
Child 1: “Ow, that hurts.”

Departure

Story Theme: Separation from parents
Characters: Mom, Dad, Grandma, Child 1, Child 2
Props: car
Experimenter: “Mom and Dad are going on a trip. The car is parked in front of the house.”
Mother: “O.K. boys, your Dad and I are leaving on our trip now. See you tomorrow, Grandma will stay with you.”

Reunion

Story Theme: Attachment, reunion with parents
Characters: Mom, Dad, Grandma, Child 1, Child 2
Props: car
Experimenter: “It’s the next day, and Grandma looks out the window.”
Grandmother: “Look boys, I think your Mom and Dad are back from their trip. I think I can see their car.”

REFERENCES


