RUNNING HEAD: Children's emotion regulation: Self-report and physiological response

Children's emotion regulation: Self-report and physiological response to peer provocation

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Abstract

Examined the notion that children's emotion regulation (ER) is a uniform skill by: (1) investigating the concordance between self-report of ER and physiological measures, and (2) examining ER in a specific context (e.g., peer provocation) and context-free manner (e.g., during a semi-structured interview of ER abilities). Time-locked measures of heart rate reactivity and recovery were obtained in response to provoking comments and vagal regulation was measured throughout the provocation session. Children who reported greater dysregulation showed increased heart rate reactivity to provocative comments (i.e., steeper HR slope) but no difference in heart rate recovery. The context-free but not the context-specific self-report measure was associated with a failure to suppress vagal tone. Implications for ER measurement and children's peer relations are discussed.

Key words: Emotion regulation, psychophysiology, peer interaction

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Children's growing ability to regulate their emotions is a crucial skill related to many areas of their social functioning. The recent surge of interest in emotion regulation (ER) has produced an abundance of studies linking children's ER to aspects of their adjustment, ranging from social competence and peer relations to externalizing and internalizing problems (Eisenberg et al., 1995; Eisenberg, 2001; Zeman, Shipman & Suveg, 2002). However the rapid growth and popularity of research in this area has only heightened the need to carefully examine previous assumptions and further refine our definition and measurement of ER.

One common conceptualization of ER is to view it as a uniform skill, or consistent pattern of response within an individual. For example, it is assumed that children who are skillful at ER will similarly be able to regulate emotion at the physiological, behavioral and experiential levels. It is also assumed that children will be equally good regulators across different contexts. However little work to date has tested these assumptions and investigated to what extent these different levels of ER are related to one another or whether children's ability to regulate emotions varies across contexts.

The present study examines the notion of ER as a uniform skill in two ways. First, we investigate relations between self-report of ER and physiological response. If ER is a uniform skill, agreement between these levels of measurement would be expected. Second, we examine ER within two different levels of context. Some studies have conceptualized ER as being context- dependent by assessing an individual's ability to regulate emotions within a specific context (e.g., Hubbard et al., 2004). Others have conceptualized ER as being context-independent by assessing an individual's ability to regulate emotion across specific situations (e.g., Calkins & Dedmon, 2000). While developmental studies have measured children's ER in different contexts (for a review, see Cole et al., 2004), little attention has been given to understanding relations between general and context-specific measures of ER or their differential ability to predict children's adjustment. For example, Lemery & Goldsmith (2003; as cited in Goldsmith & Davidson, 2004) found that out-of-context fear better predicted internalizing symptoms than in-context fearful reactions. If ER is in fact a uniform skill or ability of the child that transcends the level of context, general and context-specific measures would be expected to be related.

Controversies in the Study of ER: Implications for Conceptualization and Measurement

At a basic level most agree ER involves the modification of the intensity, quality and duration of an emotional experience in the service of accomplishing one's goals (Thompson, 1994). In addition, it has been recognized that an inability to properly regulate emotional experiences may result from either an undercontrol or overcontrol of emotional arousal (e.g., Cole, Zahn-Waxler, Fox, Usher, & Welsh, 1996). However beyond this fundamental understanding, many aspects of ER have sparked debate as researchers continue to refine a working definition of ER (e.g., Cole, Martin & Dennis, 2004; Campos, Frankel & Camras, 2004; Eisenberg & Spinrad, 2004). One of the questions at the heart of this debate is what constitutes ER, or more specifically, at what point an individual can be said to be regulating their emotional experience.

Many researchers have conceptualized ER as a two-part process whereby a child first has an emotional experience or response, followed by a regulatory response that can be separated from the emotion and assessed as ER (e.g., Cole, Martin, & Dennis, 2004). For example, Cole and colleagues (2004) define ER as changes associated with already activated emotions. However others have argued that children's emotional experience cannot in practice be separated from a child's ER (Campos et al., 2004; Stansbury & Gunnar, 1994). Campos and colleagues have proposed a unitary model of ER where emotion and regulation occur concurrently, and regulation is present throughout the emotional experience, including even prior to the emotion occurring itself. These differing definitions of ER have important implications for how we conceptualize ER and it will be important for the field to further explore.

In the current study, we conceptualize ER as being inclusive of both a child's initial emotional response, or the reactivity dimension of ER, and their ability to alter this response, the recovery dimension of ER. A child's ability to regulate their emotions could have an effect both on how they experience the initial emotion and their reaction to a stimulus, but also given their emotional reaction, how they are able to modulate their affect to achieve their goals. As Cole et al. (2004) discusses, it is very difficult given the methods currently available to distinguish between these aspects of ER, and furthermore, it can be argued whether it makes conceptual sense to do so (Campos et al., 2004). In addition, while emotion dysregulation can be viewed as both a problem of overcontrol or undercontrol of emotional arousal, the current study focuses on children who experience an undercontrol of their emotional experiences. Using this working definition of ER, relations between levels of ER are used to examine the notion of ER as a uniform skill.

Physiological indices of emotion & physiological regulation

ER can be studied on multiple levels including: the observable behaviors or facial expressions, the perceived experience or self-report of the emotional experience, and the internal physiological response to emotionally arousing stimuli. In studies of emotion using physiological measures, response has traditionally been operationalized in terms of physiological reactivity (e.g., change in HR; e.g., Hubbard et al., 2004). HR is influenced by both the sympathetic and parasympathetic branches of the autonomic nervous system (ANS) and is thought to adaptively increase during times of stress and emotional arousal. While increases in HR are adaptive and may prepare the organism to meet an environmental challenge (e.g., fight or flight), large elevations in HR may also interfere with adaptive coping (Levenson, Carstensen, & Gottman, 1994). How well a child regulates may affect how initially reactive they are to a stimulus.

In addition to physiological reactivity, it is now recognized that how an individual recovers from a stressor is also important in understanding the emotional response process (e.g., Fredrickson & Levenson, 1998; Gottman & Katz, 2002; Rothbart, 1994). In studies with adults, cardiovascular recovery has often been measured in a time-dependent manner as the amount of time it takes to return to baseline or a ratio of reactivity to baseline (e.g., Kibler & Lyons, 2004). Since the heart is not a regulatory system, measuring average HR over time does not assess the individual's ability to regulate physiological arousal. Moreover, HR is influenced by both the sympathetic and parasympathetic nervous systems, and only the parasympathetic nervous system can be considered truly regulatory (see discussion below). By examining HR, it is impossible to tease apart the parasympathetic from the sympathetic influences. However, examining HR in a time-dependent fashion does allow us to obtain measures of the emotional response that include both a reactivity and recovery component to a specific stressor. While proponents of the position that ER is a two-step process may not view the reactivity component of the HR response as an index of ER, the conceptualization of physiological recovery as an index of ER is consistent with

Thompson's (1994) definition of ER as involving the modulation of the intensity of an emotional response.

A more pure index of physiological ER in children is vagal tone (e.g., Calkins & Dedmon, 2000). Vagal tone, or respiratory sinus arrythmia (RSA), measures parasympathetic influences on the heart that occur via the vagus nerve. Since the vagus nerve acts as a brake on the heart by slowing down heart rate, parasympathetic activation functions to restore calm in the body (e.g., self-soothing; Porges, 1995). In terms of real-world functioning, vagal tone facilitates the child's ability to respond in a flexible and adaptive manner to his or her environment. Both basal vegal tone and vagal response to a stressor are thought to index ER. High basal vagal tone has generally been associated with adaptive functioning, including better emotion regulation abilities (Porges 1995; 1996). In infancy basal vagal tone has been linked with engagement with the environment and emotionally expressive behavior, while later in development it is predictive of positive outcomes including social competence (Beauchaine, 2001).

The ability to suppress vagal tone during a time of challenge has been related to greater regulation (Porges, 1995; 1996). For example, Calkins et al. (2002) found easily frustrated infants at six months were less able to regulate physiological arousal than controls, as indexed by their lower vagal suppression during an attention task. Similarly, toddlers at high risk for externalizing problems showed no difference in resting vagal tone, but exhibited lower vagal suppression across a range of challenging situations, including a frustration and fear paradigm (Calkins & Dedmon, 2000). Finally, children who showed higher vagal suppression during a parent-child interaction at age 4-5 were rated by their parents as being better able to regulate emotional experiences at age 8 (Gottman & Katz, 2002).

During resting conditions HR and vagal tone are inversely related with the tonic firing of the vagus nerve slowing down physiologically processes (e.g. HR). Under extreme physical challenge, both sympathetic and parasympathetic processes influence HR change, but act at different levels of HR. At lower HR, elevations in HR are largely due to vagal withdrawal whereas at higher HR levels, elevations in HR are largely due to greater sympathetic activity (Rowell, 1993). However little research has examined the association between vagal regulation and HR response under emotionally stressful or interpersonal conditions. In one study that attempted to address this issue, children with greater suppression of vagal tone were able to maintain a lower HR during a stressful parent-child interaction (Gottman & Katz, 2002). These results suggest that under emotionally arousing situations vagal tone and HR may not be associated in a simple linear fashion.

Relations between behavioral and physiological indices of emotion

Among the few studies that have examined the relationship between different levels of children's ER (i.e., self-report, behavioral, and physiological), the majority have focused on the concordance between behavioral and physiological indices. Problems with both behavioral undercontrol (e.g., aggression) and overcontrol (e.g., behavioral inhibition) of emotional arousal have been linked to physiological response. Some studies have investigated group differences in physiological functioning in children high and low on a behavioral dimension thought to index difficulties regulating emotions or emotional arousal (e.g., aggression). Group differences in physiological response have been found at baseline and in reaction to a stressor. Children high in aggression consistently exhibit lower baseline heart rate (HR) and greater HR reactivity (e.g., Pitts, 1997; Williams, Lochman, Philips & Barry, 2003), and greater externalizing problems in boys have been associated with lower baseline vagal tone (Eisenberg, Fabes, Murphy, Maszk, &

Karbon, 1995). On the other hand, inhibited children have been found to have higher baseline HR (Kagan, Reznick, Snidman, 1988).

Other studies have related ongoing emotional behavior within a challenging situation to the child's physiological response. Hubbard et al. (2004) found that greater displays of angry facial and nonverbal behaviors in a provoking peer interaction were related to higher skin conductance, but were not related to HR reactivity. Furthermore, in a competitive situation pre-schoolers high in emotion expressivity showed higher baseline vagal tone, lower baseline HR, and larger HR and skin conductance reactivity (Cole et al., 1996). Interestingly, Cole and colleagues (1996) found inexpressive children exhibited the opposite pattern of response, showing lower baseline vagal tone, higher baseline HR and lower physiological reactivity.

Thus, research on the relation between behavioral ER and physiological response provides support for ER as a uniform skill. In general, children who are behaviorally more dysregulated with problems controlling their emotions have been found to exhibit lower HR and vagal tone during baseline conditions, greater physiological reactivity (e.g., higher HR and skin conductance reactivity), and poorer physiological regulation (e.g., less suppression in vagal tone) in response to challenging or arousing situations. On the other hand children who have difficulty expressing their emotions, or an overcontrol of their emotional arousal, have been found to exhibit higher HR and lower basal vagal tone, and lower levels of physiological reactivity.

Self-report and physiological indices of emotion

Little work has investigated the relation between children's self-reported experience of emotions and physiological responding. Preschoolers exposed to inter-adult conflict showed no relation between self-report of emotion or emotional intensity and HR or skin conductance response (El-Sheikh, 1994). Eisenberg et al. (1988) reported children's self-report of fear during an anxiety film and sadness during a sympathy film was associated with reduced HR, but found no relation between self-report and HR during a sad film. Finally, children's report of anger within a peer interaction was unexpectedly associated with lower HR reactivity but was not related to skin conductance reactivity (Hubbard et al., 2004).

Thus, when self-report of ER or emotion and physiological responding have been examined, there is mixed support for ER as a uniform skill. Furthermore, observed relations have not always been in the predicted direction (e.g., Hubbard et al, 2004). Differences between studies may be due in part to the degree of sensitivity used to assess the physiological response. Because HR in response to a stressor can be a fleeting response, adequate measures of changes in HR and their relation to self-reported emotional experiences may require measures that time-lock physiological responding to specific behavioral events. In addition, there have been no attempts to separate out context-independent from context-dependent ER processes.

Current study

The current study examines the concordance between children's self-reported ER and physiological response in the context of a stressful peer provocation. Provocation from peers is an interpersonal stressor that is frequently experienced by children during middle childhood (Fine, 1981; Gottman & Parker, 1986; Thorne, 1986). It can cause a range of emotional reactions however the optimal social response to provocation in middle childhood is to appear unfazed or unaffected by the provocative remarks (Gottman & Parker, 1986). Given the emotionally arousing nature of peer provocation, it allows us to assess their regulation abilities in a developmentally appropriate and challenging context.

Although under highly controlled conditions there is concordance between self-report, behavioral and physiological responses to discrete emotions, in more naturalistic or interpersonal settings, mixed results continue to be reported in both children (e.g., Eisenberg et al., 1988; Hubbard et al., 2004) and adults (e.g., Cacioppo, Berntson, Larsen, Poehlmann, & Ito, 2000). This may in part be because emotions experienced in daily life are often not pure emotions but rather mixed emotional states (e.g., Campos, Frankel, & Camras, 2004). Because the present study examined ER in a naturalistic context, we conceptualize ER as involving the regulation of any emotional experience, both discrete and mixed.

Existing work on the relation between self-report of ER and physiological functioning is extended in a number of ways. First, since emotions can be regulated at different points in time (Campos et al., 2004), we assessed physiological functioning at two points in the ER process by measuring both cardiovascular reactivity and recovery. Children's cardiovascular response was time-locked to provoking comments so that children's initial physiological reaction to each comment could be obtained as well as their recovery from that comment. This was done in an effort to better understand the mixed results that have previously been found between self-report of emotional experiences and physiological response. Vagal regulation over the entire course of the peer provocation was also assessed to serve as a general measure of physiological ER and to provide a first test of relations between self-report and physiological measures of ER.

Second, both global and specific measures of children's reported ER abilities are assessed to understand how potential differences in these two measurement approaches may affect relations between self-report and physiological aspects of ER. Children's reports of ER abilities were measured in a context-independent fashion during a semi-structured interview that asked children how they experience and handle emotion in their daily lives across specific contexts, and at a context-specific level with time-locked ratings of how upset children were during a peer provocation paradigm.

Given previous research, we predict that ER will function as a uniform skill in that there will be relations across self-report of ER and physiological response. Because emotionally dysregulated children that experience problems controlling their emotions are often described as being "out of control", "volatile" and "unable to be soothed", we predicted that children higher in self-reported emotion dysregulation would show: (1) higher physiological reactivity as evidenced by a higher rate of HR reactivity, and (2) poorer physiological recovery, seen by a slower rate of HR recovery in reaction to provoking peer comments. It was also anticipated that children who reported themselves as more dysregulated would show poorer vagal regulation, indicating less physiological regulation over the course of the peer provocation.

We also tested whether children's ER will function as a uniform skill across contexts. If ER is a uniform skill, we would expect children's ER ability in a specific situation to be representative and relate to ER across other situations. We first hypothesized that the two self-report measures of ER would be associated given the previous finding that self-report of emotion was related over several contexts (Oishi, Diener, Napa Scollon, & Biswas-Diener, 2004), and that the two physiological measures of HR and vagal regulation would be related due to stability in physiological responding (e.g. baseline measures are related to reactivity). Second, a more stringent test was conducted across both contexts and measurement approaches. If ER is a uniform skill in children we would expect general self-report of ER to relate to physiological functioning within a specific context, and likewise, a general measure of physiological functioning would relate to a context-specific measure of self-reported ER abilities.

Methods

Participants

Children were originally recruited at pre-school age to participate in a longitudinal study investigating children's behavior problems and family communication. A group of target children were selected for their presence of conduct problems while normally developing children served as controls. Families were recruited through local newspapers, pre-schools, and pediatric offices. 130 families participated in the original study. Four years later families were contacted to participate in follow-up procedures. Of the original families, 12 (9%) were not eligible to participate due to the age of the children, and 85 (72%) of the remaining eligible families participated in follow-up procedures. Within this sample, data was not available for some of the children due technical difficulties or children electing not to participate in one or more relevant procedures. The final dataset included 72 children, 46 males and 26 females.

Children were an average age of 9.06 years (range = 8-10 years, SD = .37). Ethnicity of the sample was 84.7% Caucasian, 4.2% bi-racial or multi-racial, and 4.2% African-American. 6.9% of the sample did not report their ethnicity. The sample represented a diverse group ranging from normal to clinically significant behavior problems. Twenty-two percent of the sample scored at sub-clinical or clinical levels (e.g., greater than 65) on the Child Behavior Checklist total problems subscale (M=50.54, SD=11.84, range=26-80; CBCL, Achenbach & Edelbrock, 1983). In addition, 30% of the children met diagnostic criteria for one or more disruptive behavior disorders (i.e. Attention Deficit Hyperactivity Disorder, Oppositional Defiant Disorder, or Conduct Disorder) on the maternal report of the Diagnostic Interview Schedule for Children (DISC; Fisher, Wicks, Shaffer, Piacentini, & Lapin, 1993).

Procedures

Families came into the laboratory on two occasions and children completed a challenging peer interaction and a semi-structured interview about emotions. Parents completed questionnaires prior to their first session.

Self-report of global emotion regulation abilities. As part of the family's first visit, children were interviewed by a trained research assistant using the Child and Adolescent Meta-Emotion Interview (CMEI; Katz & Windecker-Nelson, 2002). The CMEI is a semi-structured interview consisting of 16 open-ended questions that ask children about their experiences, thoughts, and feelings around the emotions of sadness and anger. The same questions were repeated for each emotion. Examples of questions included: "What does it look like when you are angry?" and "Can you give me a recent example of a time when you were sad?" The unique format of a semi-structured interview allows children to express their emotional experiences while also obtaining an independent behavioral sample of how children talk about their emotions. This added layer of having an independent observer characterize children's emotion skills may be particularly important for accurately assessing emotional development in children who have difficulty reflecting on their emotional experiences or who provide inflated reports of their abilities on questionnaire measures. All interviews were tape-recorded for later coding.

Baseline Physiology. During the second session physiological equipment was placed on the child. After making a light abrasion with Omni-prep solution to ensure a clear signal, five miniature Beckman silver-silver chloride electrodes were placed on the children's chest to measure their cardiac inter-beat interval (IBI). Beckman electrolyte was used to facilitate conductivity of electrical signals. Children were then seated while they listened to a neutral story about an elephant for two minutes to collect baseline physiological data. Electrocardiogram

(EKG) data were collected using Coulbourn bioamplifiers. The EKG waveform was digitized at 128 Hz using a MetraByte A-D converter in conjunction with ASYST software that averaged IBI into one-second intervals.

Peer Provocation. After obtaining parental consent, children were then told that they would be playing a computer game against another child who was a participant in the study, while in actuality the other child was a trained same aged same gender confederate actor (Underwood, Hurley, Johanson & Mosley, 1999). Children were given five minutes to practice playing a computer game developed by Underwood and colleagues. After the practice session, the experimenter explained they would be playing the game again for ten minutes, but this time it would be a contest. Children were told there had been a coin toss and that the participant child had been selected to choose the prize for the winner of the contest. In doing so the participant child's motivation to win the contest was increased by ensuring they found the prize desirable.

Children sat side by side on the floor and guided a brightly colored line around the screen using four keys on a keyboard. The 'contest' was set up to be a provoking situation in two ways. First, during the contest the game was rigged such that the effect of the participant child's keystrokes was delayed, causing them to lose approximately 75 percent of the time. Second, the child actor was trained to make one of a standard set of bragging and teasing comments after each round of play. Teasing was game focused and included such comments as: "Why do you keep losing? Don't you want to win that prize?" Four actor children (2 males and 2 females) were recruited from a local children's theatre and trained by a children's acting coach in the delivery of provoking comments.

Protocol for the peer provocation was IRB approved and several procedures were put in place to ensure children's safety and well being, including parental consent, safety measures during the paradigm, and an extensive debriefing process with the child. Parents were told that we were interested in understanding how children react to stressful peer situations and to do so their child would engage in a competitive videogame with another child. They were also informed that we would be temporarily misleading their child since the game was set up so that their child would frequently lose and the other child was a trained actor who would make teasing remarks. During the peer provocation paradigm children were told they could end the game at any time by waving at the camera for an experimenter to come in and terminate the game. Children's reactions were also monitored by the experimenter on a screen in an adjacent room, and play was stopped if the children exhibited strong negative reactions. Five children elected to end the game by waving their hand.

The participant child underwent a thorough debriefing process. Children were told that the game had been set up so that they would lose and that the other child was asked to make teasing comments. The experimenter emphasized it was not their fault that they lost the game or that the other child teased them. Children were also told that they were contributing to research that could eventually help other children who have a difficult time with teasing. At the end of the debriefing, the participant child was given the prize that he or she had selected and given the opportunity to play the video game again with the actor child, either with no delay or with the delay set against the actor. Finally, parents were contacted two days after the laboratory session and asked how the child was feeling about the session.

Rating dial. At the end of the game and before the debriefing, the participant child was instructed to adjust a rating dial of how they felt during the peer provocation paradigm while they watched a video of themselves playing the game with the confederate child (Levenson & Gottman, 1983). The rating dial was a square box with a dial in the center and a pointer that could be adjusted 180 degrees. Children were asked to report whether they felt "very good" or "very bad" to obtain a measure of their affect valence ranging from a "positive" to "negative" emotional response (as opposed to reporting on a discrete emotion). The rating dial had a frowning face placed over the lowest rating of "0" to convey a pictorial representation of general negative affect, a neutral face over the middle rating of "5", and happy face over the highest rating of "9". Children adjusted the dial to represent how they felt on a second by second basis continuously while they watched the full ten minutes of video game play. Physiology was assessed throughout the peer provocation and rating dial procedures.

Measures

ER was assessed by both global and specific measures of children's self-report and physiological response. Parents also reported on the child's health history to assess factors related to variability in cardiovascular functioning (e.g., height, weight).

Parent questionnaire. Mother's report on four items of a health scale from the Rand Corporation Health Insurance study were used to index biological factors related to child cardiovascular functioning. These included the child's height, weight, symptoms of asthma, and history of heart problems (Hahn & Clark, 1967; Scarpa, Raine, Venables, & Mednick, 1997).

Child & Adolescent Meta-Emotion Interview (CMEI). Children's meta-emotion interviews were tape-recorded and coded using a specific checklist rating system called the Child-Adolescent Meta-Emotion Coding System (CAME; Windecker-Nelson & Katz, 2004). The dysregulation subscale of the CMEI was used to assess children's global self-report of their ER abilities. This subscale showed adequate internal consistency (Cronbach's alpha = .70) and inter-rater reliability (r=.70; Katz, Windecker-Nelson, & Hessler, 2005), and relates to measures of children's behavioral adjustment (e.g., externalizing problems on the YSR), problematic peer relations (e.g., greater use of negative strategies to repair conflictual play with a friend), and measures of vagal regulation in a parent-child context in predictable ways (Katz, Windecker-Nelson & Hessler, 2005). Because many definitions of ER highlight the importance of both the frequency and intensity of emotion, items in the CMEI dysregulation scale tapped these distinct but related aspects of ER. The CMEI scale included items to assess both the reactivity and recovery aspects of ER, with items regarding intensity and frequency tapping the reactivity aspect of ER, and items related to duration and problematic functioning related to the recovery aspect of ER. The following four items from the child dysregulation subscale were used: (1) child has difficulty regulating intensity, (2) child experiences this emotion frequently, (3) child has difficulty getting over emotion, and (4) child has had a problem or concern with this emotion. Children's responses were coded for each item on a Likert-type scale with 5 = "strongly agree" to 1 = "strongly disagree". A dysregulation scale score was derived by summing the items within an emotion. Dysregulation was calculated separately for each emotion (e.g., sadness, anger) and then summed across emotion to yield a total score. The scale was constructed so that the midpoint of the scale corresponded to a child who reported a moderate degree of dysregulation. When a child achieved any score higher than the lowest possible score, this indicated they reported some degree of regulatory problems. This could take the form of the child reporting that they experience the emotion intensely, frequently, take a long time to get over the emotion, or the emotion being problematic for them. The majority, 64 of the children (77%) of the children in the sample, reported some degree of dysregulated behavior.

Since children's dysregulation of sadness and anger were moderately correlated (Pearson $r = .45$; $p<.001$), the two subscales were combined to create one emotion dysregulation scale that assessed children's general ability to regulate their emotions[1] (Cronbach's alpha=.69). Inter-rater reliability across coders was computed on 100% of the data using correlation coefficients and reliability was good (Pearson r = .70).

Rating Dial. Children's rating dial report of how they felt during the peer provocation was used as a context-specific self-report measure of ER (Levenson & Gottman, 1983). The rating dial generated an electrical signal that was sent to an A-to-D converter, which digitized the signal and sent the information to a computer. Children's ratings were recorded on a second by second basis continuously throughout the peer provocation paradigm. The mean rating dial response for the ten seconds immediately following each provoking comment was calculated as a way to time-lock the self-report response to the provoking event and capture both the reactivity and recovery aspects of ER. An average response above five indicated a more positive response, while an average response below five indicated a more negative affective response.

Physiological Measures

Vagal Tone. Vagal tone was calculated by measuring the time between successive R-waves of the electrocardiogram (EKG). The amount of variance in the interbeat interval spectrum that was within the child's respiratory sinus frequency band was examined using spectral time-series analysis. The sum of the power densities in the IBI spectrum within the 0.33-0.42 Hz band over the total amount of power across all frequency bands was used as the measure of vagal tone (Behrman & Kliegman, 2002). This method of calculating vagal tone has been well validated in previous studies of child adjustment and has been found to relate to children's emotion regulation abilities, child adjustment, and family processes (Gottman & Katz, 1989; Katz & Gottman, 1997; Leary & Katz, 2005). It is also highly correlated with output from Porges' MXEDIT program (r=.96; Gottman, Katz & Hooven, 1997). The program SPEC from the Gottman-Williams computer program time-series package was used to conduct spectral analyses (Williams & Gottman, 1981).

Vagal tone was measured at baseline and during the peer provocation. Baseline vagal tone was calculated as the average vagal tone during the two-minute baseline period immediately prior to the children playing the video game. Vagal tone in the challenging situation was calculated as the mean vagal tone across the total ten minutes of play during the peer provocation paradigm. Vagal regulation was then calculated as the residualized change score in vagal tone from baseline to the peer provocation paradigm.

Heart Rate. HR was examined within a time window beginning with the five-seconds prior and up to 20 seconds following each provoking comment (see Figure 1). For greater ease in interpreting the results, inter-beat interval data were converted to measures of HR for each comment. Children's HR level was assessed at three points: baseline, peak, and recovery. Baseline HR was calculated as the mean HR over the five seconds immediately preceding each comment. HR peak was calculated as the highest HR that the child reached for any given second within 10 seconds of the comment. Level of HR recovery was calculated by first finding the lowest HR children reached within 10 seconds after reaching their HR peak, and then averaging the HR for the five seconds surrounding the low HR. HR was averaged across this five-second window in order to obtain a more stable assessment of HR recovery.

Insert Figure 1 about here

Two simple slope measures were calculated to examine HR reactivity and recovery. For HR reactivity, a simple slope was computed by calculating the change in HR from baseline to peak, divided by the time it took for children to reach their HR peak after the comment was made. Likewise, a HR recovery slope was calculated as the change in HR from peak to recovery, divided by the time from HR peak to HR low point. Given the direction of the calculations, a higher or more positive slope for reactivity reflected a greater rate of change, whereas a more negative slope for recovery reflected a greater rate of change.

Data Reduction

The actor child made a provoking comment after each game round in the ten-minute paradigm. Because the peer provocation was a naturalistic paradigm, dyads differed in how quickly they completed game rounds. As a result, both the number of comments children received (M=12.03, SD=4.59) and the time interval between comments differed for each child. Sometimes game rounds were very short causing two provoking comments to occur proximal to one another. To ensure children's responses to comments were not influenced by other comments occurring proximal in time, a screening protocol was designed to make certain a provoking comment did not occur before the previous comment's window of reactivity and recovery was complete. Criteria for a comment to be included in analyses was that no other comment occurred within five seconds previous to the comment to ensure a valid base or within 10 seconds after the child reached their peak HR to allow for a window of recovery time that was not influenced by other comments. If comments occurred too close together in time to allow for uncontaminated measures, comments were not included in further analyses. Using this screening process, we found 30.2% of the comments conflicted with one another. While the omitted comments decreased the total number of comments included for each child, the screening criteria ensured HR results were not influenced by the presence of other comments. The HR and rating dial variables used for analyses were averaged across the remaining 69.8% of comments.

Results

Descriptive Statistics

Descriptive analyses were performed and are presented in Table 1. Variables with high skewness or kurtosis were transformed. The CMEI dysregulation measure was moderately skewed and transformed with a log function (transformed M=1.26, sd=.053, range=1.20-1.43).

Insert Table 1 & 2 about here

Due to the nature of the naturalistic peer provocation paradigm where some children finished individual games faster than others, children varied in the number of total comments they received. A MANOVA was performed to assess whether children who received a low, moderate or high number of comments differed on any of the measures of ER. Results were not significant ($F(18, 118) = .698$, $p=.808$).

Variables that have previously been related to HR and vagal tone were next examined for their possible association with children's ER and are presented in Table 2. Four variables were examined: children's history of heart problems, asthma, body mass (calculated by multiplying the child's reported height by their weight), and gender. No children in the sample were reported to have a history of heart problems. Children's asthma and body mass were not related to any of the self-report or physiological measures of ER and thus were not included in further analyses. Gender was related to the self-report and HR level measures, with boys having a lower HR and higher self-report of emotion dysregulation. As there were no a priori hypotheses regarding gender it was considered a covariate in further analyses.

Overview of analyses

Correlations were first conducted to test relations between self-report and physiological measures of ER. A series of hierarchical multiple regressions were conducted to understand the individual contribution of each self-report measure in predicting physiology after controlling for covariates. Statistical models were constructed to predict from self-report to the more concealed internal physiological response because we were interested in examining individual physiological processes (e.g., heart rate reactivity and recovery) as separate outcomes and to achieve parsimony in the number of analyses performed. In light of the analyses above, the gender of the child was entered as a covariate at step 1 for each analysis. Because of the concern that changes in HR may be a function of children's HR prior to change (e.g., Law of Initial Values; e.g., Benjamin, 1963), appropriate steps were taken to control for HR level (e.g., intercept). In tests of HR slope variables, baseline HR was entered at step 2 to control for HR level in tests of HR reactivity slope and HR high point was entered at step 2 to control for HR level in tests of HR recovery slope. Because we had no a priori hypotheses as to whether the global CMEI dysregulation measure or the more specific rating dial measure of emotion dysregulation would better predict physiological response, both measures were entered simultaneously in the final step of each analysis.

Relations within Self-Report of Emotion Regulation and Heart Rate Measures

Correlations within the self-report and HR measures are presented in Table 3. The two self-report measures were not related to one another. The HR slope measures were negatively related to one another indicating a steeper slope of HR reactivity was related to a steeper slope of HR recovery. HR level measures were highly related to one another.

Insert Table 3 about here

Relations between Self-Report of Emotion Regulation and Heart Rate Reactivity and Recovery

Correlations (see Table 3) indicated HR reactivity slope was significantly related to the rating dial measure and marginally related to the CMEI measure, with greater positive affect on the rating dial and dysregulation on the CMEI being associated with a steeper slope of reactivity. However, HR recovery was not related to either of the self-report measures of ER.

Regressions were conducted to investigate the relationship between self-report indices of ER and the two HR slope variables (i.e., reactivity and recovery; see Table 4). For the reactivity slope, the full regression model was significant ($F(4, 66)=4.15$, $p = .005$). After controlling for gender, at step 2 the model for baseline HR was marginally significant ($F(2, 68) = 2.449$, $p = .09$), however the individual coefficient for baseline HR was significant ($t= -2.12$, $p < .05$) with lower baseline HR being associated with a steeper slope of HR reactivity. At step 3 the model was significant ($F(4, 66)=4.15$, $p = .005$) with both the CMEI dysregulation measure ($t = 1.98$, $p = .05$) and the rating dial measure ($t = 2.92$, $p < .01$) being independently related to HR reactivity. Children who reported greater dysregulation on the CMEI or had a higher mean rating dial score experienced a steeper slope, or greater rate of increase in HR reactivity following the provoking comments. Analyses of rate of change in HR recovery indicated that the self-report measures did not significantly predict HR recovery ($F(4, 66)=.63$, p=n.s.).

Insert Table 4 & 5 about here

Relations between Self-report of Emotion Regulation and Vagal Regulation

The relationship between children's self-report of emotion dysregulation and the global physiological variable, vagal regulation, was next examined. Once again, correlations were first performed to look at the relationship between each self-report measure and physiological response. This was followed by a hierarchical regression to investigate the contribution of gender and each self-report measure of ER in predicting vagal regulation.

Vagal regulation was correlated with the CMEI dysregulation measure (Pearson $r=.27$, $p<.05$) but not the rating dial (Pearson $r=.05$, $p=n.s.$). Greater self-reported dysregulation was associated with poorer vagal regulation, or less suppression of vagal tone, from baseline to the peer provocation paradigm. The overall regression model for vagal regulation was not significant (see Table 5; $F(4, 65) = 1.56$, $p = n.s.$). At step 1, gender failed to predict vagal regulation ($F(1, 69) = .36$, $p = n.s.$). At step 2, the model for the self report measures was not significant ($F(3, 66) = 1.83$, $p =.15$), however the individual coefficient for the CMEI dysregulation measure was significant ($t = 2.08$, $p < .05$) with higher dysregulation being associated with less suppression of vagal tone from baseline to peer provocation.

Are Relations between Self-report of ER and Heart Rate Reactivity Vagally Mediated?

Additional analyses were conducted to investigate whether the relation between self-report of ER and HR reactivity is due to vagal withdrawal, or a reduced parasympathetic influence on the heart (Table 6). If the relation between self-report and HR reactivity is vagally mediated, children's level of vagal regulation will explain variance in HR reactivity, while self-report will fail to predict additional variance in HR reactivity. The overall regression model was significant ($F(5, 64)=4.05$, $p<.005$). After controlling for children's gender, the model for vagal regulation was marginally significant at step 2 ($F(2, 67)=2.69$, $p=.09$). The individual coefficient for vagal regulation predicted a significant portion of the variance in HR reactivity, with less vagal suppression being associated with greater HR reactivity ($t = 2.217$, $p< .05$). At step 3, the model for baseline HR was also marginally significant ($F(3, 66)=2.17$, $p=.09$) however baseline HR did not predict an additional portion of variance in HR reactivity ($t = -1.06$, $p=n.s.$). Finally, at step 4 the model was significant ($F(5, 64)=4.05$, $p<.005$) with the CMEI predicting a marginal amount of variance ($t=1.69$, $p=.09$) and the rating dial significantly predicting variance in HR reactivity not explained by vagal regulation ($t=3.29$, $p<.005$). This suggests the relation between self-report of ER and HR reactivity is in part vagally mediated, with parasympathetic influences on the heart explaining some of the variability in HR reactivity. However the partial mediation also suggests that self-report of ER is related to sympathetic activation of the heart, above and beyond that predicted by parasympathetic influences.

Insert Table 6 about here

Discussion

In this paper we examined the idea that ER is a uniform skill in two ways: across levels of measurement (i.e., self-report and physiological response) and levels of context (i.e., general and context-specific. When we looked across self-report and physiological measures of ER, the results generally support the idea that ER is a uniform skill. As predicted, children with greater self-reported dysregulation on the CMEI had a greater rate of HR reactivity in response to provoking peer comments, coinciding with our image of dysregulated children who are undercontrolled in their emotional arousal as being emotionally volatile or unable to control their emotional responses. This finding supports earlier research that has found behaviorally expressive (Cole et al., 1996) and aggressive children (Pitts, 1997; Williams et al., 2003) to exhibit increased HR reactivity, and extends the current literature by demonstrating this relationship with children's self-report of their ER abilities.

A relationship between the rating dial self-report and HR reactivity was also found, but not in the predicted direction. Children who reported feeling more positive had a steeper rate of

HR reactivity. When using a similar context-specific self-report measure of anger, Hubbard et al. (2002) found a comparable relationship. Lower levels of reported anger were associated with greater changes in HR in a cheating peer interaction. As Hubbard et al. (2004) suggests, children in middle childhood may not yet be able to fully report on their internal emotional states, or were reporting on the behavior they see themselves displaying in the videotape rather than what they were feeling internally during game play. Another explanation for differences in the direction of the relation between the two self-report measures and HR reactivity is that the rating dial measure is subject to cognitive reappraisal. It could be that some children with emotion dysregulation difficulties underreport their negative emotions on the rating dial so as not to appear upset by the experience or show a "tough guy" attitude. Cognitive reappraisal may play less of a role in the CMEI because the CMEI obtains both a behavioral sample coded by independent raters as well as the child's self-report of their internal experience, while the rating dial involves only children's report of how they feel.

Neither the CMEI nor the rating dial self-report measures of emotion dysregulation were related to children's HR recovery, suggesting that children with greater dysregulation may physiologically recover at a similar rate as well-regulated children. However, it could also be the case that children's self-report of their emotional experience is not related to HR recovery or that the self-report measures used in the current study were geared more towards assessing children's emotional reactivity than recovery. Very few studies in the ER literature have attempted to parse out children's physiological recovery after reaching an aroused state from reactivity (for an exception, see Gottman & Katz, 2002) and further research with a variety of measures is needed.

The hypothesis that children with greater emotion dysregulation would show less physiological regulation over the course of the peer provocation session was supported. Vagal regulation was related to the CMEI self-report measure of dysregulation, but not the rating dial, at the correlational level. In line with previous findings (e.g., Gottman & Katz, 2002), poorer vagal regulation (or less vagal suppression) in a challenging context was associated with greater emotional dysregulation. Although the overall regression model was not significant this appeared to be due to children's gender and the rating dial measure being unrelated to vagal regulation.

Additional analyses revealed that vagal regulation was related to HR reactivity, with children who exhibited less vagal suppression over the course of the session showing greater HR reactivity in a time-locked measure. The relation between children's self-report of ER and HR reactivity did not appear to be fully vagally mediated. After accounting for vagal influences, the self-report measures predicted additional variance in HR reactivity (with a marginal effect for CMEI). Given that HR is influenced by both the PNS and SNS, this pattern of results suggests that children's self-report of ER is related to sympathetic influences on the heart, independent of parasympathetic influences. Thus, children with difficulty regulating emotions may experience problematic physiological responses in both branches of the autonomic nervous system.

When we looked at ER across levels of context, mixed support was found for the idea that ER is a uniform skill. A measure of both general and context-specific emotion dysregulation was obtained for children's self-report and physiological response. Contextual differences were examined *within* a given level of measurement (e.g. general self-report and context-specific self-report) and *across* levels of measurement (e.g. general self-report and context-specific physiological response). Looking within a level of measurement, physiological indices of ER were related to each other, with the more general vagal regulation measure being associated with a greater rate of both HR reactivity and recovery. However, no relation was found between the general and context-specific self-report measures. It could be that children's self-report of ER varies across contexts. However the lack of a relationship may also be attributed to differences across the two self-report measures, such as the level of cognitive reappraisal children may use to influence their report.

Mixed results were also found when the role of context was examined across self-report and physiological levels of measurement. The CMEI general self-report measure was related to the HR reactivity context-specific measure. In other words, children's report of their daily emotional experiences was related to greater HR reactivity in response to a specific stressor. In contrast, the more general physiological measure of vagal regulation was not related to the context-specific rating dial self-report measure. This suggests that how children reported they felt in response to each provoking comment was not related to their physiological regulation over the course of the entire session.

Differences obtained using general versus context-specific measures of ER were found not only in whether a relation between self-report and physiological response was observed (e.g., vagal regulation was related to CMEI but not rating dial), but also in the direction of the relationship (e.g., greater HR reactivity was related to higher dysregulation on the CMEI but greater positive affect on the CMEI). Findings illustrate the importance of utilizing multiple measures of children's ER at the self-report and physiological level. The results also suggest that the relation between self-report and physiological levels of ER may be influenced by characteristics of the measures used, such as the level of context specificity, or the format of the measure (i.e., children's direct report versus a semi-structured interview format). Use of different levels of context specificity in the measurement of ER may in part explain discrepancies in findings across studies or guide measurement choice in future work. Further work is needed to assess ER as a uniform skill by directly comparing a variety of measures across different levels of context specificity and across different specific contexts. Looking at the concordance between self-report and physiology is just one example of an approach that can start to address this question.

These results are not only statistically meaningful (i.e., self-report measures of ER accounted for 14% of the variance in HR reactivity and 7% in vagal regulation), but also have practical implications for understanding children who have difficulties regulating their emotions and how these children react in challenging interpersonal or peer contexts. Perhaps one source of dysregulated children's difficulties in negotiating peer interactions and the inevitable conflicts that can occur with peers is their heightened physiological reactivity and poor physiological self-soothing abilities seen both by their heightened HR reactivity and poor vagal tone regulation. In preschool-aged children, Katz (2004) found that children with lower vagal suppression in response to a provocative peer had more peer conflict and disconnected interaction in an unstructured play session with a best friend.

Relations between children's self-report and physiological response also speak to children's ability in middle childhood to be reliable reporters of their internal emotional experiences. While it is unclear whether children are reliable reporters on some measures that assess their direct report (i.e., rating dial), children were able to discuss their emotional experiences in the CMEI interview and their self-report of ER in the interview related to their physiological functioning in a predictable manner. It may be that children are more likely to provide inflated or defensive reports on measures that have a heavy memory or cognitive load. For example, the rating dial measure required children to think back on how they were previously feeling during the peer provocation and match their feelings to their behavior at each point in time. It may be that greater reliability can be achieved on measures such as the CMEI, which ask children to report on their emotional reactions but glean information not only from the content of what children say but also on how they say it. By examining both the content of what children say and using their report as a behavioral sample, we may better circumvent the cognitive or self-presentation issues that may otherwise arise in children's reports of their emotional states.

Finding should also be considered in the context of children's broader biological systems. When an individual interprets a situation as stressful, the central nervous system (CNS) innervates the ANS with increased sympathetic activity to the heart. The CNS also activates the endocrine system, which secretes hormones (e.g., cortisol) and supports physiological arousal. In fact, ER has been related to cortisol in children, with elevated cortisol levels being associated with lower effortful control, surgent temperament and greater displays of tense or angry affect in a competitive game (Donzella, Gunnar, Krueger, & Alwin, 2000). These results suggest children with ER difficulties may experience increased physiological reactivity or difficulty regulating arousal across multiple biological systems. At least one study has found a negative relationship between vagal tone and cortisol reactivity (Donzella et al., 2000), however future work should include several physiological measures thought to index ER to better understand the relation between physiological systems under challenging situations.

Results should be viewed in light of some limitations of the present study. First, the sample came from a study of both normally developing children and children with behavior problems, which afforded us the opportunity to include children along a full continuum of ER abilities. The majority of the children in the sample reported some degree of emotion dysregulation, however the current sample contained relatively fewer children with high levels of self-reported emotion dysregulation. Replication with a larger sample and other groups of dysregulated children is necessary to determine whether the findings are generalizable and not an artifact of the specific behavioral difficulties exhibited by children in the current sample. Future work should also examine associations between levels of ER in children who experience an overcontrol of their emotional arousal.

Second, physiological response was only assessed in one situation. While peer provocation is an interpersonal stressor that many children experience, children with greater emotion dysregulation, who have associated peer difficulties (Eisenberg et al., 1995; Rubin, Coplan, Fox, & Calkins, 1995), may have had more experience in these types of situations than other children. A difference in experience could affect the way children respond to the situation at the self-report and/or physiological level. For example, being more familiar with peer teasing could lead some children to report lower negative affect in the peer provocation situation since it is not as surprising or novel to them or alternatively, to show greater physiological reactivity because they have developed a sensitivity to the specific situation. Thus, it may be that children with greater dysregulation are more physiologically reactive across situations, or it could be that their physiological reactivity reflects greater experience with provocation from peers. Future work should extend research by assessing children's physiological response in other challenging situations. In addition, the measure of general physiological response could be extended to include information over several paradigms or situations to explore the role of context in ER.

It should also be acknowledged that while children's ER accounted for a significant amount of variability in their HR reactivity, there are a myriad of other factors that could account for the unexplained variability in HR within this challenging context. Possible factors include both children's response to the game situation (e.g., children's level of excitement while playing the game, how much they wanted to win the prize) and interpersonal characteristics (e.g., history of physical exercise or health, genetic differences). Finally, the current study did not include a measure of children's activity level while their physiological signals were recorded. While others have found children's activity level to affect their cardiac response (e.g., Hubbard et al., 2004), the current study involved a paradigm in which little movement occurred. During both the baseline and peer provocation paradigm children were seated and no children made gross body movements (e.g., standing up, walking, or crawling). Minor movements such as finger and wrist movements occurred as a natural result of video game play for all of the children. Although there is no standard rubric for assessing the degree of movement that is needed to affect cardiac activity, Katz (1991) found no relationship between children's activity level and HR in a similar video game paradigm.

The current study provides some support for ER in children to be viewed as a uniform skill. Several relations were found across self-report and physiological levels of ER. Children with higher reported dysregulation showed greater HR reactivity and less vagal suppression in a challenging peer context. Both children's experienced difficulties regulating their emotions and their pattern of physiological response may contribute to their problems handling emotionally challenging situations with peers. However relations between self-report and physiology were not found for some measures (i.e., HR recovery). Furthermore, relations were not consistently found across different levels of context. Differences across general versus context-specific levels of ER suggest the level of context in ER measurement is an important dimension to be considered in future work. Although further research is needed to better understand the nature of some of these relationships, the current study provides some insight into these links that can help us better understand both normal and abnormal emotional development.

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Footnotes

[1]Analyses were performed on anger and sadness as individual emotions with virtually identical results found.

Table 1

Descriptive Statistics for Self-report and Physiological Emotion Dysregulation Variables.

Variable	Mean	Standard Deviation	Range
CMEI Interview*	18.29	2.40	16-27
Rating dial	3.99	1.67	1.02-8.72
Baseline heart rate	99.50	12.38	76.81-147.50
Peak heart rate	107.96	11.56	84.19-148.41
Mean heart rate recovery	95.27	12.40	73.82-137.17
Heart rate reactivity slope	2.38	1.61	-0.77-7.15
Heart rate recovery slope	-3.07	1.46	-7.43- -1.16
Baseline vagal tone	34.67	13.02	7.23-64.34
Vagal tone in peer paradigm	28.45	8.24	8.53-50.72

*Raw untransformed CMEI Interview score

Table 2

Correlations between Possible Covariates and Emotion Dysregulation variables

Variable	Gender	Body mass	Asthma
CMEI Interview	-.24*	-.20	-.11
Rating dial	-.30**	.16	.09
Baseline heart rate	.42***	-.06	-.12
Peak heart rate	.42***	-.09	-.10
Mean heart rate recovery	.44***	.06	-.12
Heart rate reactivity slope	-.10	.12	.02
Heart rate recovery slope	.14	.11	-.20
Baseline vagal tone	-.08	-.14	-.13
Vagal tone in peer paradigm	-.09	-.00	-.11

+ p < .10, * p < .05, ** p < .01, *** p < .001

Table 3

Correlations among Self-report and Heart rate measures of Emotion Dysregulation

Variable	1	2	3	4	5	6	7	8
Self Report Variables								
1. CMEI Interview	—	-.02	-.27*	-.24*	-.27*	.23+	-.16	.26*
2. Rating dial		—	-.31**	-.24*	-.27*	.32**	.00	-.05
Physiological Measures								
3. Baseline HR			—	.95***	.97***	-.28*	.30**	-.52***
4. Peak HR				—	.94***	-.06	.14	-.43***
5. Mean HR recovery					—	-.26*	.38**	-.48***
6. HR reactivity slope						—	-.36**	.27*
7. HR recovery slope							—	-.39***
8. Vagal regulation								—

+ p < .10, * p < .05, ** p < .01, *** p < .001

Table 4

Hierarchical Regressions for Heart rate slope results

Step and procedures	R^2	ΔR^2	ΔF	Std. ß
HR Reactivity Slope				
1. Gender	.01			-.07
2. Baseline HR	.07	.06	4.51**	-.27*
3. CMEI dysregulation	.20	.14	5.52**	.23*
Rating dial				.35**
HR Recovery Slope				
1. Gender	.01			.11
2. HR High point	.02	.01	.41	.08
3. CMEI dysregulation	.04	.02	.63	-.13
Rating dial				.05

+ p < .10, * p < .05, ** p < .01, *** p < .001

Table 5

Hierarchical Regressions for Vagal Regulation

Step and procedures	R^2	ΔR^2	ΔF	Std. ß
Vagal Regulation				
1. Gender	.01			-.07
2. CMEI dysregulation	.08	.07	2.56^{+}	.26*
Rating dial				-.08

+ p < .10, * p < .05, ** p < .01, *** p < .001

Table 6

Hierarchical Regressions for Heart Rate Reactivity controlling for Vagal Regulation

Step and procedures	R^2	ΔR^2	ΔF	Std. ß
1. Gender	.01			-.08
2. Vagal Regulation	.07	.07	4.92**	.26*
3. Baseline HR	.09	.02	1.14	-.16
4. CMEI dysregulation	.24	.15	6.34**	.20+
Rating dial				.40**

$^{+}$ $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$

Figure Caption

Figure 1. Time-locked measures of heart rate in relation to provoking comments.

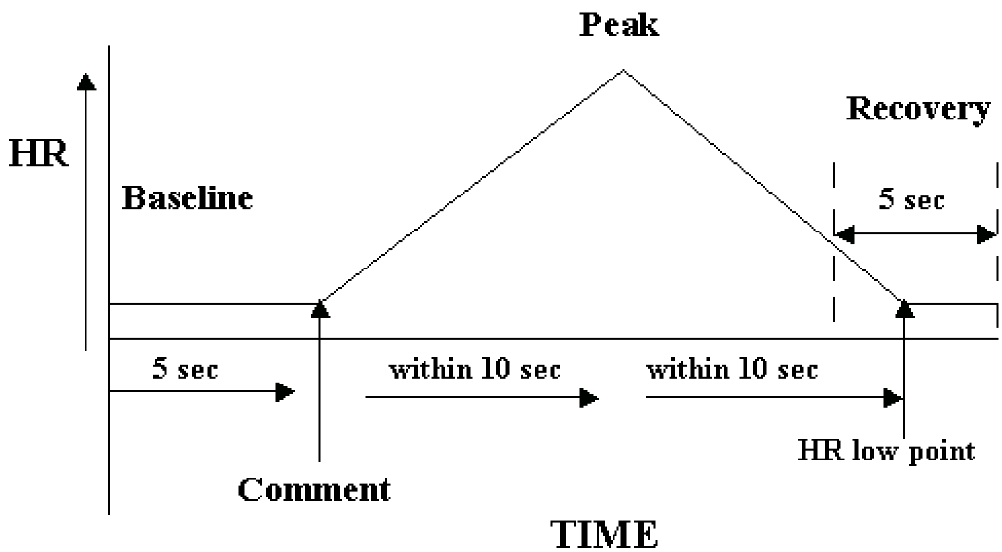
Peak
Recovery
HR
Baseline
5 sec
5 sec
within 10 sec
within 10 sec
HR low point
Comment
TIME

Figure 1