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# INDIVIDUAL DIFFERENCES IN TODDLER'S REGULATORY ABILITIES:

# EVIDENCE FOR LINKS AMONG SYSTEMS

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Abstract

In this study, we explored whether measures of emotion regulation, physiological regulation, and inhibitory control form a global indicator of individual regulation. This was tested using data from 80 toddlers during a laboratory visit at age 24 months. Principal components analyses were used to examine convergence of different facets of regulation. Emotion regulation was captured dynamically using linear and quadratic trends in distress and compared to traditional composite measures. Evidence for an individual capacity for regulation was not found using either measure. Theoretical and methodological implications for future examinations of regulation are discussed.

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# Individual Differences in Toddler's Regulatory Abilities: Evidence for Links between Systems

## *Introduction*

A frequently explored source of interpersonal variation is infant temperament, a constitutionally-based source of individual differences in reactivity and regulation (Rothbart, 1989). The more frequently studied component of temperament is reactivity, a multifaceted construct involving individual differences in positivity and negativity (Rothbart, 1986; 1988), physiological reactivity (Porges, 1996; Gunnar, 1994; Kagan, Reznick, & Snidman, 1989), patterns of neural activation (Davidson, 1994), physical activity level (Garcia-Coll, Kagan, & Reznick, 1984), and sociability (Rubin, Burgess, & Hastings, 2002). Regulation, on the other hand, has begun to receive much attention and appears to be as complex and multidimensional as reactivity.

From her perspective of temperament, Rothbart (1988; Rothbart & Posner, 1985) conceptualizes the emergence of regulation as a developmental task in that an expanding social context, neural structure, and physical growth give individuals increasing tools to monitor and control reactivity. Campos and colleagues (1989) depicted regulation as a process of maintaining one's relationship with the environment. Like other dimensions of temperament, regulation involves both aspects of developmental change and individual differences. Several dimensions of regulation have been examined including, but not limited to, behavioral self-regulation, physiological regulation, and regulation of emotions; these are often examined independently. Each has been implicated in the development of affective and behavioral adjustment (Caspi, Henry, McGee, Moffitt & Silva, 1995; Eisenberg et al., 2001; Biederman, et al., 1993). Similar relationships between adjustment and these indicators suggest that all three aspects work together as a broad individual capacity for regulation. A similar multisystemic framework has emerged for other aspects of behavior, such as with the “hot” and “cool” systems of executive function (Metcalfe & Mischel, 1999; Hongwanishkul, Happaney, Lee, & Zelazo, 2005).

A better understanding of the relationship among the components of regulation would advance knowledge about the construct, the relationship of regulation to temperamental reactivity, and the study of individual differences in socioemotional development. This study is designed to characterize regulation by examining it as multifaceted and to examine the convergent validity among different aspects of regulation as parts of an overarching regulatory capacity. We explored the possibility that differences in one or more of these facets lead to distinct individual patterns of regulation or dysregulation under stressful conditions. Because regulation is proposed to include different components, the current study focused on three of these potential aspects of regulation, including behavioral or self regulation (i.e., inhibitory control), physiological regulation, and emotion regulation. The literature in each of these areas will be reviewed.

*Inhibitory Control*

Facets of regulation involve the control of behavioral responses via attention, motor activity, error detection, and planning along with the ability to suppress or employ behavioral responses (Rothbart & Bates, 1998).  Effortful control, a related construct of regulation based in temperament, is routinely defined as an individual’s ability to inhibit dominant response patterns in order to employ subdominant responses (Rothbart, 1989; Rothbart & Ahadi, 1994). Though indicative of regulatory processes and capacities, effortful control can be used for non-regulatory purposes and so does not represent regulation per se (Eisenberg, Hofer, & Vaughan, 2008). A particular exemplar of self-regulatory ability, inhibitory control, is part of a broader construct of effortful control. Definitional and conceptual boundaries distinguishing effortful control and inhibitory control have long been indistinct; though both reference active systems of behavioral inhibition, effortful control contains elements of attention (e.g., Rothbart, Ahadi, Hershey, & Fisher, 2001) and conflict resolution (Posner & Rothbart, 2000) that measures of inhibitory control do not necessarily tap. Instead, measures of inhibitory control focus on behaviors of inhibition over those of deployment and stress the suppression of inappropriate approach responses (Kochanska, Murray, Jacques, Koenig, & Vandegeest, 1996). This behavioral definition is the one employed here.

As a system of active inhibition, inhibitory control stands in contrast to the “passive inhibition” characteristic of temperamental inhibition or infant fearful temperament (Rothbart & Bates, 1998; Kochanska & Aksan, 2006). The relationship between these two systems of inhibition shows stability through infancy and up to 24 months of age and strong ties to outcomes across development. Inhibitory control is linked with the development of internalizing (e.g., overregulation, overinhibition, etc.) and externalizing (e.g., underregulated, impulsive, etc.) behaviors (Valiente, et al., 2003; Rothbart & Posner, 2005). Nigg and Goldsmith (1994) suggest that variations in impulsivity (often related to a lack of inhibitory control), could precede adult outcomes such as Antisocial Personality Disorder or Histrionic Personality Disorder.

These findings suggest that the suppression of prepotent approach or withdrawal tendencies might serve as a precursor for the modulation of negative emotionality or the utilization of flexible coping strategies. The current study views inhibitory control in this manner and examines it along with other regulatory strategies in situations eliciting negative emotion (e.g., fear and frustration).

*Autonomic Regulation*

As with observable behaviors, physiology is an often-measured marker of self regulation. Kagan & Snidman (1991) suggest that individual variation in physiology indicates measureable biases for temperament characteristics such as shyness and impulsivity. Individuals are assumed to be inherently compelled to control physiological reactivity at optimal levels (Porges & Doussard-Roosevelt, 1997; Porges, Doussard-Roosevelt, Portales & Greenspan, 1996), which necessitates the exertion of control over highly arousing stimuli and ideally results in return to a baseline state or “typical” level of arousal. Physiological arousal can be measured in several ways, including heart rate and respiration. Several different physiological systems have been used to index regulation. These commonly include, but are not limited to, activation of the sympathetic and parasympathetic branches of the autonomic nervous system (ANS), endocrine responses such as that seen in the hypothalamic –pituitary-adrenocortical (HPA) axis, and patterns of coritcal activation.

Respiratory sinus arrhythmia (RSA) is a parasympathetic measure of the variation in time between heart cycles as controlled by the vagus nerve (also referred to as vagal tone) and has been used as an indicator of attentional, cognitive, and emotional processing (Fox, Schmidt, & Henderson, 2000). At baseline, RSA reflects an individual’s trait reactivity and arousal, with higher baseline RSA representing a balanced stated of arousal and response readiness (Calkins, 1997). An increase in baseline RSA indicates an inward orientation or a focus on the internal maintenance of equilibrium (Porges et al., 1996) whereas a decrease in baseline RSA signifies the deployment of resources to support behavioral and motor function in response to environmental threat or challenge. This decrease in RSA may or may not be accompanied by changes in sympathetic reactivity. This decrease, known as RSA suppression, reflects context-based reactivity and the use of complex regulatory responses to maintain internal homeostasis (Porges, 1991, 1996). RSA suppression is seen in children during emotional events or cognitive challenge (El-Sheikh, 2005), showing that this mechanism is present early in development, although there are mixed findings regarding stability of RSA suppression in infancy and childhood (El-Sheikh, 2005).

RSA is linked to reactivity and behavior. At the preschool and school ages, children with decreased levels of RSA in response to challenges (i.e., RSA suppression) show better regulation of emotions and fewer behavior problems (Calkins, 1994; Calkins, Smith, Gill, & Johnson, 1998; Porges et al., 1996), greater maintenance of attention (Suess, Porges, & Plude, 1994), and low numbers of aggressive behaviors during episodes of frustration. In contrast, children who display dysregulated behaviors show heightened physiological reactivity (Buss, Davidson, Kalin, & Goldsmith, 2004). Infants who cry during the presentation of fear or frustration-eliciting stimuli had higher baseline RSA than infants who did not cry to either event (Stifter & Fox, 1990; Calkins & Fox, 1992). Infants with high RSA are more reactive in early infancy, more sociable in later infancy, and express more positive and negative affect than infants with low baseline RSA (Fox, 1989; Stifter, Fox, & Porges, 1989).

One explanation for the link between physiology and behavior may be that temperamentally fearful children have lower activation thresholds for physiological response (Kagan, Reznick, & Gibbons, 1989; Gunnar, 1994). Highly inhibited children demonstrate higher and more stable heart rates than uninhibited children, and children with this pattern of physiology are more likely to remain inhibited over time than children with more variable heart rates (Kagan, Reznick, Clarke, Snidman, & Garcia-Coll, 1984; Kagan, Reznick, Snidman, Gibbons & Johnson, 1988). Highly variable heart rates, in contrast, are linked with infants' use of more self-regulatory behaviors and greater flexibility to the environment (Fox, et al., 2000).

In these ways, physiological indicators can serve as markers for periods of physical stress, affective distress, or individual arousal. They can further indicate attempts by the body to regulate arousal even before regulation can be observed behaviorally. In the current study, RSA suppression is used as an index of regulation and marker for individuals' attempts at self-regulation during periods of distress.

*Emotion Regulation*

A third construct related to the management of arousal is emotion regulation, which can be defined as changes in activated emotions (Cole, Martin, & Dennis, 2004). Frequently, the regulation of emotion is viewed as a process by which automatic response tendencies generate negative (or positive) emotion and activate cognitive tools (e.g., attention, behavior, etc.) that intensify, suppress, or maintain the emotion according to context (Derryberry & Rothbart, 1984; Berkowitz, 1990). These modifications are made for both positive and negative affective states and may result in a change in emotional intensity, the state of emotional experience, and/or changes in either initial or response behavior (Cole et al., 2004).

An infant's ability to regulate emotional distress is thought to emerge as behavioral strategies are learned through early parental interventions (Thompson, 1994; Calkins, 1994; Calkins, Dedmon, Gill, Lomax, & Johnson, 2002; Spinrad, Stifter, Donelan-McCall & Turner, 2004). Particularly for the first three to six months of life, the co-maintenance of homeostatic reactivity for a mother-child dyad leads to children's ability to self-regulate and serves as a precursor for positive adjustment (Pipp & Harmon, 1987; Moore & Calkins, 2004). During development, children move from the use of parent-driven to self-driven, simple to complex, and less effective to more effective behavioral strategies in regulating emotional distress. That is, younger children show less regulation of arousal, more distress, less complex behavioral coping, and more reliance on mothers than do older children (Gianino & Tronick, 1988; Calkins, 1994; Mangelsdorf, Shapiro, & Marzolf, 1995; Zimmerman & Stansbury, 2003). In addition to age, child temperament influences regulatory behaviors. Like younger children, shy children and children with higher levels of distress use less evolved behavioral strategies such as comfort-seeking, distraction, and gaze aversion (Mangelsdorf et al., 1995; Zimmerman & Stansbury, 2003).

Not all regulatory behaviors can be seen as equally appropriate or effective across contexts (Buss & Goldsmith, 1998, Calkins, Gill, Johnson, & Smith, 1999; Buss & Kiel, 2004). Context, as the scene for exchanges between individuals and their environment (Bronfenbrenner, 1979; Bronfenbrenner & Morris, 1998), can influence the expression and communication of emotion (Fox, 1991; Saarni, 2001). Behaviors that reduce distress may differ according to developmental level, the elicited emotion, and the novelty of the situation (Derryberry & Rothbart, 1984; 1988; Calkins et al., 1998; Stifter & Braungart, 1995; Buss & Goldsmith, 1998, Buss & Kiel, 2004). Zimmermann & Stansbury (2003) found that 3-year-olds used significantly more cognitive strategies during delay-of-gratification tasks, more comforting strategies during a stranger approach context, and more distraction during a busy-caregiver situation relative to the other contexts. Similarly, children's emotionality and regulatory ability at school, but not at home, stably predicted prosocial behavior (Eisenberg et al., 1995).

Finding such as these support the idea that individuals regulate differently as the people and environment around them change (Matsumoto, Yoo, Hirayama, & Petrova, 2005; Davidson, Jackson, & Kalin., 2000; Buss et al., 2004). Context thus becomes a standard by which to judge the degree of both regulation and dysregulation (Cole et al., 1994; Thompson, 1994; Keenan, 2000). Dysregulated emotion is marked by its maladaptive quality; it can be conceptualized as context-inappropriate emotional expression (often referring to distress), emotional inflexibility, and the failure to take advantage of available coping resources (Cole Michel, & Teti., 1994; Kalin & Shelton, 1989; Buss et al., 2004). Stated differently, dysregulated children showed long periods of distress and freezing despite the availability of other adaptive regulatory behaviors and coping mechanisms (e.g., distraction, escape, proximity to mother, etc.; Buss et al., 2004). These immediate problems with regulation predict long-term outcomes such as childhood behavior problems and psychopathology (Keenan, 2000; Beauchaine, Gatzke-Kopp & Mead, 2006).

In summary, research suggests that an ability to regulate in flexible and context-appropriate ways provides benefits such as decreased distress, minimized perceptions of threat, increased positivity, and reductions in long-term negative outcomes. This study explores this conceptualization of regulation via three regulatory pathways and their relationship with each other as part of a larger construct of regulation.

In summary, when one is able to use it flexibly and in a manner appropriate for the environment, the ability to self-regulate emotion serves to decrease distress, minimize perceived threat, increase positivity, and reduce the likelihood of long-term negative consequences. This study uses this conceptualization of emotion regulation and explores its relationship with other regulatory mechanisms and with the broader idea of one's ability to self-regulate.

### *Current Study*

The similar outcomes linked to different regulatory processes (i.e., inhibitory control, autonomic regulation, and emotion regulation) suggest a possible association among systems, although the underlying mechanism of association is unknown. Derryberry and Rothbart (1988) suggest that links among systems of biology, attention, and emotion could be impacted by higher order systems such as effortful control or by lower level systems such as RSA. It is likely that covariation between affective behaviors is affected by both the reactivity of lower-order mechanisms and the regulatory influence of higher-order systems. There are modest relationships among components of physiological and emotional regulation (Eisenberg et al., 1988; Stifter & Braungart, 1995; Calkins et al., 1998). However, studies to date have not empirically explored the idea that physiological regulation, inhibitory control, and emotion regulation are multiple aspects of the regulatory component of temperament. We hypothesize that the three are related and function together as components of a temperamentally-based individual regulatory capacity.

*Research Question 1: Are there relationships among inhibitory control, RSA suppression, and emotion regulation?*

In this investigation, we explored of the convergent validity among existing putative measures of regulation. This convergence was first assessed through bivariate correlations among autonomic regulation, emotion regulation, and inhibitory control.

*Research Question 2: Does a single latent construct underlie inhibitory control, RSA suppression, and emotion regulation as a principal component of regulation?*

An additional question of this study asked how the three individual patterns of regulation converge in anger and fear-eliciting contexts to regulate negative emotional responses. That is, to what degree do inhibitory control, autonomic regulation (i.e., RSA suppression), and emotion regulation behaviors contribute to reductions in fear and frustration? This idea was explored through a series of principal components analyses examining the use of regulatory strategies within fear and frustration-eliciting contexts. We anticipated that an individual capacity for regulation would emerge within context as a single principal component containing relatively equal contributions from all three regulatory processes. Furthermore, if this component contained regulatory processes across contexts, it would suggest stability in individual propensities to regulate and support the idea of this capacity as a temperamentally-based construct.

# *Method*

## *Participants*

Participants included 80 toddlers (39 female) at age 24-months (M = 24.53 months) recruited from birth records in local newspapers as a part of the larger Wisconsin Toddler Temperament Study (Buss, 2000). Participants were 98% white and came primarily from middle-class homes (Hollingshead Index Score = 48.66).

## *Procedure*

As part of the larger study for which they were recruited, participants were involved in a series of episodes from the *Preschool Laboratory Temperament Assessment Battery* (Lab-TAB) modified for children at age 24 months (Buss & Goldsmith, 2000). All episodes were completed over the course of two laboratory visits. Episodes in the first visit were designed to elicit primarily either fear or frustration or to measure inhibitory control. Episodes in the second visit were used to collect physiological data. Usable data were collected from 45 participants during the second visit. All participants experienced the same episode order with the exception of the two stranger approach episodes (*Stranger Highchair* and *Stranger Free Play*), which were counterbalanced. All episodes were videotaped. The child's mother was present during all of the episodes but was instructed to minimize interaction with her child.

*Fear Episodes.* Episodes designed to measure fear included two stranger approaches. During the first stranger approach (*Stranger Highchair*), the child was seated in a highchair and given a snack to eat. This episode restricted the mobility of the child and prevented the use of withdrawal or mother-oriented regulatory behaviors. The second stranger approach (*Stranger Free Play*), followed an identical protocol, but did not restrict the child's movement. Instead, toddlers played on the floor with several age-appropriate toys. During each stranger approach episode, a male stranger knocked at the door and then entered the room where the child was either playing (*Stranger Free Play*) or eating a snack (*Stranger Highchair*). After entering the room, the male stranger paused for 10 seconds at a distance of at least 8 feet from the child. The male stranger then approached the child, knelt, and looked at the child without speaking for up to 2 minutes. The episode was ended early if the child became too distressed (i.e., cried for 20 seconds without calming) or upon request of the mother.

*Frustration episodes.* Episodes designed to measure frustration included *Gentle Arm Restraint* and *Toy Removal* (a.k.a. *End of the Line*). In each context, the child was seated at a preschool-sized table and the mother was seated in a chair approximately 4 feet to the child's left. The *Gentle Arm Restraint* and *Toy Removal* tasks were designed to evoke frustration directed at the mother. The *Gentle Arm Restraint* episode began with the experimenter demonstrating a perpetual motion toy to the child. After the child became engaged with the toy, the mother gently held the child's arms against his/her body for 30 seconds, preventing play with the toy and restricting physical movement. The toy was then returned to the child. During *Toy Removal*, the experimenter demonstrated how to play with a new toy and encouraged the child to play with it for a brief period. The mother, having received prior instructions from the experimenter, removed the toy while stating she did not like it and did not want the child to play with it anymore. The removal lasted for 30 seconds, after which the mother stated that she changed her mind and returned the toy to the child.

*Inhibitory Control Episodes.* Inhibitory control was assessed using a *Snack Delay* episode and a *Tower of Patience* episode. During *Snack Delay*, the child was seated in the same way as for the frustration episode tasks. The experimenter placed a piece of candy under a transparent plastic cup on a paper plate in front of the child. She explained that the child could eat the piece of candy only after the experimenter rang a handheld bell. The child participated in a practice trial to ensure that s/he understood the rules of the game. Upon successful completion of the practice trial, the experimenter began the episode which consisted of six trials of varying wait times. Each trial ended with the child being able to eat the piece of candy. If the child ate the candy before the experimenter rang the bell, the experimenter reminded him/her of the rules of the game and continued on to the next trial. During the *Tower of Patience* episode, the child was told that s/he and the experimenter would play a game that involved each of them taking turns adding oversized cardboard blocks to a stack to form a vertical tower. By varying the number of seconds that the experimenter waited before taking her turn, the child was forced to endure varying lengths of waiting time before taking his/her turn. Between each of the six timed trials, the experimenter reminded the child of the rules of the game.

*Laboratory Visit Two.* Cardiac physiology data were gathered during a second laboratory visit. Baseline data were first collected while the child sat quietly and viewed a neutral video (“Baby Mugs”) for a period of approximately 5 minutes. Toddlers then participated in a cognitive challenge from the Bayley Scales of Infant Development (BSID-II; Bayley, 1993) that was approximately 10 minutes long. A portion of the Mental Scale consisting of a series of problems that required the child to attend and concentrate was used to induce mild behavioral and cardiovascular stress. To ensure that the task was adequately challenging, items from the scale for 36-month-old children were used. Each toddler then repeated the *Stranger Approach Highchair* and *Toy Removal* episodes while cardiac data were collected. Although 52 children participated in the second laboratory visit, six participants had missing or unusable baseline data, which prevented the calculation of RSA suppression scores. Thus RSA suppression measures were available for 46 children.

*Coding/Measures*

*Affective Behaviors.* Affective behaviors were coded as observations of children's behavioral strategies and affective displays. Fear and frustration episodes were divided into five-second intervals and scored on a 0 (not present) to 3 (highest intensity) interval scale for a variety of affective displays as defined by the AFFEX coding system (Izard, Dougherty, & Hembree, 1983). The AFFEX coding scheme assigns intensities to affective display as follows: 0 = no facial region shows codable changes to facial features or in muscle tension, 1 = only a single region of the face shows low intensity codable changes to features or muscle tension (e.g., widening of eyes as an indicator of fear), 2 = two regions of the face show codable changes to features or muscle tension or one region shows changes of high intensity (e.g., widening of eyes and raising of brows as an indicator of fear), 3 = three regions of the face show codable changes to features or muscle tension or there is another indication of a strong emotion present (e.g., widening of eyes, raising of brows, and tension around mouth with corners of lips pulled back). Crying was scored on a four point scale where 0 = no vocal indication of distress, 1 = definite whimpering, limited to a 1-2 second duration or prolonged whining or fussing, 2 = low-intensity cry with a rhythmic quality or definite non-muted crying, and 3 = full intensity crying or screaming.

The fear episodes were scored for facial fear, facial sadness, and crying; frustration episodes were scored for facial anger, facial sadness, and crying[1]. Coders recoded the maximum intensity of display for each five-second epoch during the episode. Reliabilities for type and intensity of affect for each episode ranged in agreement from 83% to 96% and kappas ranged from 0.73 to 0.81.

Some episode-specific behaviors were also coded. *Stranger Approach Highchair* was scored for escape behaviors with 0 = an absence of escape behaviors, 1 = mild or fleeting escape behaviors (e.g. turning away), 2 = moderate escape behavior or significant, but not extreme attempts to get away, 3 = intense escape behaviors often lasting for most of the epoch (e.g. leaning away or hitting at stranger). *Stranger Approach Free Play* was scored for approach behaviors on a four point scale: 0 = standing or sitting in place with no approach toward stranger, 1 = turning or leaning toward stranger, 2 = one or two hesitant steps toward stranger, 3 = one or two non-hesitant steps toward stranger, or initiating action to come within two feet of the stranger. *Stranger Approach Free Play* was also scored for avoidance behaviors on a four-point scale: 0 = stands or sits in place with no withdrawal from stranger, 1 = turning or leaning away from stranger, 2 = one or two steps away from the stranger, 3 = retreats to parent, a far corner, or tries to leave the room. *Gentle Arm Restraint* was similarly scored for intensity of struggle on a four-point scale: 0 = no resistant movement, 1= low intensity struggle (e.g., shifting, twitching, light wiggling), 2= one to two movements of medium intensity struggle (e.g., pulling away from parent, pushing against parent, etc.), 3= three to four movements of high intensity struggle or nearly continuous moderate intensity movements. *Toy Removal* was scored for protest on a three point scale: 0 = no protest, 1 = verbally demands toy, 2 = verbally and physically demands toy.

*Inhibitory Control. Snack Delay* and *Tower of Patience* episodes were scored for a child's ability to wait before eating the candy or taking his/her turn with the block, respectively, for an entire trial interval (0 = did not wait, 1 = waited). Episodes were also coded for the presence (1) or absence (0) of distraction and fidgeting behaviors during each trial.

*Cardiac Measures.* Cardiac output measures were collected using the CIC-1000™ Impedance Cardiograph, software version 7.2 (SORBA Medical Systems, 1997). Impedance measures were not used in the current study. Continuous raw electrocardiogram (ECG) signals were extracted from the SORBA output system and RSA was calculated offline. The raw ECG file was transformed into a file containing interbeat intervals (IBIs) with a program that used an adjustable threshold to detect R-waves. The IBI files were entered into MXedit software (Delta-Biometrics, Inc., Bethesda, MD; Porges, 1985) to identify and edit artifacts. Fewer than 3% of data points were edited and the majority of signals from all episodes were preserved. RSA scores reflect the natural logarithm of the variance of the frequency band between 0.24 and 1.04Hz.

*Data Reduction*

*Autonomic Regulation.* To obtain an estimate of cardiac activity, RSA was calculated by subtracting RSA during each challenge/stress task from the baseline RSA value (Myrtek, 1985, Llabre, Spitzer, Saab, Ironson, & Schneiderman, 1991; Davidson, 1994). Thus lower, more negative scores indicate greater RSA suppression. These scores were used as an indicator of physiological regulation. Methodological concerns regarding RSA measures have resulted from the high susceptibility of physiological measures to fluctuation due to individual differences, even at baseline. In addition, because decreases in RSA represent effective engagement and disengagement with the environment (Porges et al., 1996), baseline RSA may affect the degree to which children are able to evidence suppression (Wilder, 1967; Calkins et al., 1998); simply put, children with higher baseline RSA may have a greater range in which to display decreases in RSA than children whose baseline values are low. To rule out the possibility that effects related to RSA suppression result from individual differences in baseline RSA, we examined the correlations between baseline and change scores. Baseline values were not significantly correlated with RSA suppression ($r = 0.186$ to $0.286$; $p > 0.05$).

*Inhibitory Control.* Inhibitory control was determined from wait scores from the inhibitory control tasks outlined above. The ability to wait during *Snack Delay* was not significantly correlated with the ability to wait during *Tower of Patience* ($r = 0.165$, $p > 0.10$), suggesting that these two episodes tap different aspects of inhibitory control.

*Emotion Regulation*. Emotion regulation was indexed by changes in affective behaviors across each episode. In order to explore the correlations among distress behaviors, a proportion score was created by summing scores across all epochs and dividing by the total number of epochs in the episode. This accounted for situations in which episodes ended early due to child distress. For variables using intensity scores, a proportion score was created by summing the intensity scores across epochs and dividing by the total number of epochs in the episode. This again accounted for different numbers of epochs between subjects and also weights the proportion by the scored intensity of the emotion.

Traditional distress composites were formed within each episode based on observed patterns of correlations between the proportion scores for affective behaviors within each episode. For *Toy Removal*, an Anger composite was formed by summing scores for facial anger, bodily anger, and protest vocalizations; a separate Sadness composite was formed by summing facial sadness, bodily sadness and resignation. Correlations for *Toy Removal* are shown in Table 1. For *Gentle Arm Restraint*, correlations suggested a single distress composite which summed bodily anger/struggle, facial anger, facial sadness, bodily sadness, low resignation, and distress vocalizations. Correlations for *Gentle Arm Restraint* are shown in Table 2. Correlations in both *Stranger Approach Highchair* and *Stranger Approach Freeplay* suggested the creation of separate fear and sadness composites. In *Stranger Approach Highchair*, the fear composite included facial fear, vocal distress, and bodily fear. The sadness composite included facial sadness and bodily sadness. Correlations for distress in *Stranger Approach Highchair* are shown in Table 3. In *Stranger Approach Free Play*, the fear composite included facial fear, bodily fear, vocal distress, and avoidance behaviors. The *Stranger Approach Free Play* sadness composite included facial sadness, bodily sadness, and low approach behaviors. Correlations for distress in *Stranger Approach Free Play* are shown in Table 4.

An attempt to capture the dynamic properties of distress and regulation was made by identifying patterns of behavior across each episode. The need to empirically capture the complexities of emotion regulation has been discussed (Thompson, 1994; Cole, Martin, & Dennis, 2004) but has not yet been practiced due to the difficulties merging conceptual and practical issues. A composite score was created for each epoch within each episode, reflecting the intensity of distress.

Growth curve modeling was applied to these composites to estimate both linear and polynomial changes in emotion across each episode for the target emotion (i.e., anger in the anger episodes and fear in the fear episodes). Growth curve models were fit using the SAS PROC MIXED procedure to achieve the best model fit through trimming nonsignificant fixed effects and adding appropriate random components based on the individual variance of scores (Singer, 1998; Hox, 2002). To ensure that trends would reflect patterns of distress across the episode, each trend was centered at the first occasion of measurement. Each context episode was run separately and best-fitting models were determined by scores on the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC). In this context, linear trends represented an overall increase or decrease in distress, quadratic terms indicated symmetry in the rise and fall of distress, and cubic terms indicated a more rapid rise or fall than that which would be expected from a purely quadratic trend. Best-fitting models for the fear episodes showed significant positive linear ($\beta_{1,\ 1670}$=0.12, $p$<0.01) and negative quadratic trends ($\beta_{1,\ 1670}$=-0.003, $p$<0.05) in *Stranger Approach Highchair* and also significant negative linear ($\beta_{1,\ 1178}$=-0.19, $p$<0.01), significant positive quadratic ($\beta_{1,\ 1178}$=0.01, $p$<0.05), and significant negative cubic ($\beta_{1,\ 1178}$=-0.0002, $p$<0.01) trends in the *Stranger Approach Free Play* episode. Best fitting models for the anger episodes showed significant positive linear ($\beta_{1,\ 297}$=0.66, $p$<0.05) and negative quadratic ($\beta_{1,\ 297}$=-

0.15, $p$<0.01) trends in *Toy Removal* and significant positive linear ($\beta_{1, 326}$=2.20, $p$<0.01), negative quadratic ($\beta_{1, 326}$=-0.62, $p$<0.01), and positive cubic ($\beta_{1, 326}$=0.06, $p$<0.01) trends for *Gentle Arm Restraint*.

Individual parameter estimates were obtained for children within each episode based on the trends that were significant for the entire group. Thus, each child ended up with his/her own linear and quadratic trend scores for all episodes and a cubic trend score for *Stranger Approach Highchair* and *Gentle Arm Restraint*. Because the key interest is in patterns of increases and decreases in distress across the episode and not in rise time or acceleration per se, cubic trends were not included in subsequent analyses. The use of individual scores of linear and quadratic trends provides indices of overall increases and decreases across the episode. Furthermore, they determine the extent to which this pattern was nonlinear in nature. These scores thus serve as dynamic composites in contrast to the traditional composites described above.

In summary, data reduction resulted in the following set of 17 scores for each child: RSA suppression during the cognitive challenge, RSA suppression during *Stranger Approach*, RSA suppression during *Toy Removal* , *Tower of Patience* proportion of wait, *Snack Delay* Proportion of wait, *Stranger Approach Highchair* fear composite, *Stranger Approach Highchair* fear linear trend, *Stranger Approach Highchair* quadratic trend, *Stranger Approach Freeplay* fear composite, *Stranger Approach Freeplay* linear trend, *Stranger Approach Freeplay* quadratic trend, *Toy Removal* anger composite, *Toy Removal* anger linear trend, *Toy Removal* anger quadratic trend, *Arm Restraint* distress composite, *Arm Restraint* linear trend, and *Arm Restraint* quadratic trend. All variables were visually inspected and outliers removed. Because linear trends were more likely to have outliers than quadratic trends, the removal of outliers occasionally resulted in fewer participants with linear trend scores than with quadratic trend scores within the same episode. Means and standard deviations for all variables are presented in Table 5.

# *Results*

To address each research question, analyses were conducted in two steps. First, associations among regulation in different contexts and capacities were examined using bivariate correlations. Of specific interest were relationships among variables within the same context (e.g., all measures from *Stranger Approach Highchair*) and relationships among parallel variables in different contexts (e.g., traditional fear composites from *Stranger Approach Freeplay* and *Stranger Approach Highchair*). Second, evidence for an individual capacity for regulation was examined through principal components analyses to determine whether different types of regulation would cohere and whether convergence between putative measures of regulation differed when analyses included traditional composites of emotion regulation versus dynamic measures of emotion regulation.

## *Bivariate Relations Among Variables*

The correlations among variables for are shown in Table 6. There were generally low correlations among aspects of regulation, but more modest correlations among those measuring the same emotion. There were more significant correlations within than between episodes. Significant correlations were also found between composites and linear trends in the two fear episodes and between composites, linear, and quadratic trends in the two anger episodes. These between-episode correlations represent a degree of consistency in regulation between contexts that elicit the same emotion.  For instance, participants with higher scores on the distress composite during *Stranger Approach Highchair* also showed higher composites and greater linear trend scores during *Stranger Approach Freeplay*, representing stability in rank order across the two fear episodes. Some between-episode consistency was present between target emotions as well, as greater scores on the linear trend variable during *Toy Removal* were related to greater linear increases in fear during *Stranger Approach Highchair*, higher scores on the fear composite during *Stranger Approach Freeplay*, negative quadratic trends during *Stranger Approach Freeplay*, and decreases in fear during *Gentle Arm Restraint*. Finally, there was some preliminary evidence for the convergence of different facets of regulation; the ability to wait on a greater proportion of trials during *Tower of Patience* was significantly correlated with linear increases in fear during *Stranger Approach Highchair*.

The pattern of correlations among the RSA suppression, inhibitory control, and emotion regulation constructs suggest that, although some level of commonality may exist, these measures represent largely distinct aspects of regulation. Again, this can be seen in that the largest correlations are within measure and episode rather than across measures. However, it should be noted that although significant correlations are flagged in Table 6, the true meaning of this analysis lies in the patterns of correlations as evidence for coherence rather than in the interpretation of their absolute values.

*Principal Components Analysis Examining Convergence of Constructs of Regulation*

In order to investigate how different measures of regulation cohere in support of the notion of an overall capacity for regulation, a principal components analysis was performed. A principal components analysis is not only more appropriate than confirmatory factor analysis for a sample of this size (Comrey & Lee, 1992), but is arguably more appropriate for the type of question asked here because total variance, rather than shared variance, is analyzed (Tabachnick & Fidell, 2001). A principal components analysis would be preferable if, by eliminating variance that is unique to each component, we risk overestimating the relationship between the variables used in our analysis.

Three separate analyses were run because preliminary correlations suggested redundancy among traditional composites, linear, and quadratic trends, and to further enable us to compare the use of composites against the use of the trend scores. First, RSA suppression and inhibitory control variables were submitted to a principal components analysis along with traditional composite scores. In accordance with the hypothesis of an overarching regulatory capacity, a one component solution was requested. Items with factor loadings less than 0.3 were dropped and analyses were rerun. Although a factor loading of 0.4 might be considered a more traditional cutoff point, 0.33 is considered an adequate cutoff point (Tabachnnick & Fidell, 2001) and using a loading of 0.3 allowed us to maximize the power of our relatively small sample. Two subsequent analysis were performed with the linear trend variables in place of the traditional composites and then with the quadratic trend variables in place of the traditional composites.

For the first analysis, using traditional composites, the final component included eight of the nine original variables and accounted for 22.32% of the observed variance in the scores. Factor loadings for this analysis are shown in Table 7. This outcome supports the presence of the hypothesized capacity for regulation which includes elements of emotion regulation, physiological regulation, and inhibitory control. The direction of the factor loadings show that the final component includes high levels of fear and frustration,  low proportions of waiting during Snack Delay and Tower of Patience (i.e., less inhibitory control), and high RSA suppression scores (i.e., less suppression). In other words, a latent construct of regulation is reflected in lower levels of distress, greater inhibitory control, and greater suppression of RSA.

For the second analysis, individual linear trend scores were used as measures of regulation. The final component in this analysis accounted for 43.12% of the observed variance and included only the linear trends from each episode. Factor loadings for this analysis are shown in Table 8. This component represented something more specific to the dynamic changes in emotion and its regulation that the final component of the first analysis; more specifically, high scores on this factor reflected increases in fear during *Stranger Approach Highchair* and *Stranger Approach Freeplay*, increases in frustration during *Toy Removal*, and decreases in frustration during *Gentle Arm Restraint*. Using these more dynamic variables in the analysis did not directly replicate the analysis using traditional composites; suggesting that although these measures are correlated to some extent, they are not simply different measures of the same thing.

For the third analysis, the physiological regulation and inhibitory control variables along with individual scores on both linear and quadratic trend variables. Although orthogonal contrasts can be created to reduce the correlation between lower and higher order trend variables (Hox, 2002), the presence of a significant linear trend in these data suggests that linear trend scores should be examined concurrently with the quadratic trends. Therefore the final analysis included both the linear and quadratic trends along with RSA suppression and inhibitory control variables. The final component for this analysis accounted for 37.86% of the observed variance in the data and was composed solely of the emotion regulation variables. Factor loadings from this analysis are shown in Table 9. This finding echoed the result of the second analysis in suggesting that the individual polynomial trend scores captured something distinct to emotion regulation rather than part of a more global capacity for regulation. Again, although the quadratic trends were correlated with the composite scores, they did not directly replace them as an equivalent way of depicting emotion regulation.

# *Discussion*

## *Summary of Findings of the Current Study*

This study examined the convergence of measures of physiological regulation and inhibitory control with both traditional composites and indices of change in emotion regulation. Principal components analyses were used to examine how different measures of regulation cohered in support of the idea of an individual capacity for regulation.  Results suggested that physiological regulation (in the form of RSA suppression) and inhibitory control showed little convergence with composites of fear and frustration. This finding existed for both analyses that used traditional mean composites of emotion regulation variables and also for analyses that used dynamic measures of emotion within tasks.

Given the results of the principal components analyses, the hypothesis concerning an individual capacity for regulation was not supported. However, a subsidiary goal of the current study was to capture the dynamics of emotional expression as has been called for by past work (e.g., Thompson, 1994. Cole et al., 2004). When trend scores were used as variables of emotion regulation, the final principal component was composed primarily of the individual trends from each of the episodes. In this way, our results suggested that the use of linear trend scores was nonredundant with traditional composite measures and offered unique information about the nature regulation of emotion. This was particularly true for time-related variations in the expression of negative emotions. In contrast, traditional composites captured a more global component of emotion regulation that was differently related to inhibitory control autonomic regulation.

*Implications of Nonconvergence of components of regulation*

Given the number of studies that use the different measures depicted here (i.e., RSA, inhibitory control, and emotion regulation) as their sole estimates of regulation, a lack of convergence across measures is both curious and potentially problematic for interpreting findings in the current literature and for planning future investigations. It may be that different measures of regulation captured distinct aspects of the process and any generalization from a single measure should be made with caution. For example, if physiological systems enable or inhibit patterns of behavioral response (e.g., Gray, 1982), one would expect that changes in physiology prepare for changes in behavior. Thus, physiological response may prepare individuals for behavior while displays of emotion communicate affective information (Campos, Campos, & Barrett, 1989). These functional differences may have contributed to a lack of coherence observed at the level of measurement used here.

In addition to working differences in these forms of regulation, it is possible that the relationships among the variables used in this study are curvilinear in nature. There may, for example, be intermediate levels of RSA and inhibitory control that are optimal for the regulation for emotion. These more moderate levels would prevent both underregulation and overcontrol (Derryberry & Rothbart, 1997; Eisenberg & Fabes, 1992). For example, children who were classified as overcontrolled during an inhibitory control task may also display little affective information during an emotion task even though they are upset. Similarly, children who were classified as underregulated due to a lack of inhibitory control may be quick to display high levels of negative emotion in the same situation. Neither of these groups of children would be characterized as optimally regulated; both children would have difficulty engaging in appropriate social behaviors. Factor analytic models can be designed to account for curvilinear relationships among components (Cohen & Cohen, 1983), but our principal components models were not. By using methods that assumed linearity, we relinquished the idea of optimal levels and forced the conceptual notion that “more” regulation is always better.

Some further limitations of the current investigation lie in the scoring of the variables used in the analyses; these possibilities will be discussed in turn. First, the proportion scores used in the first analysis may have created heterogeneous subsets of children. Although proportions allowed us to continuously classify children has high and low in different emotions, they failed to differentiate between children who, for example, showed high intensities of a particular emotion for short periods of time and those who showed low intensities of the same emotion for long periods of time because they would have similar average scores. In practice, these may have been important distinctions and are often referenced in discussions of temperament-based differences in emotional expression and modification (Kagan, 1994; Rothbart & Sheese, 2007) This distinction was an additional reason to expect less coherence from the traditional composites (i.e., average proportion scores) than from measures that allowed for greater individual variation.

Moreover, both the traditional proportion scores and the dynamic measures of regulation may have been invalid measures of emotion regulation. In practice, they captured emotional reactivity and expression, more distal estimates of the processes assumed to underlie regulation; while they did fit the definition of regulation provided in the literature (e.g., Cole et al., 2004), emotional expression provided only a point estimate for underlying regulatory processes and not the processes themselves. If emotion expression operates on a different functional or systemic level than inhibitory control or RSA suppression, these differences in measurement may have contributed to the lack of convergence among the different regulatory systems.

Second, some of the measures used in this study may not have been reliable and/or valid measures of the constructs. In particular, the low correlation between waiting during *Tower of Patience* and *Snack Delay* was originally interpreted as evidence for the contexts differentially tapping into the construct of inhibitory control. It may be the case, however, that neither task provided the best measure of inhibitory control. In this case, the low observed correlation could have been a result of measurement error and subsequently lacked coherence with other measures. This was supported by a reliability analysis of all variables for both sets of analyses, which returned Cronbach's alphas ranging from 0.20-0.21. The combination of low overall coherence among regulatory measures and a low correlation between measures of inhibitory control likely contributed to the absence of the inhibitory control variables in several of the principal components analyses. Similar to suggestions made previously, other well established factors related to the cognitive control of emotion may be better candidates for future studies of systems of regulation. This could include other established, more specific factors of executive function such as attention and working memory (e.g., Graziano, Reavis, Keane, & Calkins, 2007), hemispheric asymmetry in patterns of neural activation (e.g., Fox, 1994), or individual differences in activation in specific neural structures (e.g., Lewis & Stieben, 2004). Future studies may consider alternative paradigms such as the day/night task (Gerstadt, Hong, & Diamond, 1994) or the walk-a-line slowly task (Kochanska, Murray, & Coy, 1997). These measures tap individual resources for holding information (e.g., rules) in mind while performing a task, inhibiting dominant response tendencies, and regulating behavior and are appropriate for samples of this age. Future studies might also consider the use of alternative methods, such as electroencephalogram (EEG) recording and the inspection of event related potentials (ERPs).

A final important issue stems from the age of the research participants. Measures of RSA suppression, inhibitory control, and emotion regulation are not uncommon in children at age 24 months, and the toddler years are considered of added value as they are a time of important and rapid acquisition, growth, and development in regulatory skills (Calkins & Hill, 2007). However, the immaturity of these systems may have created problems for coherence. That is, it may have been possible that RSA suppression, emotion regulation, and inhibitory control were linked to an overarching regulatory capacity, but the extent to which these systems were not fully developed placed limits on their measurement and on their coherence with each other and with other systems of regulation.

*Future directions and Conclusions*

Several improvements to the current study could be made in future work. First, identifying individual differences in children's regulatory styles would add to the power to detect relationships among systems of regulation. It may be that children who are more capable of regulating emotionally and physiologically in response to distress have coherence among regulatory systems that is not present in children who are less skilled at regulating their distress. It may also be the case that different temporal patterns of regulation (e.g., being able to regulate immediately following a stressor or exhibiting a more delayed response) are linked to different underlying systems. In either case, coherence of systems would be better examined among theoretically-based subsets of children.

As mentioned earlier, future work should consider including alternative measures or examining broader constructs of effortful control and/or executive attention, since behaviors associated with each may be manifestations of the development of the same prefrontal circuitry (Rothbart & Sheese, 2007; Diamond, 1988). An additional alternative is to examine this research question in an older sample whose regulatory skills are more developed, more reliably measured, and possibly more illustrative of the systemic coherence that was hypothesized.

Individual development contributes to emotion regulation and physiological regulation as well. There is strong evidence suggesting that both emotion regulation behaviors (e.g., Mangelsdorf et al., 1995) and cardiovascular responsivity (e.g., Quigley & Stifter, 2006) become greater over time. These changes are often interpreted as the stabilization of reactivity and regulation over time and suggest more reliable measurement from less specific markers or in older children.

In conclusion, although findings from this study were inconclusive about the link among different systems of regulation, they offered more dynamically sensitive measure of emotion regulation that have been called for in past research and suggestions for improvements in future work that could examine the coherence among systems of regulation.

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# Footnotes

[1]Other affective or putative regulatory behaviors were scored by separate coders using a dichotomous coding scheme to indicate the presence or absence of behaviors (Buss & Goldsmith, 1998; Mangelsdorf et al., 1995, Buss & Kiel, 2004). Behaviors were coded as either 0 (not present) or 1 (present) and included contact seeking, proximity, gaze aversion, distraction, fidgeting, self-stimulation, resisting, releasing tension, controlling situation, or leave-taking. *Contact seeking* was coded when the toddler attempted to initiate or increase contact with the caregiver. *Proximity* was coded when the toddler was within two feet of the caregiver. *Gaze aversion* was coded when participants looked away from the stimulus for a duration of less than two seconds. *Distraction* was coded when participants looked away from the stimulus for a duration of two or more seconds. *Fidgeting* involved active, "nervous," behaviors that were observed while the toddler maintained attention directed at the stimulus. *Self-stimulation* described rhythmic soothing behaviors such as thumb-sucking, hair twirling, or rocking back and forth. *Resisting* was coded when the toddler actively rejected an invitation to engage with the stimulus. *Releasing tension* was coded during bursts of high-energy instrumental behaviors that are not indicative of pleasure. *Controlling situation* was coded when a participant tried to direct the activity of the stimulus or the flow of the episode. *Looks to Mom or Experimenter* were child-initiated looks toward the caregiver or toward the main experimenter. Finally, *Leave-taking* was coded for behaviors that indicated the participant's attempt to leave the episode (e.g., putting on a coat, saying "bye, bye," etc.).

These putative regulatory behaviors did not reliably correlate with other affective behaviors, and so were not included in subsequent analyses.

# Appendix 1: Tables

**Table 1: Correlations of Distress Behaviors in *Toy Removal***

| | *1* | *2* | *3* | *4* | *5* | *6* |
|---|---|---|---|---|---|---|
| *1. Mean Facial Anger* | - | .82** | .51** | .17 | .04 | -.46** |
| *2. Mean Bodily Anger* | | - | .56** | .06 | .07 | -.55** |
| *3. Protest* | | | - | .35 | .06 | -.76** |
| *4. Mean Facial Sadness* | | | | - | .25 | -.38* |
| *5. Mean Bodily Sadness* | | | | | - | .26 |
| *6. Resignation* | | | | | | - |

*$p$<0.05 **$p$<0.01

**Table 2: Correlations of Distress Behaviors in *Gentle Arm Restraint***

| | *1* | *2* | *3* | *4* | *5* | *6* |
|---|---|---|---|---|---|---|
| *1. Mean Facial Anger* | - | .68** | .77** | .50** | .21 | -.61** |
| *2. Mean Bodily Anger* | | - | .67** | .51** | .25* | -.81** |
| *3. Protest* | | | - | .62** | .33** | -.68** |
| *4. Mean Facial Sadness* | | | | - | .43** | -.46** |
| *5. Mean Bodily Sadness* | | | | | - | -.24* |
| *6. Resignation* | | | | | | - |

*$p<0.05$ **$p<0.01$

**Table 3: Correlations of Distress Behaviors in *Stranger Approach Highchair***

| | *1* | *2* | *3* | *4* | *5* | *6* |
|---|---|---|---|---|---|---|
| *1. Mean Facial Fear* | - | .48** | .71** | .43** | .27* | -.15 |
| *2. Mean Bodily Fear* | | - | .32** | .16 | .10 | -.65 |
| *3. Vocal Distress* | | | - | .58** | .32** | -.17 |
| *4. Mean Escape Behaviors* | | | | - | .25* | -.37** |
| *5. Mean Facial Sadness* | | | | | - | -.23** |
| *6. Mean Bodily Sadness* | | | | | | - |

*$p<0.05$ **$p<0.01$

**Table 4: Correlations of Distress Behaviors in *Stranger Approach Freeplay***

| | *1* | *2* | *3* | *4* | *5* | *6* | *7* |
|---|---|---|---|---|---|---|---|
| *1. Mean Facial Fear* | - | .46** | .51** | .41** | .12 | .23* | -.07 |
| *2. Mean Bodily Fear* | | - | .44** | .24* | .43* | .48** | -.36** |
| *3. Vocal Protest* | | | - | .35** | .32** | .15 | -.11 |
| *4. Avoidance* | . | | | - | .13 | .10 | -.11 |
| *5. Mean Facial Sadness* | | | | | - | .49** | -.03 |
| *6. Mean Bodily Sadness* | | | | | | - | -.27* |
| *7. Approach* | | | | | | | - |

*$p$<0.05 **$p$<0.01

**Table 5: Means and Standard Deviations of Primary Variables**

| | N | Mean | SD |
|---|---|---|---|
| RSA Suppression | | | |
| Cognitive Challenge | 45 | -0.30 | 0.48 |
| Stranger Approach | 43 | -0.38 | 0.55 |
| Toy Removal | 39 | -0.49 | 1.13 |
| Inhibitory Control | | | |
| Tower of Patience Proportion Wait | 77 | 56.28 | 33.77 |
| Snack Delay Proportion Wait | 77 | 78.57 | 29.35 |
| Stranger Highchair Emotion Regulation | | | |
| Fear Composite | 71 | 2.72 | 1.61 |
| Fear Linear | 66 | 0.04 | 0.20 |
| Fear Quadratic | 71 | -0.00 | 0.01 |
| Stranger Freeplay Emotion Regulation | | | |
| Fear Composite | 76 | 1.27 | 0.90 |
| Fear Linear | 72 | -0.21 | 0.46 |
| Fear Quadratic | 76 | -0.01 | 0.22 |
| Toy Removal Emotion Regulation | | | |
| Anger Composite | 78 | 0.98 | 3.35 |
| Anger Linear | 78 | 0.66 | 2.03 |
| Anger Quadratic | 78 | -0.14 | 0.49 |
| Arm Restraint Emotion Regulation | | | |
| Distress Composite | 75 | 3.48 | 4.07 |
| Distress Linear | 72 | 1.74 | 2.76 |
| Distress Quadratic | 74 | -0.53 | 1.63 |

## Table 6: Correlations of Primary Variables

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RSA Suppression** | | | | | | | | | | | | | | | | |
| 1. Cognitive Challenge | - | | | | | | | | | | | | | | | |
| 2. Stranger Approach | 0.29† | - | | | | | | | | | | | | | | |
| 3. Toy Removal | 0.26 | 0.23 | - | | | | | | | | | | | | | |
| **Inhibitory Control/Wait** | | | | | | | | | | | | | | | | |
| 4. Tower of Patience | -0.18 | 0.16 | 0.00 | - | | | | | | | | | | | | |
| 5. Snack Delay | 0.02 | -0.15 | -0.09 | 0.17 | - | | | | | | | | | | | |
| **Stranger Highchair** | | | | | | | | | | | | | | | | |
| 6. Fear Composite | 0.16 | 0.02 | 0.13 | -0.07 | 0.01 | - | | | | | | | | | | |
| 7. Fear Linear | 0.07 | 0.09 | -0.14 | 0.31* | 0.07 | 0.32** | - | | | | | | | | | |
| 8. Fear Quadratic | 0.06 | -0.09 | 0.16 | -0.02 | -0.04 | -0.39** | -0.95** | - | | | | | | | | |
| **Stranger Freeplay** | | | | | | | | | | | | | | | | |
| 9. Fear Composite | 0.09 | 0.15 | -0.22 | -0.02 | 0.00 | 0.56** | 0.22† | -0.15 | - | | | | | | | |
| 10. Fear Linear | 0.07 | -0.03 | 0.04 | 0.06 | 0.01 | 0.19 | 0.28* | 0.16 | 0.22† | - | | | | | | |
| 11. Fear Quadratic | 0.07 | -0.31† | -0.01 | -0.07 | 0.14 | 0.00 | -0.09 | -0.03 | -0.28* | -0.70** | - | | | | | |
| **Arm Restraint** | | | | | | | | | | | | | | | | |
| 12. Distress Composite | 0.16 | 0.03 | 0.06 | -0.16 | 0.05 | 0.01 | -0.11 | 0.03 | 0.18 | 0.04 | -0.22† | - | | | | |
| 13. Distress Linear | -0.09 | -0.26 | -0.04 | 0.11 | -0.05 | -0.19 | -0.17 | 0.18 | 0.00 | -0.06 | 0.15 | 0.26* | - | | | |
| 14. Distress Quadratic | 0.01 | 0.31† | 0.07 | -0.11 | -0.06 | 0.16 | 0.17 | -0.02 | 0.08 | 0.01 | -0.16 | -0.13 | -0.88** | - | | |
| **Toy Removal** | | | | | | | | | | | | | | | | |
| 15. Anger Composite | 0.14 | 0.21 | -0.02 | -0.07 | 0.06 | -0.05 | -0.02 | 0.02 | 0.11 | 0.15 | -0.08 | 0.07 | -0.31** | 0.24* | - | |
| 16. Anger Linear | 0.01 | 0.14 | -0.09 | -0.07 | -0.14 | 0.19 | 0.25* | -0.13 | 0.26* | 0.14 | -0.41** | 0.00 | -0.26* | 0.20† | 0.39** | - |
| 17. Anger Quadratic | -0.11 | -0.09 | 0.09 | 0.10 | 0.15 | -0.19 | -0.10 | 0.17 | -0.22† | -0.07 | 0.19 | 0.01 | 0.28* | -0.15 | -0.38** | -0.82** |

Note: Within-context correlations are emphasized by bolded text. Cross-context correlations are emphasized by red text.
*p<0.05 **p<0.01 †p<0.10

**Table 7: Factor Loadings for Principal Component Using Traditional Composites**

| Variable | Factor Loading |
|---|---|
| RSA Suppression: Cognitive Challenge | 0.39 |
| RSA Suppression: Stranger Approach | 0.50 |
| Inhibitory Control/Wait: Tower of Patience | -0.38 |
| Inhibitory Control/Wait: Snack Delay | -0.49 |
| Stranger Highchair Fear Composite | 0.39 |
| Stranger Freeplay Fear Composite | 0.45 |
| Arm Restraint Distress Composite | 0.48 |
| Toy Removal RSA Suppression | 0.46 |
| | |
| Percent Variance | 22.32% |
| Eigenvalue | 1.79 |

**Table 8: Factor Loadings for Principal Component Using Linear Trends**

| **Variable** | **Factor Loading** |
|---|---|
| Stranger Highchair Fear Linear | 0.68 |
| Stranger Freeplay Fear Linear | 0.67 |
| Arm Restraint Distress Linear | -0.59 |
| Toy Removal Distress Linear | 0.69 |
| | |
| Total Variance | 43.12 |
| Eigenvalue | 1.73 |

**Table 9: Factor Loadings for Principal Component Using Quadratic Trends**

| Variable | Factor Loading |
|---|---|
| Stranger Highchair Fear Linear | 0.68 |
| Stranger Highchair Fear Quadratic | -0.67 |
| Stranger Freeplay Linear | 0.61 |
| Stranger Freeplay Quadratic | -0.52 |
| Arm Restraint Distress Linear | -0.58 |
| Arm Restraint Distress Quadratic | 0.51 |
| Toy Removal Anger Linear | 0.70 |
| Toy Removal Anger Quadratic | -0.62 |
| Total Variance | 37.86% |
| Eigenvalue | 3.03 |