Patterns of RSA and observed distress during the still-face paradigm predict later attachment, compliance and behavior problems: A person-centered approach

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Abstract:

This study examined profiles of infant observed distress and physiological regulation indexed by respiratory sinus arrhythmia (RSA) levels during the still-face paradigm at 6 months using a person-centered approach. Mothers and infants (N = 206) participated in the study when infants were 6 months, 1 year, and 2 years old. Attachment was assessed at 1 year via the Strange Situation. Children's compliance behaviors were assessed at 2 years during a toy clean-up task. Mothers reported children's behavior problems at 4.5 years. Latent profile analysis yielded four profiles: highly distressed, but regulating; over-regulated; resilient to distress; and under-regulated. Infants in the “resilient to distress” profile characterized by high RSA levels and low negative affect exhibited the most adaptive outcomes such as lower attachment avoidance, higher compliance, and lower behavior problems. Therefore, this study highlights the importance of considering patterns of behavioral and physiological indicators of infant emotionality together for understanding adaptive functioning.

Keywords: arousal | joint effect | regulation | RSA | still-face

Article:

1 INTRODUCTION

Recent research has demonstrated broad individual differences in how infants respond behaviorally and physiologically during distressing tasks as well as the distinct co-occurring patterns of responding across behavioral and physiological levels (Aureli, Grazia, Cardone, & Merla, 2015; Dale, O'Hara, Keen, & Porges, 2011; Lewis, Hitchcock, & Sullivan, 2004).

Additionally, evidence is mixed regarding whether behavioral and physiological responses exhibit concordant patterns and which patterns of responding are linked with subsequent adaptive or maladaptive outcomes (Buss, Goldsmith, & Davidson, 2005; Calkins, Blandon, Williford, & Keane, 2007; Quas, Hong, Alkon, & Boyce, 2000). However, to our knowledge, no prior studies have examined individual differences in joint patterns of infant negative affect and physiological regulation across the still-face procedure and how these profiles may be associated with children's subsequent functioning. To address these gaps, in the current study, we examine profiles of infant observed negative affect and physiological regulation (i.e., respiratory sinus arrhythmia) during the still-face paradigm using a person-centered approach, and we examine how children's subsequent functioning (i.e., attachment, compliance, behavioral problems) varies as a function of these profiles. We begin with an overview of respiratory sinus arrhythmia.

1.1 Respiratory sinus arrhythmia

Respiratory sinus arrhythmia (RSA), an index of vagal tone, is an important correlate of physiological regulation in infants (Calkins, 2011). A decrease, or withdrawal of vagal input to the heart facilitates an increase in heart rate, which allows individuals to shift from maintaining internal homeostasis to coping with external demands (Porges, 1996). Thus, vagal withdrawal is considered to be a physiological regulation process that leads to greater cardiac output (e.g., HR acceleration) and active coping behaviors (Calkins, Graziano, Berdean, & Degnan, 2008; Porges, 1996). Porges (1995b) identified an index of the function of the parasympathetic nervous system, vagal tone, which reflects the vagal control of the heart. Porges developed a method that assesses the variability in heart rate that occurs at the frequency of spontaneous respiration (RSA), and it can be used as a good estimate of the influence of the parasympathetic system on the heart (Calkins et al., 2008; Porges, 1996). During environmentally challenging situations, the vagal brake is withdrawn to facilitate an increase in heart rate and increased attention to the environment; this release of resources may be part of the activation of the regulatory system that reduces distress (Porges, 1995a). Empirical work has supported this view showing that infants' RSA withdrawal when confronted with a stressor is associated with concurrent observed behavioral regulation and recovery from stress (Bazhenova, Plonskaia, & Porges, 2001; Calkins, 1997). However, engaging in higher levels of RSA withdrawal has been shown to be associated with more internalizing behaviors in children (Boyce et al., 2001). Therefore, moderate levels of RSA withdrawal in young children during environmentally challenging situations are considered to be advantageous and are longitudinally associated with a range of positive outcomes, such as fewer externalizing symptoms (Calkins & Dedmon, 2000; Calkins et al., 2008), more sustained attention and soothability (Huffman et al., 1998), and adaptive social behaviors (Stifter & Corey, 2001).

On the other hand, baseline RSA can be considered a useful index of autonomic functioning. In non-threatening situations, higher baseline RSA in infants is considered an index of flexible responding (Gyurak & Ayduk, 2008) and it indicates sufficient resources in individuals to be able to engage in RSA withdrawal when facing challenges (Porges, 1995a). Empirical research with infants generally suggests that greater baseline RSA is associated with better self-regulation (Porges, 1996), sustained attention and focused attention (Hofheimer, Wood, Porges, Pearson, & Lawson, 1995; Suess, Porges, & Plude, 1994), and more sociable and exploratory behaviors (Fox, 1989). Higher baseline RSA during infancy also buffered the effect of cumulative prenatal risk on toddlers' development of aggressive behaviors (Suurland, Heijden, Huijbregts, Goozen, & Swaab, 2018). On the other hand, higher baseline RSA is associated with greater behavioral reactivity (Porges, Doussard-Roosevelt, Portales, & Suess, 1994) and heightened frustration (Calkins, Dedmon, Gill, Lomax, & Johnson, 2002) among infants. Notably, among older children, adolescents, and adults, high baseline RSA is consistently linked with more adaptive outcomes (Blandon, Calkins, Keane, & O'Brien, 2010; Forbes, Fox, Cohn, Galles, & Kovacs, 2006; Graziano & Derefinko, 2013; Hinnant & El-Sheikh, 2009; Skowron, Cipriano-Essel, Gatzke-Kopp, Teti, & Ammerman, 2014; Yaroslavsky, Rottenberg, & Kovacs, 2013). In addition, baseline RSA and RSA withdrawal have shown to be associated positively, such that infants and older children who consistently show RSA withdrawal have higher levels of RSA (Calkins, 1997; El-Sheikh, 2005; Moore & Calkins, 2004). Therefore, there is general consensus that high resting RSA and moderate RSA withdrawal when faced with challenge are adaptive. Importantly, physiological regulation in the form of RSA is expected to alter the long-term impact of behavioral distress on well-being of children (Calkins, 2011).

1.2 Patterns of observed distress and physiological regulation and implications for child outcomes

Observed facial negative affect is an indicator of an increase in arousal and activities of the sympathetic nervous system (Kreibig, 2010); RSA levels and changes indicate activities of the parasympathetic nervous system (Porges, 1995b) and RSA changes evidence signs of physiological regulation (Calkins, 2011). Although one might expect arousal and regulation to be related in a linear fashion, Lewis (1992) proposed that children's arousal threshold and their ability to inhibit or dampen their arousal are two different dimensions of the underlying processes of behavioral features of temperament. He proposed that there are likely four groups of children with specific combinations of these dimensions: children who show high arousal and high regulation, children who exhibit high arousal but engage in low regulation, children who show low arousal but demonstrate high regulation, and children who show low arousal and low regulation abilities. Likewise, Berntson, Cacioppo, and Quigley (1991) proposed unique profiles of autonomic control in individuals that reflect specific patterns of parasympathetic (reflecting regulatory processes) and sympathetic (reflecting arousal) activation. Four of the initial six proposed patterns have been supported in empirical research with children and adolescents: coactivation, coinhibition, reciprocal sympathetic activation, and reciprocal parasympathetic activation (Alkon et al., 2003; Salomon, Matthews, & Allen, 2000). Similarities exist between Lewis' and Berntson's et al. theories: the coactivation (an increase of responses in both systems) is similar to the high arousal, low regulation group; the coinhibition (a decrease of responses in both systems) is comparable to the low distress and high regulation group; the reciprocal sympathetic activation (an increase of sympathetic response, and a decrease of parasympathetic response) group is similar to the high distress and high regulation group; and the reciprocal parasympathetic activation (an increase of parasympathetic response, and a decrease of sympathetic response) is comparable to the low distress and low regulation group. Therefore, previous research and theory suggest four groups of children with distinct patterns of observed distress and RSA are likely.

Consistent with these theoretical views, prior empirical evidence indicates that arousal and physiological regulation do not show consistent associations with each other. For example, Buss et al. (2005) used a series of observational tasks including a cognitive task, a stranger approach and a toy removal task and calculated within-subject correlations between negative affect and cardiac measures across the four tasks. The results indicated that about half of the toddlers showed a negative association between negative affect and RSA, and about 37% of children showed a positive association. Furthermore, specific patterns of co-occurring arousal and physiological regulation may serve as markers for children's later well-being (Beauchaine & Gatzke-Kopp, 2012; Calkins & Fox, 2002). For example, infants who are characterized by high negative affect during challenging situations in conjunction with no vagal regulation (i.e., RSA withdrawal) are considered under/dysregulated (Calkins et al., 2007). This pattern of under-regulation in young children has been associated with attachment resistance (Braungart-Rieker, Garwood, Powers, & Wang, 2001) and with both aggressive behavior and non-compliance (Calkins & Dedmon, 2000; Degnan, Calkins, Keane, & Hill-Soderlund, 2008). In contrast, children who are high in both arousal, and regulation (i.e., high negative affect, paired with high RSA withdrawal) show lower disruptive behaviors than those with high arousal and poor regulation (Calkins & Dedmon, 2000; Degnan et al., 2008). However, high RSA withdrawal may not always be adaptive. Children who are low in arousal but high in regulation (i.e., low negative affect in challenging situations paired with high levels of RSA withdrawal) may be over-regulated. In prior research, this pattern of limited expressed negative affect and high physiological regulation has been associated with greater likelihood of having an avoidant attachment (Hill-Soderlund et al., 2008) and with higher internalizing behaviors (Boyce et al., 2001). If such a pattern is difficult to maintain over time due to physiological burnout, such infants may overtime become under-regulated and also engage in more externalizing type behaviors (Buck & Powers, 2005). Finally, no clear evidence linking the pattern of low arousal and low regulation to outcomes is apparent. It may be that infants who exhibit low negative affect and engage in limited vagal withdrawal are less reactive to stressful stimuli (i.e., temperamentally “easy”), or are resilient in the face of stress which may protect them from negative outcomes. Based on this prior research, we anticipate that infants who are aroused but well-regulated or resilient to stress (limited arousal and regulation) will demonstrate better child outcomes than infants who are aroused and poorly regulated or over-regulated.

1.3 Relevant research using the still-face paradigm

The Still-Face Paradigm (Tronick, Als, Adamson, Wise, & Brazelton, 1978) is ideal for examining the proposed patterns of arousal and regulation. The procedure consists of three brief episodes. During the engagement episode, mothers are asked to engage with their infants normally. During the still-face episode, mothers are instructed to show a neutral/impassive face and not to respond to infant signals. Then during the re-engagement episode, mothers return to normal face-to-face interaction with their infants (Tronick et al., 1978). The typical still-face effect has been well established such that, on average, infants show an increase in negative affect from the engagement episode to the still-face episode, and then a recovery of distress from the still-face episode to the re-engagement episode (Mesman & van IJzendoorn, & Bakermans-Kranenburg, 2009). Likewise, infant RSA decreases from the engagement episode to the still-face episode, and increases during the re-engagement episode, on average (Moore et al., 2009). Although this average response pattern is quite typical in the literature, vast individual differences exist in infants’ levels of negative affect and physiological reactivity across the still-face paradigm (Haley & Stansbury, 2003; Ham & Tronick, 2006; Moore & Calkins, 2004). For example, in one study, only one-third of the infants demonstrated the typical decrease in positive affect and increase in negative affect from the engagement to the still-face episode (Montirosso et al., 2015), and in another, half of the infants did not show an increase in cry faces from the engagement episode to the still-face episode (Ekas, Haltigan, & Messinger, 2013). Likewise, some infants showed RSA withdrawal, whereas some others did not during the still-face episode (Moore & Calkins, 2004), suggesting that the still-face paradigm is a useful paradigm for examining individual differences in patterns of arousal and regulation (Ham & Tronick, 2006; Moore & Calkins, 2004).

Although most studies that incorporated the still-face paradigm have focused exclusively on behavioral reactions or physiological reactions, a few studies have examined both. These studies illustrate that some infants who display high distress during the still-face episode do not exhibit RSA withdrawal, and some infants who exhibit low distress demonstrate RSA withdrawal (Ham & Tronick, 2006; Moore & Calkins, 2004). These patterns reflect different combinations of simultaneously observed arousal and regulation during the still-face, much as Lewis (1992) theorized. Although a person-oriented approach has been applied to multiple infant response modalities in the still-face paradigm in prior research (Montirosso et al., 2015; Papoušek, 2007), those studies did not include physiological indicators of infant regulation illustrating the novelty of our approach.

Moreover, patterns of infants' observed distress and RSA during the still-face may have meaningful predictive value for child outcomes given that mixed findings are reported on the main effect of infant distress on their subsequent problem behaviors. For example, in one study, infants who did not cry during the still-face episode at 6 months showed fewer internalizing behaviors at 18 months of age (Moore, Cohn, & Campbell, 2001). In contrast, in other studies, increased crying/negative reactivity during the still-face procedure was associated with fewer subsequent behavior problems (Ekas et al., 2013; Wagner et al., 2016). Thus, previous research illustrates that levels of infant negative affect during the still-face episode do not operate as a consistent predictor of child outcomes, perhaps because such associations are dependent on co-occurring levels of physiological regulation. To our knowledge, this proposition has yet to be tested. On the other hand, infants' RSA withdrawal during the still-face has been associated with positive outcomes (e.g., positive engagement, dyadic synchrony) during the normal play and reunion episode cross-sectionally (Bazhenova et al., 2001; Moore & Calkins, 2004; Provenzi et al., 2015), but no longitudinal associations between RSA withdrawal during the still-face and children's subsequent outcomes have been explored. Therefore, the current study is novel in that we examined the profiles of behavioral and physiological indicators during infancy in relation to children's subsequent functioning between age 1 and 4.

1.4 The current study

In the current study, we apply a latent profile analysis approach to examine patterns of concurrent infant observed distress and RSA during the still-face paradigm. Latent profile analysis is a person-centered statistical procedure that can classify individuals into subgroups based on similar responses across a set of indicators, and the characterization of the profiles is determined by an iterative process (Geiser, 2013). This analysis takes into account the individual's probability of being in more than one profile and it provides a probability estimate for each individual being assigned to each profile (Hagenaars & McCutcheon, 2002). In contrast to a variable-centered approach which examines the average pattern of behaviors across the sample, a person-centered approach can better detect individual differences by classifying individuals into profiles and this approach can test hypotheses about how child outcomes vary by profile membership (Lanza, Tan, & Bray, 2013). The goal of the current study is to examine the co-occurring patterns of infants' physiological and behavioral indicators of infant emotionality; therefore, this approach is chosen to examine patterns of individual differences in these co-occurring patterns and how these patterns may differentially predict children's subsequent functioning.

Based on Lewis' (1992) conceptualization, we expected four profiles to emerge during the engagement episode to the still-face episode: (a) infants who show high distress but no RSA withdrawal (i.e., under-regulated), (b) infants who display an increase in distress and RSA withdrawal (i.e., aroused, but regulated), (c) infants who exhibit low distress and engage in RSA withdrawal (i.e., over-regulated), (d) and infants who show low distress and no RSA withdrawal (i.e., resilient to challenge). We anticipated recovery from the still-face to the re-engagement episode to vary also, but did not have specific predictions given the lack of prior empirical evidence or theorizing about this. Furthermore, we hypothesized that infants' subsequent outcomes would vary as a function of profile membership such that: (1) infants in the under-regulated and over-regulated profiles would have poorer developmental outcomes than infants in the other two profiles; (2) infants in the under-regulated profile would be prone to heightened attachment resistance, aggression, and defiance; and (3) infants in the over-regulated profile would be prone to heightened attachment avoidance and internalizing behaviors.

2 METHOD

2.1 Participants

Participants in the current study were drawn from a prospective longitudinal study investigating the origins of maternal sensitivity during infancy. The initial sample consisted of 259 primiparous mothers (128 European American, 131 African American) and their infants. At recruitment, participants ranged in age from 18 to 44 years (*M* = 25 years). Twenty-seven percent of the participants had a high school degree or less, 27% had some college, and 46% had a 4-year college degree or beyond. Most (71%) mothers were married or living with their child's father, 11% were dating but not living with their child's father, and 18% were single or not living with the child's father. Annual family income ranged from <$2,000 to over $100,000; median income was $35,000. The analysis sample consists of 206 dyads. The children who did not have data at 6 months did not differ from the initial sample on race, gender, attachment status at 1 year, nor on situational compliance, defiance at 2 years, nor on aggressive and internalizing behaviors at 4.5 years.

2.2 Procedure

Expectant mothers were recruited during their third trimester from childbirth education classes, breastfeeding classes, obstetric practices, and via word of mouth. Mothers and infants visited our laboratory for a videotaped observation of mother–infant interaction including the Still-Face

Paradigm within 2 weeks of the infant's 6-month birthday (*M* = 6.39 months, *SD* = 0.72) and the Strange Situation when infants were 14 months old (*M* = 13.9, *SD* = 0.98). The toy clean-up task was completed in the laboratory when infants were 2 years of age (*M* = 27.32, *SD* = 2.52). Mothers completed the Child Behavior Checklist 1.5–5 when children were 4.5 years via an online survey. At the conclusion of each data collection wave, mothers were compensated $50–$120 and children received a small gift at each visit. All procedures were approved by the university's institutional review board.

2.2.1 RSA: still-face paradigm (6 months)

During the 6 month visit, electrodes were placed on the infant's right back near the collarbone, and one on each side of the lower ribs. Electrodes were then connected to the Biolog (UFI, Morrow Bay, CA), which stored heart rate data until uploaded to a computer for artifact editing and analysis. Once physiological devices were placed, infants were strapped in a high chair facing their mothers such that they were eye level with one another, and Velcro was used to secure the Biolog to the back of the infant's seat. Mothers were then instructed to engage in the Still-Face Procedure (Tronick et al., 1978) by playing with their infants as they normally would for 2 min (engagement phase), then looking at their infants with a still face for 2 min (still-face phase), and lastly, playing with their infants as they normally would for 2 min (re-engagement or reunion phase).

RSA scores were calculated using Porges’ (1985) method in 15-s epochs. Brief epochs have been validated for short duration tasks such as this one (Huffman et al., 1998; Moore et al., 2009). In cases in which artifact editing was >10%, RSA data was treated as missing and subsequently imputed based on available RSA data and race. This occurred in 42 (16%) of cases. Infant's mean RSA level was calculated for each episode of the still-face paradigm.

2.2.2 Observed distress: still-face paradigm (6 months)

Infant affect was continuously rated from digital files using INTERACT 9 (Mangold, Arnstorf, Germany). Infant affect was rated on a 7-point scale ranging from (1) high positive affect (open mouth, intense smile, can be laughing or squealing) to (7) high negative affect (screams, wails, sobs intensely; mouth wide), adapted from Braungart-Rieker and Stifter (1996) based on infants’ vocalizations, facial expressions, and body tension. Continuous event-based coding was used, meaning once a code was activated, it remained active until another code was selected. Thirty-four cases were double coded to calculate reliability; weighted κ = 0.76. Percentage scores were created reflecting the amount of time that infants displayed negative affect (i.e., a rating of 5, 6 or 7) for each episode of the still-face paradigm.

2.2.3 Attachment (1 year)

Infant-mother attachment security was assessed at 1 year using the Strange Situation Procedure (Ainsworth & Wittig, 1969; Ainsworth, Blehar, Waters, & Wall, 1978). The Strange Situation Procedure is a 25-min procedure which contains brief episodes of increasing stress for the infant, including two mother–infant separations and reunions. The Strange Situation was administered according to standard procedures and videotapes of all Strange Situations were coded by E.

Carlson. Using the traditional 3-category system, 168 infants were secure, 19 were resistant, and 16 were avoidant. Given low frequencies in the insecure subtypes, we utilize dimensional/continuous scores in our research using Fraley and Spieker's (2003) method. Specifically, the mean of proximity seeking (reversed), contact maintenance (reversed), and avoidance ratings from episodes 5 and 8 constituted the avoidance dimension ($\alpha = 0.86$); and the mean of resistance ratings from episodes 5 and 8 and the disorganization score constituted the resistance/disorganization scale ($\alpha = 0.53$). Given that resistance/disorganization included only three ratings, the relatively low internal consistency was acceptable (Cronbach, 1951). The inter-rater reliability for these composite scores based on 30 double-coded cases was good; intra-class correlation coefficients were .98 for avoidance and .86 for resistance/disorganized.

2.2.4 Compliance task/clean-up task (2 year)

The clean-up task was adapted from previous work conducted by Crockenberg and Litman (1990) and Kochanska and Aksan (1995). First, children played with a variety of age appropriate toys, and then the experimenter brought in 2 containers and instructed the mothers to get their child to clean up all of the toys. They were told that they could handle it any way they wanted, but they had to involve their child. The task ended either when the 5 min were over or when all of the toys were in the containers. Child compliance was continuously coded using event-based coding in Interact (Mangold, Arnstorf, Germany). Kochanska and Aksan's (1995) coding scheme was used. Situational compliance refers to the child being cooperative and accepting the mothers' agenda, but needing maternal prompting to get started or stay on task. Defiance refers to the child whining, fussing, crying, yelling, having a tantrum or throwing toys/kicking basket in an aggressive/angry manner when asked to clean up. Other compliance behaviors were coded as well. However, refusal and committed compliance (i.e., fully embracing the mothers' requests to clean up with little need for prompting) behaviors were low in frequency and duration, and passive non-compliance (i.e., calmly ignoring the mothers' request) is a relatively benign behavior. Therefore, we selected situational compliance and defiance as our focal behaviors of interest given the former reflects a clearly adaptive behavior and the latter a maladaptive behavior, and both had good distributional properties. Thirty cases were double-coded for reliability, $\kappa = 0.75$. The percent of task time that a child engaged in situational compliance and defiance were calculated.

2.2.5 The child behavior checklist 1.5–5 (4.5 years)

Mothers completed the Child Behavior Checklist 1.5–5 (CBCL; Achenbach & Rescorla, 2000) via a secure online survey administered via Qualtrics when children were 4 years old. The 99 items were rated on a 3-point scale (0 = not true, 1 = sometimes true, and 2 = very true). In this study, we focused on aggression (19 items, $\alpha = 0.88$) and internalizing symptoms (36 items, $\alpha = 0.84$). Internalizing symptoms included the sum of emotionally reactive behavior, anxious-depressed behavior, somatic complaints, and withdrawn behaviors. The aggression subscale was selected for use instead of the externalizing scale because the externalizing scale contains items that assess children's ADHD symptoms, which are not the key focus of this study.

3 RESULTS

3.1 Descriptive statistics and preliminary analyses

Descriptive statistics are reported in Table 1. As a manipulation check, we examined mean differences in observed negative affect and RSA across episodes of the still-face using repeated measures ANOVAs. In both cases, there were significant mean differences across episodes, F (2, 404) = 121.88, $p < .01$ for observed affect and F (2, 390) = 8.47, $p < .01$ for RSA. Follow-up pairwise comparisons demonstrated that RSA during each episode varied significantly from each other. The pattern was consistent with the typical still-face effect such that (a) infant negative affect increased significantly during the still-face, and (b) decreased significantly during the reunion compared to the still-face, but remained significantly higher than the initial phase. Matching the patterns of negative affect, (a) infant RSA declined during the still-face and was significantly lower than during the engagement phase, and (b) RSA during the re-engagement increased such that it was higher than during the still-face at a trend level, but remained significantly lower than during the engagement episode. Thus, as a group, infants in this sample displayed the typical still-face effect.

Table 1. Correlations and descriptive statistics
Table 1 may be found at the end of this document.

Next, we examined the zero-order correlations which also appear in Table 1. Correlations between (a) infant race and gender and maternal education and (b) infant negative affect, RSA, and child outcomes were calculated to identify possible covariates (i.e., those that correlated with both a predictor and outcome). African American/multi-race infants had higher RSA across the still-face episodes and higher attachment resistance scores than European American infants. Infants of more educated mothers' had lower attachment avoidance, defiance, and internalizing behaviors.

Then, cross-episode stability was examined for RSA and negative affect. Across episodes, negative affect was positively correlated with each other, and so was RSA, and these associations were large in magnitude, demonstrating high stability across episodes. Next, the correlations between negative affect and RSA were examined. Infants who exhibited higher negative affect during the engagement and re-engagement episode had lower RSA scores during the re-engagement episode, but these associations were small in magnitude, and the correlations between negative affect and RSA across other episodes of the still-face were near zero. These modest associations suggest heterogeneity in co-occurring patterns of affect and RSA in the sample. Finally, the correlations between RSA/negative affect and child outcomes were examined. Higher negative affect during the engagement and still-face episode was associated with more defiance during the clean-up task at 2 years. In addition, higher negative affect during the engagement episode was associated with lower compliance behavior during the clean-up task. In contrast, RSA scores were not associated with child outcomes.

3.2 Latent profile analysis

Latent profile analysis was used to examine profiles of individual differences in co-occurring negative affect and RSA. Latent profile analysis is a statistical procedure that can be used to classify individuals into latent types using a set of continuous indicators (Geiser, 2013). The optimal number of profiles is determined using the statistical indices such as the Bayesian Information Criterion (BIC), Akaike Information Criterion (AIC), Adjusted Bayesian Information Criterion (ABIC), entropy, and the Lo-Mendell-Rubin LRT likelihood (LMR) test and Vuong-Lo-Mendell Rubin likelihood ratio (VLMR) test as well as by considering the principle of parsimony and model interpretation (i.e., considering substantive theory, profile size, meaningfulness of each profile) (Brinkley-Rubinstein & Craven, 2014; Chung, Anthony, & Schafer, 2011; Muthén, 2003; Nylund, Asparouhov, & Muthén, 2007). Generally, smaller BIC, AIC and ABIC and larger entropy values indicate better model fit (Geiser, 2013). However, because none of the information criteria are certain to reach a single lowest value; in such cases, one can explore the "diminishing gains" in model fit based on these indices with the use of an "elbow" plot, which is similar to the use of scree plot of Eigen values in exploratory factor analysis (Masyn, 2013). That is, as the number of profiles increases, the "marginal gain" in fit may decrease, leading to the appearance of an angle, or elbow in the plot. The number of profiles at this point meets the "elbow" criteria, as is considered the best solution under these circumstances (Masyn, 2013). This approach has been applied in prior research using latent class/profile analysis (Harring & Houser, 2017; Petras & Masyn, 2010). Therefore, if the BIC, AIC or ABIC values did not reach a lowest point, the "elbow" point could be considered as the optimal profile solution. Other fit indices can also aid the interpretation: a significant VLMR or LMR test indicates that adding one more profile improves model fit (Geiser, 2013). For example, if the test of VLMR is significant for an N-profile model, then it indicates that the N-profile is a better solution compared to the N-1 profile model. When inconsistency in patterns emerge across different fit indices, theoretical conceptualizations are often used to determine the best solution (Bauer & Shanahan, 2007). Furthermore, various model fit indices have different degrees of power in detecting the correct number of profiles. Simulation studies indicate that the BIC performs consistently better than other indices including the AIC, ABIC, LMR and VLMR tests in deciding the correct number of profiles given that there is no adjustment for sample size for the AIC, and the LMR test is subjected to inflated type-1 error (Nylund et al., 2007).

In the current study, two to seven profiles were tested to find the model with the best fit (see Table 2 for model fit indices). Although the BIC value continued to decrease for the 5-, 6-, or 7-profile solutions, the "marginal gain" was trivial, and the BIC reached an "elbow" at 4 profiles from the scree plot. According to the principle of parsimony (Brinkley-Rubinstein & Craven, 2014; Chung et al., 2011), the 4-profile was a better solution compared to the 5-,6-, or 7-profile solution. On the other hand, the VLMR and LMR likelihood ratio tests indicated that the 3-profile was better than the 2-profile solution, but adding additional profiles beyond 3 did not improve fit. When there is inconsistency between difference indices, conceptual perspectives can help balance mildly contradictory statistics and aid the interpretation (Muthén, 2003; Nylund et al., 2007). Lewis' (1992) and Berntson Cacioppo & Quigley (1991) theories support a four-profile solution. Furthermore, the BIC performs better in detecting the correct number of profiles compared to the LMR and VLMR tests (Nylund et al., 2007), so the information provided from the BIC was weighed more heavily compared to the results from the VLMR and LMR tests. Therefore, the 4-profile solution was selected on the basis of the BIC "elbow" test and conceptual grounds. Thirty-seven percent of children (N = 76) were classified into profile 1, 33% (N = 68) into profile 2, 14% into profile 3 (N = 29) and 16% into profile 4 (N = 33). Next, profile membership was obtained for each individual based on their highest profile probability. To best interpret/describe the profiles, two-way repeated measures ANOVA analyses were conducted for negative affect and RSA with the profile membership as the between-subject variable and still-face episode as the within-subject variable.

Table 2. Model fit indices of profiles
Table 2 may be found at the end of this document.

3.2.1 Between-profile differences in overall negative affect and RSA

There were significant main effects of profile on overall levels of negative affect, F (3, 199) = 234.51, $p < .01$, and RSA, F (3, 192) = 97.61, $p < .01$ during the still-face paradigm. As displayed in Table 3, and apparent from inspecting Figure 1, profiles 1 and 4 exhibited significantly higher negative affect compared to profile 2 and 3 across the episodes during the still-face paradigm and none of the other comparisons were significant. With regard to RSA, profile 3 and 4 showed significantly higher RSA across the episodes during the still-face paradigm compared to profile 1 and 2, and none of the other comparisons were significant. Thus, the 4 profiles were somewhat characterized by overall mean differences in levels of affect and RSA across episodes.

Table 3. Mean (SD) comparisons of negative affect and RSA by profile and episode
Table 3 may be found at the end of this document.

FIGURE 1 IS OMITTED FROM THIS FORMATTED DOCUMENT
Figure 1. Patterns or RSA and negative affect in different profiles. The left axis refers to the percentage of time that infants exhibited negative affect, and the right axis refers to the values of RSA scores. Letters followed by a prime (') refer to means in RSA; letters without a prime refer to means in negative affect. Episodes noted by different letters differed from one another significantly. For example, a' and b' indicate that RSA during the two episodes significantly differed from each other, whereas a' and a' indicate that RSA during the two episodes did not significantly differ from each other. Aff, negative affect; en, engagement; sf, still-face; re, re-engagement

3.2.2 Within-profile differences in negative affect and RSA

In addition to the main effects of episodes on negative affect and RSA (as reported in the descriptive section) and the main effects of profile membership described above, there were also significant profile by episode interactions for negative affect (F (6, 398) = 14.15, $p < .01$) and for RSA (F (6, 384) = 2.26, $p < .05$). To further probe the interactions, two repeated measures ANOVA with still-face episodes as the within-subject factor were run for each profile: one for observed affect and one for RSA. Each of these analyses was significant except for the analyses of RSA for profile 3 and 4. The results are described below by profile (see Figure 1). For profile 1, F (2, 150) = 96. 28, $p < .01$, for negative affect, and F (2, 142) = 8.68, $p < .01$ for RSA; for profile 2, F (2, 134) = 21.49, $p < .01$ for negative affect, and F(2, 128) = 3.61, $p < .05$ for RSA, indicating that the changes across the episodes were significant for both negative affect and RSA for profile 1 and profile 2. For Profile 3, F (2, 52) = 6.94, $p < .01$ for negative affect, and F (2, 52) = .68, p = n.s. for RSA; for profile 4, F (2, 62) = 55.82, $p < .01$ for negative affect; F (2,

62) = .49, *p* = n.s. for RSA, indicating that negative affect, but not RSA values showed significant changes across the episodes for profile 3 and 4.

The alternative approach to probing the profile by episode interactions for negative affect and RSA was also considered by examining between-profile differences within each still-face episode (see Table 3). During the still-face and the re-engagement episodes, the differences across profiles were consistent with the main effects such that profile 1 and profile 4 showed higher negative affect compared to profile 2 and 3. However, during the engagement episode, profile 1 showed higher negative affect compared to profile 4, indicating that profile 1 started out with more negative affect compared to profile 4 (see Figure 2). In addition, the patterns of significant differences in RSA values across profiles within an episode were all consistent with the main effects such that profile 3 and 4 showed higher RSA compared to profile 1 and 2. Therefore, the majority of the within-profile differences were consistent with the between-profile differences.

FIGURE 2 IS OMITTED FROM THIS FORMATTED DOCUMENT

Figure 2. Profiles in relation to child outcomes. Profile 1 (highly distress, but regulating), profile 2 (over-regulated), profile 3 (resilient to distress), profile 4 (under-regulating)

3.2.3 Profiles

Profile 1 was characterized by overall high negative affect and low RSA levels across episodes. During the still-face episode, this profile showed a significant increase in negative affect and RSA withdrawal, indicating that infants in this profile experienced the still-face effect. However, this profile showed no recovery in either RSA or negative affect during the reunion episode. Thus, this profile was termed “highly distressed, but regulating.”.

Profile 2 was characterized by relatively low negative affect and low overall RSA levels across episodes. This profile of infants exhibited a significant increase in negative affect and significant RSA withdrawal during the still-face episode, indicating signs of physiological regulation, and a significant recovery of both at reunion. Given physiological regulation occurred in the context of low distress relative to other groups, this profile was termed “over-regulated.”.

Profile 3 was characterized by low negative affect and high overall RSA levels across the episodes. This profile showed a significant increase in negative affect during the still-face episode, and a significant recovery of distress at the re-engagement episode, which was consistent with the still-face effect. Although changes in RSA across episodes were not statistically significant, descriptively they were in the prototypic pattern (i.e., withdrawal, followed by recovery). This profile appeared relatively resilient to the still-face with low levels of distress that were similar to profile 2, but the two differed in that profile 3 had higher “baseline” and overall RSA levels, thus this profile was termed “resilient to distress.”.

Profile 4 was characterized by overall high levels of negative affect and high levels of RSA across the still-face paradigm. This group showed a significant increase in negative affect during the still-face episode, and no recovery of distress at reunion. RSA did not change significantly across the episodes. Considering that profile 4 demonstrated high distress throughout with no signs of physiological regulation, this profile was termed “under-regulated.”.

3.3 Profile differences in child outcomes

Before examining profile-based differences in child outcomes, whether the potential covariates identified above (infant race and maternal education) vary based on profiles was examined. The results showed that maternal education did not differ among profiles, but infant race did. African American infants were more likely to be in profile 3 and 4 compared to profile 1 and 2. Given that infant race was also associated with child outcomes, it was controlled in the subsequent analysis using the Bolck-Croon-Hagenaars (BCH) method (Bolck, Croon, & Hagenaars, 2004). The BCH method is recommended for analyses that examine how profiles are associated with child outcomes while controlling for covariates, given that this method can better account for individual probabilities of belonging to a specific profile compared to forcing each individual into a profile, which may inflate the estimated error rate (Asparouhov & Muthén, 2014). First, the LPA model with the covariate race was estimated, and the BCH weights were saved. Next, controlling for infant race, the effects of the latent profiles on each child outcome were examined. The *p*-value of Wald Test of Parameter Constraints was used to examine the mean difference among profiles in pairs (e.g., whether m1 = m2, m1 = m3, m2 = m4). For example, in a comparison of profiles 1 and 2, a *p*-value that is less than .05 indicates that the null hypothesis of m1 = m2 is rejected, and there is a mean difference between profile 1 and profile 2 on a specific child outcome (e.g., aggression) after controlling for infant race. The means are displayed in Figure 3 and Table 4and all significant between-profile differences are noted in Table 4.

FIGURE 3 IS OMITTED FROM THIS FORMATTED DOCUMENT
Figure 3. The graphs depicting the interactions between episodes and profiles for negative affect and RSA. en, engagement, sf, stillface, re, re-engagement. p1, profile 1 (highly distress, but regulating); p2, profile 2 (over-regulated); p3, profile 3 (resilient to distress); p4, profile 4 (under-regulating)

Table 4. Means (*SD*) comparison of outcomes based on profiles
Table 4 may be found at the end of this document.

First, profile 3 (resilient to distress) demonstrated the most significant differences with other profiles and the clearest pattern such that infants in profile 3 generally had more adaptive outcomes. That is, three out of three significant differences indicated better outcomes for profile 3 relative to profile 1 (distressed but regulating) including: lower aggression and internalizing behaviors, and higher compliance. Likewise, three out of three significant differences between profile 3 and profile 2 (over-regulated) demonstrated more favorable outcomes for profile 3: lower avoidance and internalizing behavior (at a trend level), and higher compliance. Finally, in contrast to profile 4 (under-regulated), profile 3 had lower aggression at 4.5 years. Thus, the “resilient to distress” profile was generally characterized by more adaptive outcomes than the other profiles, consistent with expectation.

Beyond the generally poorer outcomes for profile 1 (distressed, but regulating) compared to profile 3, fewer and less consistent differences were apparent when profile 1 was compared to profiles 2 (over-regulated) and 4 (under-regulated). On the one hand, profile 1 demonstrated a poorer outcome, higher defiance, than profiles 2 and 4, but also better attachment outcomes than profiles 2 and 4 (lower attachment avoidance and resistance respectively). In sum, the finding that the "distressed but regulating" profile did not demonstrate consistently more adaptive outcomes than the "under-regulated" or "over-regulated" profiles was unexpected.

Relatively few group comparisons involving profiles 2 (over-regulated) and 4 (under-regulated) were significant, but some difference emerged that were somewhat consistent with expectation. Specifically, profile 2 (over-regulated) demonstrated the highest levels of attachment avoidance and higher internalizing behaviors, and differed significantly from profile 3 on both and profile 1 on avoidance. Profile 4, under-regulated, was highest on attachment resistance and significantly moreso than profiles 1 and 2. Profile 4 also had higher level of aggression, but only differed significantly form profile 3 in this regard.

In sum, profile 3 (resilient to distress) demonstrated more adaptive outcomes compared to the three other profiles. Profile 1 (highly distressed, but regulating) displayed a mixed pattern of outcomes characterized by higher defiant behaviors, better attachment outcomes and higher behavior problems. Profile 2 (over-regulated) scored higher on attachment avoidance and internalizing behaviors and lower on defiant behavior. Profile 4 (under-regulated) scored higher on attachment resistance, lower on defiance and higher on aggressive behaviors. Notably, the profile that is characterized by overall high levels of RSA and lower distress (profile 3) demonstrated the best outcomes.

4 DISCUSSION

This study examined infant profiles of observed distress and RSA across the three episodes of the still-face paradigm procedure using a person-centered approach. We hypothesized that four profiles that differed based on specific patterns of RSA and observed distress across the episodes during the still-face procedure would emerge, and these profiles would be uniquely associated with child outcomes. The results from the latent profile analysis generally supported our hypothesis that four profiles would emerge based on different combinations of observed distress and RSA, and these were somewhat consistent with expectation. Further, as expected, profiles based on combinations of observed affect and RSA were more predictive of subsequent child outcomes than either measure on its own. In the following paragraphs we describe each profile and affiliated outcomes in relation to our hypotheses and existing literature.

Consistent with prediction, four profiles that were somewhat consistent with Lewis' (1992) proposition and with Bertson's et al. (1991) theory of autonomic space emerged. Profile 1 (highly distressed, but regulating) was characterized by higher overall distress, lower overall RSA levels, and RSA withdrawal during the still-face episode. However, this profile demonstrated ongoing distress and RSA withdrawal during the re-engagement episode suggesting that infants' regulatory efforts were not particularly effective in the moment. Thus, this profile was somewhat, but not fully consistent with Lewis' (1992) notion of a highly distressed but well-regulated group. Contrary to prediction, infants in the "highly distressed, but regulating" profile did not demonstrate consistently better outcomes than the “over-regulated” and “under-regulated” profiles. They were more likely to be defiant suggesting elevated distress during frustrating situations with their mother, but they had more adaptive attachment outcomes than the over- and under-regulated profiles. However, they had consistently poorer outcomes than infants who were resilient to distress. The overall depressed RSA levels in this profile may reflect relatively lower resources to draw from to help them return to homeostasis when aroused (Porges, 2011). Therefore, these children may be more likely to vent their frustration rather than having appropriate ways of dealing with it (Moore et al., 2001). Obtaining more information from these children's social environment will help researchers understand the etiology of their lower RSA levels and possible moderators of links with child outcomes over time.

Profile 2 (over-regulated), demonstrated the typical still-face effect with evidence of both arousal and regulation followed by recovery, but the mean levels of distress and RSA were quite low. This suggests that infants were engaging in a relatively high degree of physiological regulation in the context of limited distress fitting with the notion of low arousal and high regulation (Lewis, 1992). Infants in the “over-regulated” profile were higher in attachment avoidance and internalizing behaviors. This pattern is consistent with prediction and prior research. That is, children with an avoidant attachment are more likely to minimize their observed distress but actually experience high physiological arousal (Cassidy, 1994; Hill-Soderlund et al., 2008). They may engage in physiological regulation to downregulate their arousal; however, without the caregiver's assistance, their physiological regulation is likely to be ineffective (Calkins & Leerkes, 2011). Therefore, these children's tendency to internalize their distress and their failed attempts at physiological regulation place them at risk for developing internalizing behaviors (Boyce et al., 2001).

Profile 3 (resilient to distress) showed overall lower distress with an increase during the still-face and higher overall RSA levels that did not change significantly across still-face episodes. The limited distress reaction followed by recovery with no evidence of physiological regulation suggests that it was relatively easy for these infants to maintain their composure in the still-face. This group is consistent with Lewis’ (1992) notion of a low arousal, low regulation group. This profile had the most adaptive outcomes including lower attachment avoidance, higher compliance behavior and lower behavior problems. This group of infants might have a relatively easy temperament or be relatively less vulnerable to stress protecting them from negative outcomes over time. This pattern is consistent with prior research showing that low levels of infant distress during the still-face was associated with a range of positive outcomes (Moore et al., 2001), and that higher baseline RSA is indicative of good emotion regulation abilities (Calkins, 1997) and fewer behavior problems (Suurland et al., 2018).

Last, profile 4 (under-regulated) was characterized by showing overall high distress and RSA levels, increased distress during the still-face without recovery and no change in RSA across the still-face episodes. The very high and sustained distress reaction with no evidence of regulation suggests that these infants did not engage in physiological regulation despite a clear need, which is consistent with a high arousal, low regulation group (Lewis, 1992). The “under-regulated” profile demonstrated the fewest differences with other profiles. Consistent with prediction, the “under-regulated” profile showed higher attachment resistance at 1 year compared to the “high distressed, but regulating” and the “over-regulated” profiles. Somewhat consistent with the hypothesis that the “under-regulated” profile would show more aggressive behaviors (Degnan et al., 2008), they showed higher aggressive behaviors at 4.5 years compared to the “resilient to distress” profile. This profile did not differ from the other profiles on most of the other outcomes. Considering that this group did not attempt to engage in physiological regulation despite experiencing high distress, facilitating the development of physiological regulation abilities in this group would be beneficial (Calkins & Leerkes, 2011).

Generally, our findings suggest that infants in profiles with lower overall RSA levels (profile 1 and 2) were more likely to show maladaptive outcomes, especially compared to infants in profile 3 characterized by higher overall levels of RSA and lower distress. Therefore, it seems that the levels of RSA that distinguish the profiles moreso compared to the changes in RSA across the episodes. This is also supported by the fact that despite that the omnibus tests of the interactions between profiles and still-face episodes were significant for both RSA and negative affect, all the significant differences were consistent with the main effects across profiles except for that negative affect during the engagement episode was higher for profile 1 (high distressed but regulating) compared to profile 4 (under-regulated). These findings are in line with Porges’ (1995a) proposition that an enduring depressed vagal tone, indexed by lower RSA levels, indicates compromised homeostasis in individuals and vulnerability to stress at a physiological level. Infants with chronic lower RSA levels may have a difficult time engaging in physiological regulation during a stressful situation, serving as a risk factor for developing externalizing and internalizing behaviors in the future. The findings from the current study are aligned with a body of literature showing that higher RSA levels are associated with a host of adaptive outcomes among infants (Fox, 1989; Porges et al., 1994; Suess et al., 1994), older children, adolescents, and adults (Blandon et al., 2010; Forbes et al., 2006; Graziano & Derefinko, 2013; Hinnant & El-Sheikh, 2009; Skowron et al., 2014; Yaroslavsky et al., 2013). Given evidence that lower RSA levels are a function of chronic daily stress (Porges, 1995a), it may be the case that observed associations are driven by negative environmental conditions which constrain RSA functioning.

The findings from the current study are not contradictory with the previous literature demonstrating the advantages of engaging in RSA withdrawal given that infants with higher baseline RSA would have more psychological resources or higher potentials to engage in RSA withdrawal during challenging situations (Calkins, 1997; El-Sheikh, 2005; Moore & Calkins, 2004). Furthermore, recent literature usually examined the two indices together to predict child functioning. For example, school-aged children who showed both lower baseline RSA and higher RSA withdrawal had higher internalizing symptoms, whereas those who demonstrated lower baseline RSA and RSA augmentation had higher externalizing symptoms (Hinnant & El-Sheikh, 2009). Therefore, children's RSA withdrawal needs to be considered in the context of their RSA levels, and engaging in RSA withdrawal when RSA levels are already low may be less effective and is associated with future behavior problems. Additional work of this sort with infant sample is needed.

In sum, the most consistent differences were between profile 3 (resilient to distress) and the other profiles. These findings indicated that high levels of RSA are adaptive in conjunction with lower negative affect. However, the infants in profile 3 (resilient to distress) were not particularly distressed by the still-face, so the lack of RSA withdrawal in this context is not particularly surprising. Importantly, profile 3 was the smallest group and may reflect a relatively rare pattern.

Nevertheless, these findings still have implications for the literature in that much prior research has focused solely on RSA rather than looking at changes in the context of initial or overall levels of RSA, or concurrent arousal/affect (e.g., Bazhenova et al., 2001; Moore & Calkins, 2004). Furthermore, the findings from this study showed that both indices of RSA: baseline RSA and RSA withdrawal need to be considered to predict child outcomes. An important contribution of this study is the inclusion of behavioral and physiological indicators of infant affect. None of the previous studies have included both physiological and behavioral indicators across the three episodes during the still-face procedure using a person-centered approach. This study also examined how these profiles were associated with subsequent child functioning including attachment, compliance behavior and behavior problems between age 1 and 4. Additionally, previous studies examining the still-face paradigm have usually focused on one or two episodes. This study takes the overall patterns of observed distress and RSA into consideration, which gives a more complete picture of the dynamic changes in children's behavior and physiology during the still-face paradigm. Strengths of the study include the diverse sample, inclusion of both observed and mother-reported child outcomes, and the use of latent profile analyses with attention to covariates.

The limitations of this study include the fact that the still-face paradigm took place after some other distressing tasks including an arm restraint and a novel toy task. Even though there was a break in between the previous tasks and the still-face task, it is possible that infants might have carried over some distress to the still-face procedure. Additionally, recent research has found that RSA levels can be considered as a biological sensitivity factor as RSA levels interact with children's social environment/maternal characteristics to predict children's subsequent outcome (Conradt, Measelle, & Ablow, 2013; Peltola et al., 2017). Therefore, to better understand the role of RSA levels play in children's adjustment, the caregiving environment/maternal characteristics may need to be considered in the future. Furthermore, future work could also use a more direct measure of the activities of the sympathetic nervous system such as PEP (pre-ejection period) to better examine Bertson and colleagues' (1991) theory on the individual differences in the activities of the autonomic nervous system.

In sum, this study identified four profiles of infants by examining the joint effects of overall RSA levels and observed distress during the still-face paradigm. The four profiles were associated with differential child outcomes. The findings showed that higher overall levels of RSA are adaptive in conjunction with lower negative affect. This study illustrated the need to include indicators from multiple levels of analysis (i.e., behavioral and physiological) and to use a person-centered approach to better understand individual differences in emotional functioning during infancy.

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Table 1. Correlations and descriptive statistics

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13 (race)**	**14 (edu)**
Negative affect														
1. Engagement		.63**	.64**	−.02	−.14	−.15*	−.06	.11	−.20**	.24**	.04	−.04	−.02	-.09
2. Still-face			.77*	.07	−.06	−.06	−.02	.14	−.07	.15*	−.04	−.05	−.05	-.04
3. Reengage				.02	−.07	−.17*	−.08	.14	−.09	.07	.02	−.02	−.04	−.04
RSA														
4. Engagement					.72**	.69**	−.10	.07	−.00	−.12	−.04	−.05	−.36**	−.08
5. Still-face						.74**	−.13	.03	−.00	−.13	−.09	−.08	−.31**	-.08
6. Reengage							−.12	.00	−.02	−.10	−.09	−.06	−.27**	-.01
Attachment														
7. Avoidance								−.16*	−.14	.23**	.09	.17*	.04	−.28**
8. Resistance									−.01	−.04	.07	.06	−.15*	.08
Compliance														
9. Situational										−.30**	−.01	.00	.05	.14*
10. Defiance											.01	−.03	−.04	−.21**
Child outcomes														
11. Aggression												.71**	.03	−.18*
12. Internalizing													−.11	−.22**
M	0.30^{a}	0.60^{b}	0.54^{c}	3.65^{a}	3.40^{b}	3.51^{b}	3.94	2.22	18.64	6.89	7.81	7.11		
SD	0.31	0.38	0.39	0.99	1.09	1.31	1.14	1.08	15.08	17.02	5.57	6.38		

Different superscripts for means in negative affect and RSA indicate that the values differed significantly from each other.
$^{*}p < .05$, $^{**}p < .01$

Table 2. Model fit indices of profiles

Number of profiles	**AIC**	**BIC**	**ABIC**	**Entropy**	**Vuong-Lo-Mendell-Rubin likelihood ratio test (VLMR)**	**Lo-Mendell-Rubin test (LMR)**
2 profiles	1,934	1,997	1,937	0.97	$p = .00$	$p = .00$
3 profiles	1,850	1,936	1,854	0.89	$p = .03$	$p = .03$
4 profiles	1,762	1,872	1,767	0.88	$p = .10$	$p = .11$
5 profiles	1,700	1,832	1,706	0.88	$p = .11$	$p = .12$
6 profiles	1,643	1,780	1,651	0.88	$p = .13$	$p = .14$
7 profiles	1,596	1,776	1,604	0.89	$p = .57$	$p = .58$

Table 3. Mean (SD) comparisons of negative affect and RSA by profile and episode

Episode	Profile 1 (highly distressed, but regulating)	Profile 2 (over-regulated)	Profile 3 (resilient to distress)	Profile 4 (under-regulated)	Sig. profile differences
Negative affect					
Engagement	0.51 (0.29)	0.10 (0.14)	0.08 (0.12)	0.39 (0.32)	1 > 2,3,4;4 > 2
Still-face	0.87 (0.19)	0.30 (0.30)	0.26 (0.28)	0.86 (0.18)	1 > 2,3;4 > 2,3
Re-engagement	0.89 (0.14)	0.17 (0.16)	0.13 (0.16)	0.83 (0.17)	1 > 2,3;4 > 2,3
Means across episodes	0.76 (0.21)	0.19 (0.20)	0.15 (0.19)	0.70 (0.22)	1 > 2,3;4 > 2,3
RSA					
Engagement	3.24 (0.71)	3.13 (0.68)	4.78 (0.67)	4.70 (0.67)	3 > 1,2;4 > 1,2
Still-face	2.80 (0.85)	2.94 (0.67)	4.65 (0.51)	4.61 (0.71)	3 > 1,2;4 > 1,2
Re-engagement	2.80 (1.15)	3.12 (0.81)	4.84 (0.95)	4.76 (1.03)	3 > 1,2;4 > 1,2
Means across episodes	2.94 (0.90)	3.06 (0.72)	4.76 (0.71)	4.69 (0.80)	3 > 1,2;4 > 1,2

p-values for all the significant differences were below .01 level except for 1 > 4 ($p < .05$).

Table 4. Means (*SD*) comparison of outcomes based on profiles

	Profile 1 (highly distressed, but regulating)	Profile 2 (over-regulated)	Profile 3 (resilient to distress)	Profile 4 (under-regulated)	Sig. profile differences
Avoidance 1 year	0.06 (0.97)	0.19 (0.93)	−0.34 (1.05)	−0.53 (0.93)	2 > 1;2 > 3
Resistance 1 year	0.11 (0.93)	−0.26 (0.94)	0.09 (0.96)	0.15 (1.06)	4 > 1,2
Compliance 2 year	−0.23 (0.97)	0.13 (0.97)	0.26 (1.08)	0.07 (0.98)	3 > 1,2
Defiance 2 year	0.14 (0.99)	−0.01 (0.89)	−0.13 (0.90)	−0.37 (0.90)	1 > 2,4
Aggression 4.5 year	−0.02 (0.10)	0.08 (1.01)	−0.35 (1.03)	0.01 (1.02)	1 > 3;4 > 3
Internalizing 4.5 year	0.05 (1.02)	0.15 (1.04)	−0.13 (1.09)	−0.17 (1.02)	1 > 3;2 > 3†

p-values for all the significant differences were below. 05 level except for 2 > 3 ($p = .087$).