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Infant Regulatory Disorders: Temperamental, Physiological, and Behavioral Features

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Abstract

Successful development during the first year of life is dependent on the infant's ability to regulate behavioral and physiological state in response to unpredictable environmental challenges. While most infants develop skills to self-soothe and regulate behavior, a subset lacks these skills and develops regulatory disorders (RD).

Objectives—To evaluate the component features of RD by determining if infants with RD differ from typically developing infants on measures of temperament, respiratory sinus arrhythmia, heart rate, and mother-infant interactions.

Methods—Parents of 50 9-month old infants completed behavioral questionnaires that provided information necessary to complete the Regulatory Disorders Checklist, which evaluates for difficulties in self-regulation and hypersensitivities. Infants with difficulties in both domains were assigned to the RD group. Mothers and their infants were videotaped interacting for 10 minutes. Infant heart rate was monitored before and during the mental development test.

Results—The RD group (n=10) was more temperamentally difficult and exhibited atypical physiological regulation relative to infants with difficulties in either self-regulation or hypersensitivity (n=25) or infants with no difficulties (n=15). During the mother-infant interactions, the RD group exhibited more high-level withdrawal behaviors, including verbal and physical protests, although there were no differences in the quantity and quality of the maternal approaches.

Conclusion—Infants with RD have both temperamental and physiological regulation difficulties, and may be in a physiologically state that makes it difficult to moderate behavior in response to social demands. Mothers of RD infants might be taught to modify their behavior to help their infants regulate behavioral and physiological state.

Keywords

Infants; regulatory disorders; difficult temperament; heart rate variability; respiratory sinus arrhythmia; mother-child interaction

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Successful development during the first year of life is dependent on the infant's ability to regulate behavioral and physiological state in response to unpredictable environmental challenges. Most infants develop skills to self-soothe and to regulate behavioral state in a variety of contexts by 6-months of age¹. However, there is a subset of infants who persist with problems of regulation. This small subset, perhaps due to atypical neural regulation of physiological state, may have a regulatory disorder (RD). Due to a deficit in self-regulation, RD infants may have a low threshold to become behaviorally and physiologically aroused (i.e., expressed as increases in heart rate and other physiological manifestations of excitation of the sympathetic nervous system) in high-level stimulating environmental situations.

The expression of regulatory problems is a difficult challenge for any parent, especially first-time parents who are unfamiliar with the range of normal infant behavior and are still figuring out how to regulate their child's behavior. The parents may follow advice from well-meaning grandparents or others without success and start to believe that their parenting is inadequate. This may lead to feelings of ineptness, along with guilt, related to the negative feelings elicited by the child's behavior. The words of a mother, who stated that she loved her child but just didn't like him, and felt guilty about her feelings, captures the difficulty of the situation. Thus, for parents who believe that their child's behaviors are their fault the early detection of RD is crucial.

DeGangi and colleagues² postulated that infants with regulatory disorders needed to meet at least two diagnostic criteria that included difficulties with sleeping, consoling, feeding, and hyperarousal. Following this, Greenspan developed clinical criteria for RD included in the Diagnostic Classification: Zero to Three³. The criteria included behavioral patterns (i.e., sleep and feeding problems) as well as difficulty with sensory, sensory-motor, and organizational processing that greatly impact the child's functioning. More recent research⁴ proposed that a diagnosis of RD be given to infants who had both poor self-regulation and hypersensitivities to touch and/or movement. However, the proposed RD definition excludes sleep difficulties from the diagnostic criteria, since sleep difficulties are a developmental issue that often resolves. These new criteria were incorporated into our definition of RD as a disorder involving both difficulties with self-regulation and hypersensitivities without significant developmental delays.

Researchers have investigated infant temperament as a dimension of RD, which may relate to later behavioral problems. A study comparing infants with RD with typically developing infants found that higher parental reports of difficult temperament were related to negative developmental outcomes only for infants with RD, whereas this construct was related to positive developmental outcomes for typically developing infants⁵.

Research exploring whether RD infants have a unique patterns of physiological reactivity has focused on respiratory sinus arrhythmia (RSA), a measure of cardiac vagal tone reflecting the amplitude of periodic changes in heart rate at approximately the frequency of spontaneous breathing⁶. While the infants without RD exhibited a suppression of RSA during a cognitive challenge, the RD infants tended to have higher baseline RSA and not to reliably suppress RSA during the challenge².

A study⁵ exploring developmental outcome found that infants, who were rated as more temperamentally difficult and who had higher baseline RSA, exhibited more behavioral difficulties at 4 years of age. The results of this and another study⁴ suggest that children with early regulatory difficulties are at risk of developing later emotional/behavioral, language, perceptual, and sensory integrative difficulties in the preschool years.

The manifestations of RD may negatively impact mother-child interactions. DeGangi and colleagues⁷ reported that, in contrast to typically developing peers, infants with regulatory

disorders displayed more flat affect and aggressive and noncontingent responses, and did less tactile exploration during play. Although this study provides useful information, their coding system was unable to determine whether the response of the infants with RD differed as a function of the type of maternal approaches.

The importance of understanding that individual factors lead to the infant responsiveness to maternal approaches is consistent with Schneirla's theory⁸, which can be applied to the developing child. According to Schneirla's model, whether the organism approaches (comes closer) or withdraws (moves away) from the stimulation is determined by the intensity of stimulation (i.e., physical characteristics of the stimulus) and the ability of the autonomic nervous system (parasympathetic or sympathetic components) to regulate physiological and behavioral state (i.e., individual difference in physiological and behavioral regulation). Generally, during low-level stimulation, the parasympathetic system will be favored and the organism will approach the stimulus. In contrast, during high-level stimulation, the sympathetic system will be favored and defensive mobilization strategies (i.e., fight or flight behaviors) will be elicited and the organism will withdraw from the stimulus.

Conceptually, the Polyvagal Theory^{6,9, 10}, which expands Schneirla's approach-withdrawal model, provides a hierarchical model based on the phylogeny of the autonomic nervous system that links physiological state to adaptive behaviors. According to the Polyvagal model, reciprocal social engagement behavior requires an ability to efficiently regulate visceral state by the rapid withdrawal and re-engagement of a uniquely mammalian myelinated vagus. Without the re-engagement of the myelinated vagus, sympathetic excitation may support mobilization fight/flight behaviors (e.g., withdrawal), and in absence of mobilization strategies an unmyelinated vagal system may result in behavioral shutdown, dissociative states, and syncope.

Given the need to understand how the quality of maternal engagement strategies influences the infants' responses, the Approach-Withdrawal Interaction Coding System¹¹ (AWICS), which is based on Schneirla's theory of approach and withdrawal⁸, was developed. Doussard-Roosevelt and colleagues¹² used this measure to compare the mother-child interactions of autistic and nonautistic children. They reported that the children with autism were less contingent to maternal approaches. The autistic children responded with an approach behavior (either high or low-level approach behaviors rather than high or low-level withdrawal behaviors) 41% of the time, whereas the nonautistic children responded with an approach behavior 63% of the time. In addition, the autistic children exhibited fewer behaviors that send a clear message to the parent about wanting to continue the interaction (i.e., high-level approaches). The authors proposed that the use of the AWICS could benefit parents of autistic children and their clinicians, because the AWICS identifies the characteristics of maternal approaches most likely to lead to prosocial responses in the child.

The AWICS may be a useful tool to study RD, since RD infants constitute another group of children who become easily over-stimulated and behaviorally disruptive during mother-infant interactions. Given that infant temperament^{13,14,15} and autonomic regulation¹⁶ may affect their interactions with their parents, the current study compares how infants with and without RD differ according to temperament, RSA, heart rate, and maternal and infant behaviors during mother-child interaction. Since RD involves both difficulties with self-regulation and hypersensitivities, infants with RD were compared to infants with difficulties in only one of these domains (One Domain group) and infants with no difficulties in these domains (No Difficulties Group). It was hypothesized that infants with RD would be more temperamentally difficult, exhibit more atypical physiological regulation, and display less contingent and more withdrawal behaviors in response to their mother approaches during

play. If the hypotheses are supported, it would suggest that infants with RD are uniquely different from infants with temperamental difficultness or hypersensitivities.

METHODS

Participants

Participants were recruited as a part of a larger prospective study assessing the relationship between RD, temperament, RSA, heart rate, and behavioral patterns among children from 9 to 54 months of age. Participants were recruited from the metropolitan Washington, DC area via newspaper advertisements and flyers (posted at physician's offices) inviting mothers of 7 to 9 month old infants to participate in the research project. To insure a broad range of infant behaviors, separate advertisements invited parents with difficult infants and parents with non-difficult infants. All parents who called the laboratory were screened during a brief telephone interview to ensure that their children were within the appropriate age range and did not meet any of the exclusion criteria (i.e., low birth weight, prematurity, and neurological damage). Of the 66 dyads evaluated when the infants were 9 months old, 16 dyads were excluded from the current study due to difficulties in videotaping of the parent-child interactions or because the dyad included fathers.

The current paper describes the 50 infants (24 males, 26 females) with behavioral data and their mothers. All infants were born full term with no major medical complications. Two infants were slightly outside of the average weight for full term babies¹⁷. Average birth weight was 3505.09 grams ($SD = 418.06$) and the average age at time of assessment was 9 months ($M = 9.23$; $SD = .92$). The majority of the infants (66%) were first born. The mothers were all married and between 20 and 39 years of age ($M = 31.90$; $SD = 4.65$) and had an average of 16.28 years of education (range 10 to 21 years; $SD = 2.29$).

Ten of the 50 dyads had incomplete infant physiological data and were excluded from the analyses of RSA and heart period. Analyses determined that these 10 dyads did not differ from the dyads with physiological data on the infant/maternal characteristics or the mother-child interaction variables.

Procedure

After eligibility for the study was determined, an appointment was scheduled. Measures assessing infant and maternal characteristics were mailed out a few days before the appointment for the parents to complete and bring to the session. When the dyads arrived for the session, the researchers collected the measures and did not review them in order to ensure that they were unaware of the temperamental qualities of the infants during the evaluation. During the session, mental and motor development were assessed, ECG was monitored, and the participants were given a small gift for their participation.

Measures and Constructs

Infant Measures—The extent of regulatory disorders was measured via the Regulatory Disorders Checklist (RDC), which conceptualizes RD as proposed by DeGangi and colleagues⁴. The RDC is a diagnostic checklist indicating regulatory disorder characteristics among infants completed by researchers from information provided by the parents and observed by the researchers during the developmental test. The RDC is scored according to available information from the Fussy Baby Questionnaire¹⁸, Infant Characteristics Questionnaire¹⁹, Infant Behavior Questionnaire²⁰, and the Infant Behavior Record, Mental Development Index, and Psychomotor Development Index of the Bayley Scales of Infant Development²¹. The items in the RDC fall into the: 1) self-regulation difficulties domain (i.e., difficulties in regulating emotional lability, self-consoling, change in routine, contact

by others, feeding, and elimination); 2) hypersensitivities domain (i.e., specific sensory modalities including hypersensitivity to tactile, oral-ingestive, olfactory, auditory, visual-spatial, and kinesthetic stimulation); and 3) other developmental concerns domain identifies difficulties in activity level, attention, sleep, muscle tone and stability, gross and fine motor activity, receptive and expressive language, and mental development. Based on these criteria, the infants were categorized into three groups: 1) No Difficulties (i.e., the infant did not meet the criteria for either the self-regulation or hypersensitivities domain), One Domain (i.e., the infant met the criteria for either the self-regulation or hypersensitivities domains), and RD (i.e., if the infant met the criteria for both the self-regulation and hypersensitivities domains).

To assess difficultness, each parent completed the 6-month version of the Infant Characteristics Questionnaire¹⁹ (ICQ) prior to the 9-month session. Higher scale scores on the difficultness scale indicate more emotionally problematic characteristics. In addition, the Bayley Scales of Infant Development²¹ were administered to ensure that the participants were developing within the typical range. The Bayley provides two overall scores: the Mental Development Index (MDI), which assesses cognitive and perceptual abilities, and the Psychomotor Developmental Index (PDI), which assesses gross and fine motor skills. The scales are standardized with a mean of 100 and a standard deviation of 15²¹.

Mother-Child Interactions—The quality of the mother-child interactions was assessed via the AWICS¹¹. The approach behaviors of each mother were coded according to type of approach. Physical approaches involve physical movement toward and/or contact with the infant. Social approaches involve the use of social cues to engage the infant (e.g., facial, gestural, vocal cues). Object approaches involve the use of an object to engage or sustain the attention of the infant. Both the social and object approaches are further subdivided depending on whether the mother was talking or not during the approach. Thus, there were six approach types (i.e., verbal social, nonverbal social, verbal object, nonverbal object, physical proximity, and physical contact) that were not mutually exclusive. For example, a parent may have approached in a manner that involved touching the child (physical contact) while introducing a toy. Each approach was also described with regard to the corresponding intensity (low-, mid-, or high-level intensity) and affect (positive, neutral, or negative).

For each maternal approach, the infant's response was coded as either an approach response, which serves to continue the interaction, or a withdrawal response, which serves to end the interaction. Approach and withdrawal responses were further subdivided according to the intensity of the response (i.e., low- or high-level). Thus, the infant can respond to the maternal approach with a high-level approach response, low-level approach response, low-level withdrawal response, or high-level withdrawal response. Using two raters blinded to RD status, inter-rater reliability was calculated for 10 dyads. Pearson correlations, which ranged from .93 to .98, suggest that the coders were highly reliable in their coding of maternal approaches and infant responses per participant.

Quantification of Heart Rate and RSA—The ECG was monitored via three Ag-AgCl placed on the infant's chest. The output of the ECG amplifier was stored on a Vetter C-4 FM tape recorder (A. R. Vetter; Rebersberg, PA). The data were quantified off-line by replaying the tapes into the Vagal Tone Monitor (Delta-Biometrics, Inc., Bethesda, MD). The vagal tone monitor detected the peak of the R-wave with 1-ms accuracy and timed sequential heart periods to the nearest millisecond (ms). The sequential heart periods were stored in a file on a computer. The amplitude of RSA was assessed to provide an accurate description of impact on beat-to-beat heart rate by the nucleus ambiguus branch of the vagus nerve^{9,22}.

MXedit software (Delta-Biometrics, Inc., Bethesda, MD) was used to visually display the heart period data, to edit outliers, and to quantify the heart period and the amplitude of RSA. MXedit incorporates the Porges²² method of calculating the amplitude of RSA. This method contains a detrending algorithm to remove from the heart rate pattern the variance associated with the complex aperiodic baseline and oscillations slower than RSA. The detrending algorithm requires heart period values (i.e., the time between successive heart beats) to be measured with msec accuracy and includes the resampling of the heart period data every 250 msec, removal of trend and slow oscillations with a moving polynomial filter (3rd order 21-point) and the extraction of RSA with a band-pass filter (.24-1.04 Hz). The analysis represents the variance of RSA reported in natural logarithmic units. In this study, each heart rate parameter (i.e., heart period and RSA) was calculated for sequential 30-second epochs during a 3-minutes baseline condition and the first 7 minutes of the Bayley MDI to determine change in RSA in response to the attentional demands of the mental development test. The mean of the epochs was used in the data analyses.

Data Analyses

Independent samples t-test and chi-square analysis compared the regulatory disorder groups with regard to the demographic characteristics. One-way analysis of variance examined whether the groups differed among temperamental characteristics and mother-child interaction variables. Repeated measures analyses of variance determined if the groups differed in their levels of RSA and heart period during baseline and the mental development test. Post-hoc logistic regression analysis investigated Difficultness and RSA Regulation as predictors of RD. Lastly, post-hoc analysis assessed how infant difficultness and physiological regulation influenced the infants' responsiveness during the mother-child interactions.

RESULTS

The 15 infants (8 males and 7 females), who were coded as having no difficulties in either domain, formed a No Difficulties group. Ten infants (5 males and 5 females), who were coded with both self-regulation difficulties and hypersensitivities, met the criteria for the RD group. Twenty-five infants (11 males and 14 females), coded with difficulties in only one domain (4 infants with only self-regulation difficulties and 21 infants with only hypersensitivities), formed the One Domain group. Inspection of the mean and standard deviation scores suggested that there were no differences between the infants with only self-regulation difficulties and the infants with only hypersensitivities in terms of any of the infant or maternal measures or RSA and heart period reactivity. For example, the difficultness of the infants with only self-regulation difficulties ($M = 17.50$, $SD = 10.54$) was more similar to the infants with only hypersensitivities ($M = 18.29$, $SD = 5.76$) than to the RD infants ($M = 23.70$, $SD = 7.67$). Similarly, RSA regulation of the infants with only self-regulation difficulties ($M = -0.33$, $SD = 0.49$) was more similar to the infants with only hypersensitivities infants ($M = -0.15$, $SD = 0.70$) than to the RD infants ($M = 0.70$, $SD = 0.52$). The results of the subsequent analyses include these four children in the One Domain group. The results were similar whether or not these four infants were included.

Comparison of Regulatory Groups According to the Infant Characteristics

Due to the observation that only first born infants were in the RD group, the ratio of first born to other birth order was significantly different among the groups, $\chi^2(2, N = 50) = 6.63$, $p < .05$. Birth weight was covaried out of the subsequent analysis since the groups also differed on birth weight, $F(2, 47) = 3.90$, $p < .05$, with the No Difficulties group having significantly higher birth weights than either the One Domain or RD groups (see Table 1).

Analyses of variance indicated that the groups differed on temperamental difficultness, $F(3, 46) = 5.77, p < .01$, with the RD group being significantly more difficult than either the No Difficulties or One Domain groups. The groups did not differ on the other infant variables (i.e., gender, age at testing, extent or types of other developmental difficulties, and mental and motor development).

Repeated measures analyses of variance indicated a significant Group $\times$ Condition (i.e., baseline and MDI conditions) interaction for RSA, $F(2, 36) = 6.47, p < .01$. The pattern of responding differed among the groups. As illustrated in Figure 1, during the MDI test the RD group increased RSA, while RSA remained at approximately base level for the other groups. Consistent with the above parametric analysis, χ^2 analysis confirmed the significant propensity of the RD infants, relative to the infants in the other groups, to increase RSA during the MDI. All eight RD infants with complete physiological data increased RSA during the mental development test, $\chi^2(2, N = 40) = 12.56, p < .01$. Repeated measures analysis of variance indicated no group, condition, or interaction differences in the heart period pattern.

Logistic regression analysis investigated Difficultness and RSA Regulation as predictors of RD. Infants were partitioned into RD or No RD groups. The analysis resulted in a significant model, $\chi^2(2, N = 40) = 20.89, p < .001$. Statistically, both RSA Regulation and Difficultness contributed to the prediction model.

Comparison of the Regulation Groups According to Mother-Child Interaction Variables

Analyses of variance identified differences in the mother-infant behavioral interactions among the regulation groups. The groups did not differ on maternal approach behaviors and the percent of infant contingent behaviors (see Table 2). However, the groups differed on the overall percent of high-level infant withdrawal responses, $F(3, 46) = 3.07, p < .05$ (see Table 3). Post hoc analyses indicated that the RD group exhibited significantly more high-level withdrawal responses than One Domain group. The groups differed on the percent of high-level withdrawal responses in response to nonverbal social approaches, verbal object approaches, and physical approaches involving proximity and contact, $F(3, 46) = 3.77, p < .05$; $F(3, 46) = 3.50, p < .05$; $F(3, 46) = 5.60, p < .01$; and $F(3, 46) = 2.80, p = .05$, as well as mid-level and neutral affect approaches, $F(3, 46) = 6.17, p < .01$ and $F(3, 46) = 3.21, p < .05$. Post hoc analyses indicated that the RD group exhibited significantly more high-level withdrawal responses in response to maternal approaches categorized as nonverbal social, verbal object, physical proximity, and mid-level intensity than either the No Difficulties or One Domain groups. The infants in the RD group exhibited significantly more high-level withdrawal behaviors in response to maternal approaches involving physical contact than the No Difficulties group and more high-level withdrawal behaviors in response to neutral maternal approaches than the One Domain group.

For the infants with RD, additional analyses determined which maternal behaviors elicited the most infant contingency (see Table 2). Specifically, paired sample t-tests compared the percent of overall contingency to each maternal approach type (e.g., Nonverbal Object, Positive Affect). These comparisons provide information on whether the level of contingency was dependent on the type of approach, level of approach, and accompanying affect. Although the infants with RD were contingent 62% of the time, they were contingent significantly more often when the maternal approach contained verbal object (70%), $t(9) = -3.30, p < .01$; nonverbal object (73%), $t(9) = -3.32, p < .01$; mid-level intensity (72%), $t(9) = -4.75, p < .01$; and positive affect (89%), $t(8) = -4.76, p < .01$.

Given that RD groups differed on both infant difficultness and physiological regulation, correlations examined whether Difficultness and RSA regulation were related to the infants'

percent of contingency and high-level withdrawal behaviors. More difficult infants were less contingent and exhibited more high-level withdrawal responses, $r(50) = -.37, p < .01$ and $r(50) = .50, p < .001$. A partial correlation (removing the influence of baseline RSA) indicated that the infants who displayed greater increases in RSA exhibited more high-level withdrawal responses, $r(df = 37) = .39, p < .05$.

DISCUSSION

The current study compares how infants with and without RD differ on measures of temperament, RSA, heart rate, and maternal and infant behaviors during mother-child interaction. Infants with RD, who fail to pass the colic stage and remain fussy/difficult at 9-months of age, represent a very small percentage of normal births. Given current research (Porges, personal communication) suggest that the percent of infants who are fussy/difficult at 6-months of age decreases to approximately 10%, identifying infants who at 9-months have fussy/difficult features is a relatively low probability event.

Via our recruitment strategy, we were able to test 10 infants who met the criteria for RD (i.e., difficulties in both the self-regulation and hypersensitivity domains). Twenty-five infants had difficulties in only one domain (4 infants with only self-regulation difficulties and 21 infants with only hypersensitivities) formed the One Domain group. Although one might suspect that within the One Domain group there would be differences in the infant or maternal characteristics between those with self-regulation difficulties and those with hypersensitivities, there appeared to be no differences. The infants in these subgroups were more similar to each other than the 10 infants in the RD group and the 15 infants who formed the No Difficulties group.

Analyses focused on comparing the RD, One Domain, and No Difficulties groups indicated that all the infants with RD were first born. In addition, our research suggests that infants with higher birth weights may be at decreased risk of developing RD or any of the RD components. This finding is consistent with the temperament literature²³ that reports a relationship between birth weight and infant difficultness.

As hypothesized, the infants with RD were more temperamentally difficult and they exhibited a different physiological pattern of responding during the MDI test. In response to the MDI test, the RD group increased RSA, while RSA remained at approximately base level for the other groups. Additional analyses indicated that all eight RD infants with physiological data increased RSA during the mental development test, as had been observed². The logistic regression analyses identified RSA regulation and Difficultness as significant predictors of RD, a finding consistent with the literature suggesting that both temperamental difficultness and deficits in behavioral and physiological regulation (i.e., the ability to self-soothe and calm) relate to the RD categorization.

Given the above findings, it is not surprising that these infants exhibited more high-level withdrawal responses than the infants in the other two groups. Since high-level withdrawal responses include physical or vocal protest in response to maternal approach behaviors, our results appear consistent with research⁷ that found more social disengagement in RD infants.

The characteristic feature of the social interaction was different between the RD infants in our study and the autistic children also evaluated with the AWICS¹². The autistic children exhibited few contingent high-level approach responses to their mothers' approaches, which is consistent with the conceptualization of autism as a disorder involving little reinforcement of the mothers by their infants during social interactions. In contrast, the RD infants exhibited more frequent high-level withdrawal responses, which is consistent with the

conceptualization of RD as a disorder in which children exhibit withdrawal behaviors as a result of being easily overwhelmed.

The infants without RD exhibited high-level withdrawal response about 1% of the time, while the RD infants exhibited high-level withdrawal behaviors 7% of the time. Although this percentage is small, the occurrence of these intense behaviors is meaningful since they send a clear message about needing to disengage from the interaction. The differences in high-level withdrawal responses observed in the RD infants were not related to differences in maternal behaviors since the groups did not differ with regard to the quantity and quality of maternal approach behaviors.

Although the differences were significant for only six of the 11 maternal approach categories, the propensity toward more high-level withdrawal behaviors in the infants with RD appeared pervasive. For 10 of the 11 maternal approach categories (i.e., positive affect) the occurrence of high-level withdrawal responses was highest for the RD group. These results suggest that for RD infants, most types and levels of maternal approaches appear to be equally likely to overwhelm their autonomic nervous system, a belief consistent with Schneirla⁸ and the Polyvagal Theory^{6,9,10}. The RD infants may be too physiologically aroused by the dynamically challenging context to adjust their behaviors according to social demands.

Along with identifying differences among the infant regulatory disorder groups, the AWICS was also useful in identifying the maternal behaviors that elicited the most contingency from infants with RD. The RD infants were more contingent to maternal approaches that were of mid-level intensity and involved the use of an object to engage the child, regardless of whether or not the object approach involved talking from the mothers. Similar to most infants, infants with RD were more contingent to approaches involving positive affect.

The two primary features of RD, infant difficultness and RSA regulation difficulties, were also related to the infants' ability to deal with stimulation during mother-child interactions. Infants who were more temperamentally difficult were less contingent and more likely to exhibit high-level withdrawal responses. Similarly, infants who displayed less suppression of RSA exhibited more high-level withdrawal responses.

Our results support the usefulness of categorizing infants as RD consistent with the criteria suggested by DeGangi and colleagues⁴. As they suggested, we categorized infants as RD only if they had both poor self-regulation and hypersensitivities. Since infants with both types of difficulties differed from infants with difficulties in only one domain on measures of difficultness and RSA regulation, our findings support the importance of including both components in the definition of RD.

Although the recruitment efforts produced a sample of infants that could be categorized into the three regulation groups, the size of the individual groups was small. Another limitation of this study relates to the behavioral measures, which relied on parental report and thus, may have been influenced by individual differences in the parent's perception of appropriate behavior and wellbeing. For example, parents experiencing more stress may be more likely to view their children's temperament and behaviors as problematic. To address this concern, future studies should include behavior observations of the children in order to supplement the parent reports.

We coded the infant response to each maternal approach and excluded dyads including fathers from the study, thus limiting the generalizability of our study. In addition, there is concern about the usefulness of our coding system in dealing with maternal approaches that combined two or three different approach types. For example, a mother could have

approached by getting closer to the infants while presenting an object. Thus, this approach would be coded as including a physical proximity approach and a nonverbal object approach, and the infants response would be coded the same for both of these approaches. However, we are unable to know if an infant responding with a high-level withdrawal was responding because of the change in physical proximity, use of the object, or the combination of the two approach types. Future research should examine how this combination approach may influence the parent-child interactions of infants with RD and include in the dyads with mothers and fathers.

Our results indicate that infants with RD have both temperamental and physiological regulation difficulties. Although an infant's regulatory difficulties may stress the mother-child relationship, the AWICS identified types of maternal approaches that may work best for infants with regulatory difficulties and types of maternal approaches that may overwhelm infants with regulatory disorders. Parents of RD infants could be taught to modify their behavior to help their infants regulate behavioral and physiological state. This could be tested via a randomized control trial in which the parent-child interactions are videotaped at baseline, psychoeducation is provided for the parents in the intervention group, and follow-up interactions are assessed. The comparison of baseline and follow-up data for the groups would indicate whether the parents in the intervention group were able to learn to adjust their behaviors in response to the individual needs of their child and, in turn, whether the infants were more contingent.

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Figure 1. Respiratory Sinus Arrhythmia Reactivity for the Regulation Groups during the Administration of the Mental Development Index (MDI) of the Bayley Scales of Infant Development.

Note. Repeated measures analyses of variance indicated a significant Group $\times$ Condition (i.e., baseline and MDI conditions) interaction for RSA, $p < .01$.

Table 1

Comparison of the Regulation Groups With Regard to the Infant and Maternal Characteristic: Mean and Standard Deviation scores and ANOVA Results

	No Difficulties Group (n = 15)	One Domain Group (n = 25)	RD Group (n = 10)	Sig.
Infant Characteristics				
Birth weight (grams)	3733.33 (347.34)	3441.61 (410.86)	3321.45 (422.21)	*
Age at Testing (months)	9.29 (1.00)	9.18 (.85)	9.26 (1.09)	
Mental Development	112.93 (18.95)	122.48 (15.13)	114.20 (16.57)	
Motor Development	101.80 (16.17)	113.40 (19.11)	111.70 (10.75)	
Difficultness	14.67 (4.00)	18.16 (6.45)	23.70 (7.67)	*
Maternal Characteristics				
Age (years)	34.20 (4.00)	31.16 (5.40)	33.00 (3.560)	
Education (years)	16.80 (2.76)	16.36 (1.73)	15.30 (2.67)	

Note. Mental and motor development means are from the Bayley MDI and PDI scales. Difficultness was assessed via the Infant Characteristics Questionnaire.

*
 $p < .05$

Table 2

Infant Contingency: Comparison of Regulation Groups by Maternal Approach Factors: Mean Percent, Standard Deviation Scores, and ANOVA Results

	No Domain Group (n = 15)	One Domain Group (n = 25)	RD Group (n = 10)
Overall	.68 (.10)	.67 (.11)	.62 (.16)
Type of Approach			
Physical Approaches			
Proximity	.73 (.12)	.72 (.13)	.64 (.13)
Contact	.63 (.24)	.52 (.25)	.42 (.13)
Social Approaches			
Verbal	.39 (.28)	.50 (.33)	.27 (.27)
Nonverbal	.60 (.42)	.64 (.35)	.51 (.30)
Object Approaches			
Verbal	.70 (.10)	.69 (.13)	.70 (.11)
Nonverbal	.78 (.09)	.78 (.11)	.73 (.19)
Intensity of Approach			
Low	.64 (.12)	.63 (.14)	.61 (.18)
Mid	.81 (.09)	.79 (.11)	.72 (.10)
High	.51 (.35)	.52 (.41)	.40 (.32)
Affect during Approach			
Positive	.69 (.35)	.76 (.29)	.89 (.17)
Neutral	.67 (.11)	.66 (.10)	.60 (.15)

Note. The numbers presented represent the mean (standard deviation) percent of contingency in response to each type of maternal approach. Thus, .68 indicates that the infants were contingent an average of 68% of the time. No group comparisons were significant at the $p < .05$ level

Table 3

Infant High-Level Withdrawal Responses: Comparison of Regulation Groups by Maternal Approach Factors: Mean Percent, Standard Deviation Scores, and ANOVA Results

	No Domain Group (n = 15)	One Domain Group (n = 25)	RD Group (n = 10)	Sig.
Overall	.01 (.02)	.01 (.02)	.07 (.14)	*
Type of Approach				
Physical Approaches				
Proximity	.01 (.04)	.02 (.03)	.08 (.10)	**
Contact	.02 (.07)	.09 (.13)	.16 (.14)	*
Social Approaches				
Verbal	.02 (.06)	.02 (.05)	.03 (.05)	
Nonverbal	.00 (.00)	.00 (.00)	.08 (.14)	*
Object Approaches				
Verbal	.01 (.02)	.01 (.02)	.06 (.10)	*
Nonverbal	.01 (.02)	.01 (.02)	.07 (.17)	
Intensity of Approach				
Low	.02 (.04)	.01 (.02)	.08 (.19)	
Mid	.01 (.01)	.02 (.03)	.06 (.08)	**
High	.06 (.14)	.17 (.31)	.13 (.17)	
Affect during Approach				
Positive	.00 (.00)	.01 (.04)	.00 (.00)	
Neutral	.01 (.02)	.01 (.02)	.08 (.14)	*

Note. The numbers presented represent the mean (standard deviation) percent of high-level withdrawal behaviors in response to each type of approach. Thus, .01 (.02) indicates that the high-level withdrawal behaviors occurred 1% of the time.

*
 $p < .05$

**
 $p < .01$.