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Exploring an integrative model of infant behavior: What is the relationship among temperament, sensory processing, and neurobehavioral measures?

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ABSTRACT

Traditionally, developmental psychology, occupational/physical therapy, and behavioral pediatrics view similar infant behaviors from temperament, sensory processing, or neurobehavioral theoretical perspectives. This study examined the relations between similar and unique summary scores of three infant assessments (Early Infancy Temperament Questionnaire – EITQ, the Infant Sensory Profile – ISP, and the NICU Network Neurobehavioral Scale – NNNS) in a healthy sample of 100, one-month-old infants. A Principal Components Analysis of selected subscale scores derived from the three assessments suggested a three-factor model. Temperament and sensory summary scores had the strongest relations on two factors: Sensory-Affective Reactivity and Engagement. A third factor had strong relations between state regulation and motor competence. This new integrative model also validates an existing model and expands explanation of infant behavior across disciplines and methods which have significant implications for assessment, intervention, and management practices.

1. Introduction

Clinicians and researchers from different disciplines must deal with the challenge of conducting rapid and discriminative infant assessments for clinical diagnoses or research purposes, yet no unified, integrated measurement system exists for evaluating infant behavior. The purpose of infant assessment is to identify at-risk infants and provide evidence-based early intervention services that promote positive infant development and healthy parent–infant relationships (Lipkin, Schertz, & Accardo, 2008; Love et al., 2002; Stern, 2006). There are multiple extant measures of infant behavior used in different disciplines, which serve apparently different purposes. Yet the items included in these instruments appear to have a significant degree of empirical and conceptual overlap, both within and across measures. For instance, in the disciplines of developmental psychology, occupational/physical therapy, and behavioral pediatrics, researchers and clinicians have attempted to

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identify "types" of infants from different frames of reference, including, temperament, sensory processing, or neurobehavior perspectives. These discipline-specific assessments identify different foundations for describing the same infant behaviors, i.e., temperament, sensory processing, or neurobehavior. However, the conceptual separation of these constructs remains unclear and may yield a different interpretation of the same behaviors. Further confounds stem from whether the assessment reflects an objective examination or parental report.

The primary goal of this study, was to examine the extent to which three widely used, state-of-the-art infant assessments, from these three disciplines, assess similar versus unique features of infant behavior: The three assessments include: The Early Infancy Temperament Questionnaire (EITQ), the Infant Sensory Profile (ISP), and the NICU Network Neurobehavioral Scale (NNNS). We expect to find substantial similarity among these measures, which may challenge the current use of multiple concepts of infant behavior and may contribute to a new integrative model of identifying conceptual "types" of infants. In turn, the development of a more integrated behavioral assessment approach for infants could potentially give clinicians and researchers in these disciplines a better understanding of infant behavior and help identify possible problems and pathologies more effectively.

Although the disciplines of psychology, occupational/physical therapy, and developmental pediatrics view infant behaviors differently, the theoretical concepts used in each of these disciplines may be linked. For instance, developmental psychologists often present theories that focus on the psychobiological underpinnings of temperament, with the most prominent emphasis highlighting the association between sensory reactivity of the nervous system and infants' subsequent capacity for self-regulation (Rothbart, Ahadi, & Hershey, 1994). These neural-based foundations (i.e., reactivity and regulation) have more recently been associated with the later emergence of effortful control and executive attention processes (Rueda & Rothbart, 2009). Temperament theorists also argue that innate characteristics of the newborn (e.g., sensory response thresholds, soothability, and frequency/duration of a response), may lead to variations in regulation of attention, emotions, and motor reactivity (Lewis, Worobey, & Thomas, 1989). Psychologists have long incorporated sensory reactivity and self-regulation into their constructs of temperament such as the "difficult child" (Bates, 1980; Bates, Freeland, & Lounsbury, 1979; Thomas, Chess, Birch, & Hertzig, 1961) or "inhibited child" (Kagan, Reznick, & Snidman, 1984). Both difficult temperament and behavioral inhibition are linked to an increased risk for later behavioral and emotional problems (Kagan & Snidman, 1999).

In the field of occupational therapy, clinicians and researchers have focused primarily on sensory processing theory, which also emphasizes the neural foundations of behavior. Specifically, this perspective proposes that the ability to take in, sort, and discriminate sensory information is an integral skill needed to support regulation, attention/interaction, and adaptive functioning. During assessment, occupational therapists examine specific sensory systems in order to understand how different sensory stimuli (i.e., tactile, visual, auditory, or vestibular) contribute to behavior. In turn, clinicians and researchers in the field of developmental and behavioral pediatrics focus primarily on regulation theories including polyvagal (Porges, 1992) and synactive theories of development (Als, 1982). These approaches reflect the interrelated nature of central nervous system functions with respect to arousal state, alertness/interactive capacity, and motor systems. Collectively, the perspective espoused in each of these disciplines share a similar tenet, namely the importance of understanding the underlying neural processes that govern infant behavior and development. For instance, characteristics of "sensory reactive infants" and "behaviorally inhibited toddlers" coined from the psychology discipline (Kagan, 1994), show striking similarities to children labeled by occupational therapists as having a Regulatory Disorder (DeGangi & Breinbauer, 1997) or Sensory Modulation Disorder (McIntosh, Miller, Shyu, & Hagerman, 1999). In each perspective, identification of disorders is based on sensory processing and regulation theories (Als, 1982; Ayres, 1979; Porges & Greenspan, 1991). Such theories propose that the sensory-reactive infant's nervous system is inefficient in coordinating internal and external sensations which can result in greater than typical irritability and jeopardize parent–infant interactions (DeSantis, Coster, Bigsby, & Lester, 2004). Moreover, sensory and regulatory disorders may reflect variations in specific sensory thresholds and habituation responses which have been linked to a highly sensitive characteristic (Dunn & Brown, 1997; McIntosh et al., 1999), emotional/behavioral regulation difficulties (Kagan et al., 1999), and/or motor difficulties across the lifespan (DeGangi, Breinbauer, Doussard-Roosevelt, Porges, & Greenspan, 2000). The associations among sensory and temperament processes revealed in this body of research (Blum, Taubman, Tretina, & Heyward, 2002; Canivet, Jakobsson, & Hagander, 2000; DeSantis et al., 2004) further underscore the confusion and potential for shared underlying constructs in these fields. The sensory mechanisms (e.g., sensory thresholds) that underlie these behaviors are often subsumed within the construct of temperament in developmental psychology or pediatrics (Blum et al., 2002; Rothbart, 1989; Thomas & Chess, 1977), but may need a greater representation on measurement tools from other disciplines to characterize the full range of infant behavior regulation.

Conversely, sensory processing is a neglected area of infant assessment in developmental psychology or pediatrics, and behaviors associated with sensory processing in these disciplines are often interpreted as temperament. For example, assessment of vestibular processing which governs processes such as position in space, head orientation, muscle tone, and emotional security with gravity, is often neglected/misunderstood when observed through the lens of developmental psychology or pediatrics. Repeated movement of an infant with a hypersensitive vestibular system (e.g., tipping the baby back during caregiving activities, or as part of the newborn neurobehavioral assessment) may result in the production of infant behaviors that are interpreted as irritability and intensity on temperament instruments, rather than as indicative of vestibular processing difficulties. For example, a temperament instrument's item "Fusses when placed on back to change diaper" may be similar to a vestibular item on a sensory measure "My child fusses whenever I try to move him/her" or a tactile item "My child fusses during diaper change." Recognition of the behavioral expressions of vestibular or tactile pro-

cessing difficulties assessed in these items may offer a clearer understanding of individual infant's behavioral differences and subsequent intervention strategies.

Another area of similarity among infant measures not explicitly examined is the impact of motor competence/muscle tone on regulatory and temperamental qualities. The diagnostic category "Regulatory Disorders" refers to infants that demonstrate difficulty in both sensory and motor systems (Zero to Three, 2005). Others have identified motor competence as a mediator of infant state and emotional regulation (Als, 1982; McIntosh et al., 1999). While empirical evidence for these models is limited, there is some support for relations among motor competence and self-regulatory behavior (Barton & Robins, 2000). Variations in muscle tone and movement quality, as examined on the NICU Network Neurobehavioral Scale (NNNS), have been associated with infant vestibular and tactile processing (Als, 1982; DeGangi and Breinbauer, 1997; McIntosh et al., 1999), but have not been documented with infant sensory measures such as the Infant Sensory Profile, ISP (Dunn, 2002a). Neonatal neurobehavioral examinations further demonstrate shared theoretical elements in that they typically include assessments of motor integrity, muscle tone, and reflexes as well as typical "temperament" dimensions such as sensory reactivity, irritability/mood, and activity level/arousal. Measures of alertness/orientation, motor integrity, and state regulation from the Neonatal Behavioral Assessment Scale (NBAS) are associated with comparable measures from the Early Infant Temperament Questionnaire, EITQ (Peters-Martin & Wachs, 1984). In the Peters-Martin and Wachs study, infants rated as behaviorally organized (i.e., exhibiting more interactive behavior, motor maturity, and state control) on the NBAS at one month of age, were more likely to be categorized as being temperamentally "easy" at 6 months. Similarly, Tirosh et al. (1992) reported that 4-month-old infants with increased competence of the motor system were more skilled at minimizing overstimulation in comparison to those who were less motorically mature.

A growing number of researchers investigating infant temperament, sensory processing, and/or neurobehavior have independently pursued the most parsimonious constructs to represent individual differences in these domains. The initial nine-dimension temperament model developed by Thomas, Chess and colleagues' New York Longitudinal Study – NYLS (Thomas et al., 1961), later assessed by the EITQ (Medoff-Cooper, Carey, & McDevitt, 1993), has more recently been substantially revised into a refined three-dimensional model of temperament with the Infant Behavior Questionnaire-Revised (IBQ-R) (Gartstein & Rothbart, 2003). These three dimensions (Orienting/Alerting, Negative Emotionality, and Surgency/Extraversion) have been consistently confirmed in a variety of samples varying in race/ethnicity and age from 6 months to adults (Posner & Rothbart, 2007; Rothbart & Ahadi, 1994). In addition, sensory-based behavioral constructs developed by occupational therapists and psychologists are increasingly incorporated in the assessment of regulatory-disordered infants. Such constructs include, Low Threshold, Low Registration and Sensation Seeking (Dunn & Westman, 1997) and Hypersensitive (sensory reactive), Hyposensitive/Under-responsive, and Sensation Seeking/Motorically Impulsive (Zero to Three, 2005). However, these sensory-based constructs have not been cross-validated with temperament or neurobehavioral models. Finally, researchers in developmental and behavioral pediatrics propose that infant behavior may be represented by two to thirteen constructs on measures such as the NBAS or the NNNS (Azuma, Malee, Kavanach, & Debbish, 1991; Brazelton, 1973; Lester & Tronick, 2005), with Orientation/Attention and arousal/irritability being the most prevalent.

Another element of confusion in the field of infant assessment is the reported variability in correspondence between mothers and other observers of infant behavior and temperament. Some studies show minimal correlations between different types of raters and suggest that maternal ratings reflect the mother's subjective perceptions of the child which may be influenced by variations in personality, mental health, or cultural beliefs and values, more strongly than the child's constitutional make up or behavioral characteristics (Kagan, 1994; Seifer, 2000; Vaughn, Taraldson, Crichton, & Egeland, 1981). However, other researchers have demonstrated moderate correlations between parental and observer ratings (Bates, Wachs, Emde, Bates, & Wachs, 1994; Matheny, Wilson, & Thoben, 1987; Rothbart, Ahadi, Hershey, & Fisher, 2001). Some have argued that parent report may reflect a combination of an objective component representing the child's true behavior, as well as a subjective component which projects parental perceptions of the child (Bates & Bayles, 1984). More recently, Stifter, Willoughby, and Towe-Goodman (2008) reported a moderate level of parent–observer correlation for infants' positive emotionality but not for negative reactivity.

Variability in parent–observer correspondence might also reflect a lack of consensus in accurate classification of infant temperament. While early researchers viewed temperament as a continuous construct along an easy–difficult continuum (Thomas, Chess, Birch, Hertzig, & Korn, 1963), others have utilized a categorical conceptualization (Kagan, Snidman, Arcus, Rubin, & Asendorpf, 1993). During the past decade, a broader scope of temperament conceptualization has emerged (i.e., Orienting/Alertness, Negative Emotionality, and Surgency–Extraversion). These temperament dimensions are part of a hierarchical structure that subsumes aspects of neuroscience, adaptation, and constitutional aspects of infant behavior (Rothbart, Chew, & Gartstein, 2001). More recent interpretations have focused on the psychobiological components of infant behavior within the infant–caregiver system as essential in understanding infant behavior which includes parent, observer, and physiological measures (Hofer, 1994; Lyons-Ruth, Zeanah, Benoit, Mash, & Barkley, 2003; Stifter et al., 2008). Given the controversy regarding both the classification of temperament and issues surrounding inconsistencies in parent and observer reports, researchers now endorse the use of multiple, repeated measures by mixed raters in varying environments, and at different time points, which are likely to make important contributions to our understanding of the complexity of infant behavior and temperament as part of the parent–infant system (Hane, Fox, Polak-Toste, Ghera, & Guner, 2006; Rothbart & Hwang, 2002; Rueda, Posner, & Rothbart, 2005).

In the present study, we sought to shed further light on these issues by examining the associations among two parent-reported measures (one assessing infant temperament and the other sensory processing) and an examiner-administered

infant neurobehavior assessment. Our aim was to evaluate whether it is feasible to propose a new integrated model of infant behavior in the first month of life that could incorporate these seemingly distinct, but related perspectives. Although we expected to find some variability between parent and observer raters, we also anticipated significant associations among the measures, especially in the areas of sensory processing and temperament. Moreover, given that the majority of parent–observer correspondence studies reported on infants starting at the 3-month age level, the current study of 1-month-old infants offers the possibility of providing new information on parent–observer rating correspondence at an earlier age which can extend and elaborate our understanding of infant measurement and behavior. The findings from this study may also help to clarify the associations among current theoretical and measurement constructs during early infancy, which would help clinical and research professionals in diverse disciplines: (a) articulate common domains of functioning; (b) discern typical versus atypical behaviors; and (c) coordinate clinical management.

Specifically, the current study sought to evaluate the associations among subscale scores of three widely used infant assessments (the Early Infant Temperament Questionnaire – EITQ, the Infant Sensory Profile – ISP, and the NICU Network Neurobehavioral Scale – NNNS) in a sample of term, healthy one-month-old infants. The following hypotheses were generated from research studies cited previously as well as examination of similarities among subscales and items across measures (refer to Item Categorization below for more detailed item examination). It was expected that there would be a: (1) strong association between sensory (ISP) and temperament (EITQ) subscale scores; (2) moderate association between sensory (ISP)/temperament (EITQ) subscale measures and the neonatal exam (NNNS); and (3) moderate association between neurobehavior subscale measures (NNNS muscle tone, regulation), and ISP subscale measures of tolerance/threshold to sensory stimuli.

2. Method

2.1. Participants

A sample of 130 clinically normal mothers and infants were recruited on a daily basis from the well-child newborn nurseries at a large metropolitan teaching hospital in the northeastern United States as part of an ongoing NICHD-funded project between 1999 and 2004 (standardization of the NRN-Neurobehavioral Scale, NNNS). Mother–infant dyads were screened for eligibility to participate in the study through review of medical records and nursing reports. Inclusion criteria for the newborns included the following: full term birth (37–42 weeks gestation), healthy and clinically normal at delivery as determined by pediatric exam (i.e., no major malformations, chromosomal abnormalities, drug/alcohol exposure, HIV or neurological disorders), age at time of the first NNNS exam between 12 and 60 h old, and discharge to home within the expected 4-day period. Infants were excluded if they had been circumcised <12 h before the NNS exam or were on medication. Mothers were recruited regardless of race, ethnicity, marital status, or education. Maternal inclusion criteria included the following: at least 18 years of age at the time of the baby's delivery, and no major cognitive deficits or mental retardation, serious chronic medical problems, prenatal/postnatal complications, history of substance abuse, or major psychiatric conditions, and willingness to commit to participating in the one-month follow-up visit. A researcher contacted eligible parents by phone at 2 weeks post partum and reviewed the study. If the parents were interested in participating in the follow-up, an appointment was scheduled within five days of the baby's 1-month birthday ($\pm$5 days). Possible participants were removed if parents did not respond to several phone calls.

Out of 1121 records screened at the newborn period, 517 infants met the inclusion criteria. Of these, 146 mothers were not part of study due to scheduling problems, early discharge, nurse recommendation, or other technical reasons. Of the remaining 371 eligible families, 55 declined participation; 99 were interested but could not commit to follow-up; 26 declined because of enrollment in another study or other medical exams; and 61 changed their minds, wanted to think about it, or were unable to coordinate the exam time, resulting in a final sample of 130 dyads. The 130 dyads who agreed to participate did not differ from eligible non-participants on any demographic or medical variables, indicating no differential attrition. Of the 130 dyads whose newborns were examined during the newborn period, 101 (77.7%) returned for the 1-month follow-up study (23% attrition at 1-month visit). An additional dyad was eliminated due to incomplete data on the parent questionnaires. The 30 dyads who declined participation for the one-month follow up did not differ on any demographic or medical variables. Data analysis in the present study were based on the sample of 100, mother–infant dyads (52 girls and 48 boys) who had completed longitudinal data at both the newborn and 1-month follow-up visits. Descriptive statistics for both the participants and eligible non-participants are provided in Table 1.

2.2. Procedures

Data analyses in the present study were based on measures administered at the 1-month follow-up visit, which took place in a child development laboratory at a large metropolitan teaching hospital. Upon their arrival, families were escorted to a private waiting room with a one-way mirror adjacent to an exam room and received an explanation of the consent form and procedures for the 1-month visit. After obtaining written consent, a trained NNNS examiner took the infant into the adjacent exam room, controlled for light and temperature, and administered the NNNS exam in standardized fashion. During the NNNS exam, the mother completed two infant questionnaires (EITQ and ISP)

Table 1
Demographics for mothers and 1-month infants, low-risk sample ($N = 100$), and non-responders ($N = 30$).

Variable	*N*	%	Non-responders	%	*p*=
Infant gender					
Male	48	48	14	46.6	.679
Female	52	52	16	53.3	
Mother's education					
1–12 years	8	8.5	6	20	
High School/GED	7	7.4	5	16.6	
Some College	21	22.3	6	20	.08
Bachelor's degree	23	24.5	6	20	
MS/MBA	18	19.1	4	13.3	
MD/PhD	17	18.1	3	10	
Mother's work status					
Full-time	60	63.8	18	60	
Part-time	20	21.3	7	23.3	0 .547
No work	14	14.9	5	16.6	
Mother's race/ethnicity					
White	50	50	13	43.3	
African American/Black	15	15	16	53.3	
Hispanic	17	17	0	.0	.09
Asian	9	9	1	3.3	
Other	9	9	0	.0	
Mother's marital status					
Single	26	26	12	40	
Married	74	74	17	56.6	.110
Divorced	0	0	1	3.3	
Four-Factor Index of Social Status					
1 (high SES)	36	36	5	16.6	
2	31	31	11	36.6	
3	15	15	8	26.6	.197
4	3	3	5	16.6	
5 (low SES)	15	15	1	3.3	
	Mean (SD)	Range	Mean (SD)	Range	*p*
Maternal age (years)	31 (5.4)	19–41 years	29.5 (5.2)	19–40	.19
Infant age (days)	30.3 (2.9)	25–35 days	NA	NA	
Birthweight (g)	3395 (542.3)	2126–5525	3513.1 (479.7)	2637–4290	.287

p values were based on the results of X2 analyses (categorical variables) or *t*-tests (continuous variables).

with a research assistant present to answer any questions. After the NNNS examination, the infant was returned to mother.

2.3. Measures

Data analyses were based on subscale scores on three measures of infant behavior obtained at the 1-month follow-up visit: the EITQ, the ISP, and the NNNS. In general, the EITQ measures the degree of emotional responsiveness around daily care activities, the ISP categorizes behavior in terms of sensory systems that drive behavioral responses, and the NNNS assesses neurobehavioral aspects of infant behavior with respect to regulation, reflexes, and muscle tone.

Early Infancy Temperament Questionnaire (EITQ): The EITQ is an 86 question, parent-reported temperament scale developed during the New York Longitudinal study (Medoff-Cooper, Carey, & McDevitt, 1995). The EITQ yields nine subscale scores derived from 1 to 6 point Likert ratings which categorize infant behavior along a continuum from difficult/less desirable (higher scores) to easy/more desirable characteristics (lower scores). The Easy/Difficult composite (sum of Adaptability, Approach, Rhythmicity, Intensity, and Mood) and dimensions of Activity Level, Persistence, Distractibility, and Threshold were used for analysis in the present study. Test–retest reliability of the EITQ in a sample of 404 infants was .64 to .79 (Medoff-Cooper et al., 1993). In the present study, coefficient alphas on the EITQ were comparable to those reported in the standardization sample (range = .612–.695), with one exception: Activity Level (.435).

Infant Sensory Profile (ISP): The ISP is a 36-item, nationally standardized parent report measure of infant responsivity to sensory events (Dunn, 2002b). Each item on the ISP is rated on a 5-point Likert scale, and item scores are combined to create four factor quadrants: (1) Low Registration, (2) Sensory Seeking, (3) Sensory Sensitivity, and (4) Sensory Avoiding (Sensory Sensitivity and Sensory Avoiding can also be combined into a Low Threshold quadrant). Lower scores reflect less efficient sensory processing. Normative standardization of the ISP was carried out on an ethnically diverse nationwide sample of 1100 typically developing infants between birth and 36 months. Coefficient alphas for the quadrant groupings ranged from .56 to .79 in the birth to 6-month range. Test–retest reliability of .86 for the sensory processing subscales suggesting good stability of caregiver ratings over time. Coefficient alphas for the current sample were comparable with the normatization sample and ranged from .599 to .779.

Table 2
Definitions of subscales and composite scores: EITQ, ISP, and NNNS.

Assessment subscales	Definition of dimensions
Early Infancy Temperament Questionnaire (EITQ) Dimensions	*Explanation of Scores: Lower scores represent more desirable characteristics*
Activity Level	The amount of physical motion during sleep, eating, play, dressing, bathing, etc.
Persistence/Attention Span	The length of time particular activities are pursued by the child with or without obstacles
Distractibility	Soothability: The effectiveness of extraneous environmental stimuli in interfering with ongoing behaviors
Threshold (Sensory Reactivity)	The amount of stimulation, such as sounds or light, necessary to evoke discernible responses in the child
Easy/Difficult Classification Composite:	Combines the following 5 dimensions:
Adaptability	The ease or difficulty with which reactions to stimuli can be modified in a desired way
Approach/Withdrawal	The nature of initial responses to new stimuli: people, situations, places, foods, toys, procedures
Intensity	The energy level of responses regardless of quality or direction
Mood	Amount of pleasant and friendly or unpleasant and unfriendly behavior in various situations
Rhythmicity/Predictability	The regularity of physiology functions such as hunger, sleep, and elimination
Infant Sensory Profile Quadrants (ISP)	*Definition of Quadrant Scores: Higher scores means – does so at a rate typical of most infants*
Low Registration	Measures the infant's awareness of all types of sensation available; infants with low registration appear uninterested, may have a dull affect and low energy levels
Sensations Seeking	Measures the infant's interest in and pleasure with all types of sensation; infants who are active, excitable, and continuously engaged with environment driven to meet threshold
Low Threshold	Combines Sensory Sensitivity and Sensory Avoiding:
Sensory Sensitivity	Measures the infant's ability to notice all types of sensations; infants may be distractible, over-reactive to stimuli, easily upset, difficulty habituating to stimuli
Sensory Avoiding	Measures the infant's need to control the amount and type of sensations available at any time; infant actively works to keep sensory events at a distance by either withdrawing or emotional distress
Assessment subscales	Definition of subscales
NICU Network Neurobehavioral Scale (NNNS) Summary Scores	*Definition of Summary Scores: A higher score on each scale means a higher level of the construct*
Arousal	Level of arousal including state and motor activity during the examination
Orientation/Attention	Response to animate (face and voice) and inanimate (rattle, red ball) auditory and visual stimuli
Regulation	Capacity to organize motor activity, physiology, and state during exam and to respond to cuddling, consoling and negative stimuli
Quality of Movement	Measures of motor control including smoothness, maturity, lack of startles and tremors
Stress/Abstinence	Amount of stress and abstinence signs observed during examination including physiologic, autonomic, Central nervous system, skin, visual, and gastrointestinal
Non-optimal Reflexes	Any non-optimal response to reflex elicitation includes upper and lower extremity reflexes

NICU Network Neurobehavioral Scale (NNNS): The NNNS is a 128-item direct assessment of neurological, behavioral, and stress/abstinence neurobehavioral functions designed for infants ranging in age from 32 weeks gestation to 8 weeks post term (Lester & Tronick, 2001). The neurological component includes items that assess active and passive muscle tone, primitive reflexes, integrity of the central nervous system, and maturity of the infant. The NNNS generates scores for 13 separate subscales such as signs of stress, neurological functioning including reflexes and tone, and behavioral regulation. The following six subscales were evaluated in this study: Arousal, Orientation, Regulation, Quality of Movement, Stress/Abstinence, and Non-Optimal Reflexes. Higher numbers on each scale represent higher levels of the construct (Table 2).

The NNNS has been standardized on a total of 325 infants in two samples during the newborn period by Lester and Tronick (2004) and Lester et al. (2005) and has good to moderate levels of internal consistency (range of coefficient alphas: .85–.37; $M = .58$). In the current study, coefficient alphas were comparable to those in the standardization sample (range = .504–.834), with the exception of Stress/Abstinence (.374). In prior research, these NNNS measures discriminated infants with and without intrauterine cocaine exposure, and were associated with newborn health and minor medical complications (Messinger et al., 2004).

Examiner Training and Reliability on the NNNS: Prior to the study's onset, the first author and a research assistant were trained and certified on NNNS administration and scoring by a gold standard master trainer from an external site using the

rigorous method described in the NNNS manual (Lester et al., 2004), p. 201. A criterion reliability level of no more than a 2-point disagreement was used, consistent with that used in other newborn behavioral assessments. Inter-rater reliability was evaluated during the first month of the study and again at 4 months into the study, using the same criteria to prevent inter-coder drift. At both time periods, any discrepancies in scoring were discussed and resolved with the master trainer, consistent with procedures outlined in the NNNS manual (Lester et al., 2004).

Hollingshead Four-Factor Index of Social Status (Hollingshead, 1975): The Hollingshead was used to evaluate variations in familial socioeconomic status (SES). The Hollingshead yields a composite score based on parents' education and occupational status, which was converted to a 5-level ordinal scale (1 = higher SES, 5 = lower SES).

3. Results

3.1. Preliminary analysis

Analysis of Demographic Data: Results of univariate and bivariate analyses revealed a normal distribution for all variables with no outliers except for mild skewness/kurtosis noted on the NNNS Regulation summary score. There was missing data on several items on the ISP and EITQ when parents reported that their 1-month-old infant did not yet have the opportunity (e.g., "looks in the mirror") or were too young (e.g., "needs more support for sitting") to perform the task. In that case, the mean of the remaining scored items for that subscale was used to estimate the missing value.

Evaluation of Potential Covariates: Pearson correlations were used to examine relations between demographic variables (e.g., SES, maternal education, maternal age, and infant gender) and the infant behavioral measures (EITQ, ISP, and NNNS scores). No statistically significant relationships were found among the parental demographic measures and infant behavioral measures, with one exception: higher maternal age was negatively correlated with EITQ Distractibility ($r = -.288$, $p \leq .005$) indicating that older mothers reported their babies were more soothable. Multiple *t*-tests with a Bonferonni correction examined the association of infant gender to infant scores on the three scales. Gender was significantly associated with only one of the 12 NNNS subscale scores (Quality of Movement; $t = -2.44$, $p \leq .01$), with females showing more mature responses. Therefore, parental demographic variables and infant gender were not evaluated further as possible covariates in the statistical analyses of this study.

Instrument Item Categorization: A primary goal was to look at overlap across subscales on the three infant assessments. Rather than relying solely on *a priori* constructs defined by the temperament, sensory, and neurobehavioral literatures, we defined and classified each item into one of six mutually exclusive primary categories of basic sensory, motor/neurobehavior and regulation: tactile stimuli, auditory stimuli, vestibular stimuli, visual stimuli, muscle tone, and regulatory processes. These six categories were derived from theoretical models and findings in the literature regarding sensory processing theory/neural networks (Ayres, 1979; Posner and Rothbart, 2007); neurobehavior/synactive (Als, 1982; Ayres, 1979; Prechtl, 1977); and arousal/state regulation (Gianino and Tronick, 1988; Porges, 1993). After defining these six theoretically derived categories, the first author assigned each item on the three infant scales into one of the six categories. To evaluate the reliability of these item assignments, four experts from mixed disciplines (psychology, occupational therapy, and physical therapy), each with greater than 20 years of experience with newborn and infant assessment, independently categorized the items into one of the six primary categories. Percent agreement between the first author and each expert coder was high ($M = 85\%$, range = 72–99%). To correct for chance agreement, Cohen's Kappa was also calculated and indicated excellent inter-judge agreement ($M = .79$, range .61–.98). This classification system provided the basis for generating the study's hypotheses regarding subscale overlap (see Table 3 for *a priori* item categorization examples).

Principal Components Analysis: In consultation with three expert statisticians, Exploratory Factor Analysis (PCA) was used to answer the study's questions regarding instrument overlap. Confirmatory Factor Analysis was not used because there were no previous predictions of this nature in the literature. Subscale scores rather than individual items from each measure were used in this analysis, as the individual items resulted in too many variables for a factor analysis with a sample size of 100. To further reduce the number of variables, the following 14 subscale scores that were most representative of behaviors assessed in each instrument were selected (*EITQ*: Activity Level, Persistence, Distractibility/soothability, and Threshold dimensions and the Easy/Difficult composite score; *ISP*: Low Threshold, Sensation Seeking, and Low Registration quadrant scores; *NNNS*: Arousal, Orientation/Attention, Regulation, Quality of Movement, Stress, and Non Optimal Reflexes summary scores). The NNNS summary scores assessing Lethargy, Excitability, Hypotonicity and Hypertonicity, Handling, and Asymmetrical Reflexes were excluded because multiple items were duplicated in other subscales and showed high correlations with the NNNS summary scores selected for factor analysis. We did not use habituation because of missing data (only 19 of 100 infants were in the required sleep state for administering these items).

We entered the 14 subscale scores representing all three measures into a Principal Component Analysis (PCA) with Varimax Orthogonal Rotation using SPSS 14 and assessed the suitability of the data for factor analysis. The Kaiser–Meyer–Oklin value for the PCA Varimax Rotation was .626, exceeding the recommended value of .60 (Kaiser, 1970, 1974). The Barlett's Test of Sphericity (Bartlett, 1954) reached statistical significance ($p < .0001$), supporting the factorability of the correlation matrix. Prior to varimax rotation, the number of factors retained for varimax rotation investigation were corroborated by three processes: (1) systematically comparing eigenvalues to the corresponding criterion values obtained from the Monte Carlo PCA for Parallel Analysis (developed by Marley Watkins, 2000); (2) the scree plot; and (3) percents of variance accounted for by the factors. Results of the PCA indicated that a 3 factor model could be retained from the varimax rotation which accounted

Table 3
Principal Components Analysis Structure Matrix Correlations with Varimax Orthogonal Rotation: EITQ, ISP, and NNNS Subscale Scores ($N = 100$).

Summary scores	Factor 1 Regulation and Coordination of Movement	Factor 2 Sensory-Affective Reactivity	Factor 3 Engagement	Communality coefficient
Arousal (NNNS)	−.814	.360		.822
Quality of Movement (NNNS)	.783			.764
Regulation (NNNS)	.753	−.283	.130	.680
Orientation (NNNS)	.649			.435
Stress (NNNS)	−.534	−.113	−.134	.631
Non Optimal Reflexes (NNNS)	.360			.638
Easy/Difficult Composite (EITQ)		.919		.846
Distractibility (EITQ)		.787	−.182	.657
Activity Level (EITQ)		.658	.304	.552
Low Threshold (ISP)		−.682	.422	.667
Threshold (EITQ)	.197	.170	.726	.606
Persistence (EITQ)		.267	.681	.519
Low Registration (ISP)	−.138		−.667	.490
Sensation Seeking (ISP)			−.624	.405
Eigenvalues	2.751	2.663	2.185	7.599
% Variance Explained (%)	19.65%	19.02%	15.60%	54.28%

for 54.28% of the variance. Eigenvalues ranged from 2.75 on component one to 2.18 on component three. Individual variable loadings of ±.30 or higher were retained for interpretation. Three factors emerged: (1) Regulation and Coordination of Movement; (2) Sensory-Affective Reactivity of Proximal Body Senses; and (3) Engagement through Distal Body Senses. Overall, results indicated strong correlations between the parent-report temperament and sensory measures on Factors 2 and 3, but only minimal relations between direct-assessment NNNS and parent-report temperament or sensory processing measures. This suggests the possibility of method variance due to data collection method (parental report versus observation) (see Table 3).

Exploratory Item Factor Analyses: The next phase included an examination of the individual items that comprised the subscales included in each factor to explore latent constructs underlying three factors from the PCA. We completed an Exploratory Factor Analysis (i.e., one-factor solution) using the items from the three factors identified by the Principal Components Analysis. Each Exploratory Factor Analysis yielded a one-factor solution with factor loadings for each item entered. For each exploratory analysis, items with the strongest loadings (.30 and above) were retained and then examined in the context of *a priori* item categorization reflecting domains of underlying tactile, auditory, visual, vestibular, muscle tone/reflexes, and arousal/state-regulation (see Table 4). Results were then used to support a proposed integrative model of infant behavior.

An Integrative Model of Infant Behavior: The first factor, "Regulation and Coordination of Movement" reflected relations between infant state regulation and motor competence. The Principal Components Analysis resulted in factor loadings between $r = .360$ and .814 on all six NNNS subscales with the strongest correlation coefficients reflecting Arousal (negatively loaded), Quality of Movement, and Regulation. However, contrary to hypothesized relationships, aspects of sensory thresholds and temperament constructs loaded weakly on this factor (see Table 3). The one-factor solution Factor Analysis of the subscales' items of this factor found the items of alertness (arousal), irritability, tracking a rattle, following face and voice, skin color lability, and smoothness of muscle tone to have the highest loadings (greater than .30). These items reflect behavioral characteristics that support the hypothesized relation between the infant's ability to remain well-regulated/alert and their degree of motor system competence (see Table 4). These findings do not support hypothesis two where we expected a moderate relationship between sensory (ISP)/temperament (EITQ) and neonatal exam (NNNS).

Factors Two and Three reflected two different patterns of similarity between temperament and sensory processing measures. For Factor Two: "Sensory-Affective Reactivity," the Principal Component Analysis revealed three subscales from the EITQ (Easy/Difficult Composite, Distractibility, and Activity Level), one subscale from the ISP (Low Threshold) and one from the NNNS (Arousal). The strongest (positive) loadings ($r = .658$ to .919) were EITQ Activity, Distractibility, and Easy/Difficult Composite consisting of Adaptability, Mood, Intensity, Rhythmicity, and Approach, and ISP Low Threshold (loaded negatively). Results provide support for hypothesis one where we predicted a strong relation between sensory processing, reflected in reduced tolerance to sensory stimuli on the ISP of infants with temperaments rated as more difficult, less soothable, and more active on the EITQ. The NNNS Arousal subscale score had a positive loading (more aroused/excitable) in contrast to its negative loading on Factor 1 (less aroused/alert) (see Table 3). The one-factor item analysis on Factor 2 found that the individual items of the ISP and EITQ with the strongest correlations reflected constructs related to sensory processing of proximal senses (tactile and vestibular) stimulated through daily care activities, i.e., bathing, diapering, hair/face washing (see Table 4).

The Principal Component Analysis for Factor Three: "Engagement through Regulation of Distal Body Senses" included five subscale scores; two from the ISP (Sensation Seeking and Low Registration, both loaded negatively) and three temperament dimensions (Activity Level, Threshold, and Persistence, all loaded positively). The strongest loadings ranged between $r = .626$

Table 4
Exploratory one-factor analysis of items derived from PCA Three-Factor Model: Instruments' Subscale Score Domain and Respective *a priori* category.

Factors and Items[a]	Instruments' Subscale Score Domain	Experts' *a priori* category
Factor 1: Regulation and Coordination of Movement		
Alertness (NNNS)	Orientation/Attention	State regulation
Irritability (NNNS)	Arousal	State regulation
Consolability (NNNS)	Regulation	State regulation
Motor Maturity (NNNS)	Quality of Movement	Muscle tone
Lability of state (NNNS)	Regulation	State regulation
Tracks Rattle (NNNS)	Orientation/Attention	Muscle tone (visual motor)
Skin response to stress (NNNS)	Stress/Abstinence	State regulation (Autonomic)
Self Quiets (NNNS)	Regulation	State regulation
Cuddles Arm (NNNS)	Regulation	State regulation (tactile)
Follow face and voice (NNNS)	Orientation/Attention	Muscle tone (visual/auditory-motor integration)
Factor 2 – Sensory-Affective Reactivity: Regulation of Proximal Body Senses related to daily care activities		
Fusses during bath (EITQ)	Mood	Tactile
Accepts routine washing of diaper area (EITQ)	Adaptability	Tactile
Resists Dressing/Undressing (EITQ)	Distractibility	Tactile
My child becomes agitated when having hair washed (ISP)	Low Threshold	Tactile
Resists having head tipped back during bathing (ISP)	Low Threshold	Vestibular
Fusses whenever moved (ISP)	Low Threshold	Vestibular
Becomes upset when placed on back to change diapers (ISP)	Low Threshold	Vestibular
Factor 3 – Engagement through Distal Body Senses		
Notices (turns, quiets) music or voices in next room (EITQ)	Threshold	Auditory
Continuously watches parents during clothing changes (EITQ)	Persistence	Visual
Takes a long time to respond even to familiar voices (ISP)	Low Registration	Auditory
Persistently watches parents' face while parent is talking or singing (EITQ)	Persistence	Visual
My child ignores me when I talk (ISP)	Sensation Seeking	Auditory
I have to speak loudly to get my child's attention (ISP)	Low Registration	Auditory

[a] This is a sample of instrument items with one-factor solution loadings >.30 that comprised each of the three primary factors derived from subscale scores.

and .764 on EITQ Threshold and Persistence, and ISP Low Registration. Both the EITQ Activity Level ($r = .304$) and ISP Low Threshold ($r = .422$) loaded weakly on this factor and more strongly on Factor Two (see Table 3). The one-factor analysis found that the items with the strongest loadings reflected constructs related to use of distal body senses (visual and auditory) to engage and respond to the environment; i.e., responding to sounds, faces, and voice during typical daily routines such as clothing and diaper change (see Table 4).

The factors that emerged in this study were based on infant measures widely used in the fields of psychology, occupational/physical therapy, and developmental pediatrics. These factors provide support for a cross-disciplinary model of infant behavior that is similar to other currently accepted models. Additionally, this model sheds light on how sensory processes and motor abilities influence infant behavior. Table 5 presents a comparison of various models of infant behavior.

4. Discussion

Results from this study suggest a unique three-factor model of infant behavior that offers a multi-disciplinary, integrative perspective and a comprehensive analysis of the infant. This model also suggests possible external validation in its similarity to the well-established three-factor temperament model developed from the Infant Behavior Questionnaire-Revised (Gartstein et al., 2003; Rothbart, Chew, et al., 2001). The current study's Factor One: "Regulation and Coordination of Movement," is comparable to Rothbart and colleagues' "Orienting/Alerting" construct associated with soothability, cuddliness, attention, orientation, and positive affect (Rothbart, Ellis, Rosario Rueda, & Posner, 2003). The current study relates the concept of regulation to motor quality while Rothbart et al., discussed the concept of effortful control in relation to infant motor and arousal reactivity (i.e., response and orientation abilities to stimuli). Thus, Factor One of this study suggests that motor maturity and attentional processes underlie the infant's ability for external means of state regulation adding further support for motor-state regulation relationships.

The pattern of subscale score loadings on Factor Two (Sensory-Affective Reactivity) supports an association between sensory processing and emotional reactivity and reflects a subgroup of infants who were more difficult, less soothable, more active, and more sensitive to sensory stimulation. This is similar to a previously identified pattern of low tolerance to sensory stimuli in conjunction with persistent irritability and lack of soothability identified in older infants (DeGangi and Breinbauer, 1997; DeSantis et al., 2004). The concept of Low Sensory Threshold (one of the strongest loadings on this factor) in relation

Table 5
Comparison of infant behavior models.

New Model Factor	Experts' *a priori* categorization	EITQ Medoff-Cooper et al. (1993)	ISP Dunn and Westman (1997)	NNNS Lester and Tronick (2005)	IBQ-R Rothbart et al. (2000)
Factor 1: Regulation and Coordination of Movement (orientation to stimuli and quality of movement in the context of Arousal Regulation)	State regulation, muscle tone/reflexes	None	None	Orientation/Attention, Arousal, Regulation, Quality of Movement, Non-Optimal Reflexes, Stress/Abstinence	Orienting/Reactive (Arousal/Attention or Effortful Control)
Factor 2: Sensory-Affective Reactivity: Regulation of proximal body senses related to daily care activities	Proximal senses: tactile and vestibular	Easy/Difficult Composite, Distractibility, Activity Level	Low Threshold (Sensory Sensitivity and Sensory Avoiding)	Arousal	Negative Reactivity (Early Precursor to Fear/Anxiety)
Factor 3: Engagement through Coordination of Movement and Distal Body Senses	Distal senses: auditory and visual	Threshold, Persistence, Activity Level	Sensation Seeking Low Registration	None	Surgency/Extra-version (Positive engagement)

to infant reactivity and emotionality in the early newborn stage reframes behaviors in a subset of children who might be considered more temperamentally difficult, less competent in self-regulatory capacities, and less tolerant of (lower threshold for) sensory stimuli, and thereby expand our understanding of infant emotionality and temperament. For example, repeated exposure to uncomfortable sensory experiences might lead to avoidance or irritability as expressed in temperament aspects of withdrawal, reactivity, and fearfulness/inhibition (Kagan et al., 1984; Strelau, 1998b). Results of this study suggest that this sensory-temperament relationship may be particularly important when understanding infant behavioral regulation following tactile and vestibular stimuli (proximal body senses) which are repeatedly stimulated during daily care tasks, cuddling, and feeding. Furthermore, the Sensory-Affective Reactivity construct that emerged in Factor Two of this study corresponds to the Negative Emotionality construct obtained from the Rothbart study (Rothbart, Ahadi, & Evans, 2000) at older ages. In the newborn period, negative emotionality may manifest as irritability, unsoothability, and fearfulness. This state, if persistent, is associated with heightened negative affect, decreased attention and inhibition, and more variability in activity level during toddlerhood (Rothbart & Bates, 1998). These findings highlight the consistent parallels between expression of emotionality and sensory processing patterns throughout early childhood.

The third factor, "Regulation of Distal Body Senses," revealed a different sensory/temperament pattern than represented by Factor Two. The strong pattern of significant relationships between temperament and sensory measures on both Factors Two and Three, suggest that these factors measure similar but different constructs of infant behavior; Sensory-Affective Reactivity and Engagement. Specifically, Factor Three reflects sensory/temperamental aspects representing the infant's capacity to be inquisitive (i.e., be persistent when engaging with the caregivers in the physical and social environment or be more sensation seeking) and to register and react to sensory information from auditory and visual distal senses (as revealed in the item exploratory analysis). In the current study, this pattern was observed in self-regulation, emerging social drives, and sensation seeking/active environmental exploration on Factor Three. This pattern is similar to Rothbart's Surgency/Extraversion construct that refers to an awareness and active exploration of new stimuli and reflects the infant's ability to self-regulate responses and to appropriately interact with key individuals. However, indices of self-regulation in Rothbart et al.'s studies were derived from infants older than 3 months of age. Although these indices have been consistently conceptualized and observed to cluster separately from the more reactive aspects of temperament at 3 months of age and beyond, findings in the current sample of one-month-olds do not demonstrate such individual differences. This may reflect the fact that development is less differentiated and integrated at this age, consistent with the orthogenetic principle of development (Werner, 1948).

Furthermore, variability in aspects of engagement and surgency has been reported in infants who may be sensitive to environmental stimuli and are impulsive with a high activity level when in stimulating environments (Rothbart et al., 2000). Specifically, excessively active toddlers might be more likely to be classified as Sensation Seeking/Motorically Impulsive as reported in Regulatory Disorders research than less active toddlers (Zero to Three, 2005). This concept emerged in this study's Factor 3, which describes intercorrelations among sensation seeking, sensory thresholds, persistence, and activity level. Understanding the relation between sensory processing and temperament may better explain the fearful/hyper-arousal responses some infants demonstrate in response to the environment (Kagan et al., 1984). In addition, the relationship between sensory and temperament measures has been reported in toddlers and young children (Burns Daniels, 2004; DeGangi et al., 2000; DeSantis et al., 2004). This study extends this conceptual similarity to very young infants.

The lack of a significant association between motor competence and sensory processing or temperament measures on Factor One failed to support hypothesis three which posited a moderate association between the NNNS muscle tone/regulation and ISP sensory threshold subscales. In addition, the weak loadings between the motor competence aspects of the NNNS and

the sensory/temperament measures were contrary to current theories proposing relations among sensory, motor, mood, and state regulation (Als, 1982; Canivet et al., 2000; DeGangi et al., 2000; DeGangi, Porges, Sickel, & Greenspan, 1993). Method variance (e.g., parent report versus observational assessment) may account in part for this finding. However, the limited variability and repertoire of motor skills in this study's very young infants may also have contributed to our inability to detect strong patterns of similarity among the three measures. Although strong relations were not found among sensory processing/temperament and motor competence subscales, a relation between self-regulation and motor maturation with respect to quality of movement and reflexes was identified among the NNNS variables compromising Factor One. This factor structure revealed a pattern of more competent self-regulation, lower arousal, more mature quality of movement and reflexes, more alertness when orienting to stimuli, and less autonomic stress responses.

Overall, the factors emerged in this study are theoretically reasonable and generally consistent with those repeated for older infants. Our findings may reflect the variability of behavior that typically emerges in 1-month infants (i.e., even very young infants can be highly reactive and poorly regulated but have periods of focused alertness). As expected, findings from the factor analyses based on subscales from all three measures contribute to a more comprehensive understanding of infant behavior at one month of age and support the idea that both maternal perceptions and objective measures encompassing sensory, temperament, and motor behaviors are meaningful and contribute to a greater understanding of infant behavior.

4.1. Strengths and limitations

This study has several strengths in the large, normative sample of one-month-olds with complete data. The measures used are state of the art infant assessments in three fields yielding an integrative factor model. Some potential limitations include minimal correspondence found between parent and observer ratings. Although this finding is consistent with prior reports (Bates et al., 1984; Rothbart, Chew, et al., 2001; Stifter et al., 2008) the reasons for it are difficult to determine. Consistent with the orthogenetic principle (Werner, 1948), this finding may reflect that one-month-old infants' behavior is less differentiated and integrated than it is during later infancy. The minimal correspondence between parent and observer measures may also suggest that parents were biased in their perceptions of their infants, or that the measures selected for evaluation in this study were ineffective measurement tools. However, these instruments were chosen for study because they currently are considered the gold-standard for assessing infant behavior in the three disciplines considered, and assess different yet overlapping dimensions of infant behavior. Moreover, results of the factor analysis show similar associations to those reported in the literature for older infants (Rothbart, Chew, et al., 2001) suggesting that results cannot be explained solely as a function of method variance. Rather, our findings support claims that both parent and observer ratings provide important and unique contributions to our understanding of the complexity of infant behavior (Rothbart, 2004). The NNNS offers a valuable component to the model in its focus on neurobehavior and is a valuable addition to existing sensory and temperament measures. This direct observational exam may assess underlying components reflective of the integrity and maturity of the central nervous system not routinely observable by parents. Expanding this to current knowledge of neuroscience which states sensory and motor processes share indirect neurological circuitry of later cognitive and executive control processes (Denckla, 2005; Rothbart & Posner, 2005), infant examination which includes sensory, temperament, and neurologically based motor information may offer key information in understanding the trajectory of later development.

4.2. Future directions for research

Despite impressive advances in the field of infant and child temperament, the results of this study indicate a need for an integrated model of infant development. Such a model has the potential to guide the development of a uniform, integrated approach to infant assessment that is empirically and objectively based. It is also possible for stronger associations among infant assessments to emerge at the item level or in studies in larger, more heterogeneous, or more at-risk samples. The results of this study should also be evaluated longitudinally in order to examine developmental changes in the expression of behavior over the child's lifespan.

The current study examined underlying constructs of multi-disciplinary assessments at the subscale level. However, many of the underlying items with the strongest one-factor loadings that emerged within each of the three factors (Table 3) appear to be similar and might not all be necessary in the development of an integrated assessment instrument. Thus, the next step would be systematic reduction of the numerous individual items of the discipline measures in larger, more socially diverse samples to propose a more parsimonious assessment instrument that captures the most salient features of infant behavior. The current study was based on a healthy term sample and provides important normative data with translational significance for research with at-risk samples of infants. The data reported here provide a first step in the exploration of the similar and unique constructs of cross-disciplinary measures to expand our understanding of infant behavior.

4.3. Clinical implications

An integrated concept of temperament, sensory, and neurobehavior provides a broad and novel interpretation of infant behavior which opens opportunities for specifically tailored assessment and intervention practices to support infant and child emotional regulation. As a result, the disciplines of psychology, occupational/physical therapy, and developmental pediatrics can develop more targeted assessment and intervention approaches for temperamentally challenging and at-risk

infants. For example, an unusually irritable, less soothable infant who is also described from a sensory perspective as experiencing vestibular and tactile hypersensitivities, would benefit from specific guidance about how best to move and touch the infant, as well as ways to minimize infant sensory overstimulation. If an irritable infant also exhibits reduced motor competence, he/she may demonstrate less proficiency in independently moving/adjusting the body or bringing thumb to mouth to self-soothe. Such difficulties can significantly compromise the process of parent–infant attachment. Thus, intervention might include specific ways to hold and position the baby to support the motor and self-regulatory abilities and provide appropriate methods to promote motor competence (i.e., prone propping, additional infant shoulder support when lifting). This perspective provides specifically focused treatment suggestions geared toward organizing infant sensory, motor, and regulatory processes to improve upon the parent–infant relationship. The results from this study provide a timely amalgamation of infant assessments which is a first step toward unifying cross-discipline concepts, coordinating clinical management, and facilitating parent–infant emotional well-being.

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