



Predicting infant temperament from neonatal reactivity for AGA/SGA twin pairs

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The predictive relation between neonatal reactivity and 12-, 18-, and 24-month temperament was assessed for 22 appropriate-for-gestational-age (AGA)/small-for-gestational-age (SGA) twin pairs. Neonatal reactivity included ratings of visual and auditory orienting responses to a bull's-eye, rattle, bell, voice, and face plus voice combined, as well as alertness. Infant temperament ratings were made of emotional tone, activity, attentiveness, and social orientation to staff during age-appropriate activities in the laboratory. There were no group differences in the neonatal or infant ratings. For AGA twins, a pattern of predictive correlations was obtained between neonatal reactivity and temperament at each age. A similar predictive pattern was not observed for the SGA twins. Group differences in rates of maturation related to stresses associated with intrauterine growth retardation influenced the significance of the neonatal variables for later temperament development.

Keywords: twins, size-for-gestational-age, neonate, infant, temperament, development, orienting, intrauterine growth retardation

Introduction

When one twin of a pair is born small-for-gestational-age (SGA) and the co-twin is born at an appropriate-size-for-gestational-age (AGA), questions arise regarding appropriate development for the SGA twin. Research comparing cognitive development in heavier and lighter (not all of whom were SGA) co-twins has not been consistent in predictive findings. For example, no differences were reported between lighter and heavier MZ co-twins on 8-month Bayley Scales of Infant Development scores or on 4-year Stanford-Binet Intelligence Scale scores.¹ In contrast, lower scores were reported for lighter than for heavier MZ co-twins between 4.5 and 17 years of age on the Stanford-Binet Intelligence Scale, the Verbal Scale of the Wechsler Intelligence Scale for Children, and the Peabody Picture Vocabulary Test;^{2,3} between 9 and 17 years of age for global and performance IQ scores;⁴ and between 7 and 15 years of age for male co-twins on the Block Design Level Test⁵ (although in this latter study no differences were found on tests of verbal and nonverbal skills).

For the general population, when compared with AGA children, SGA children have been found to be

at risk for psychomotor, behavioral, and neurological abnormalities, lower scores on developmental tests, and learning difficulties.^{6–8} Differences observed between these two groups in infancy included those in motor and reflex behavior,^{9,10} habituation rates,¹¹ neurological integrity,¹² and psychomotor development.¹³

In the area of temperament development, potential differences between AGA and SGA co-twins have begun to be examined in this laboratory. Temperament is a psychobiological concept and has constitutional components that reflect genetic, prenatal, and perinatal variables.^{14–16} In the neonatal period, full-term SGA infants have been found to be less irritable than their AGA co-twins.¹⁷ Those findings indicated that the SGA twin's irritability ratings were comparable to previous ratings received by other high-risk, less mature infants. Neonatal temperament has been found to be related to behavior assessed later in infancy.^{18–21} Previous research in this laboratory had found predictive relations between temperament assessed in the hospital nursery and mothers' ratings of temperament between 6 and 30 months of age for AGA infants, whereas a similar pattern of predictive relations was not demonstrated for the SGA co-twins.²²

In the present study, the predictive relation between neonatal reactivity and a laboratory assessment of temperament was examined for the same sample of AGA/SGA co-twins. This measure of reactivity is a component of temperament that

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reflects responsivity to environmental stimuli and is a measure of individual differences, eg Korner & Grobstein.²³ Moreover, auditory and visual abilities are important for processing environmental stimuli.²⁴ The purpose of this study was to determine if measures of neonatal reactivity, as predictors of an objective measure of early temperament development, might be informative for differentiating between AGA and high-risk SGA co-twins. For this purpose, the predictive relation between neonatal reactivity and laboratory-assessed temperament at 12, 18, and 24 months of age was assessed for AGA and SGA twins.

Method

Participants

The sample included 22 pairs of same sex (8 male, 14 female) twins in which one twin of the pair was appropriate-for-gestational-age (AGA) and the other twin was small-for-gestational-age (SGA). The norms from Lubchenco et al.²⁵ were used to determine size for gestational age. These norms define small-for-gestational-age as being in the lower 10th percentile of weight for gestational age. The use of these criteria for both clinical and research purposes has been recommended by the National Institutes of Child Health and Human Development.²⁶ Furthermore, these criteria have been recommended for use in the evaluation of intrauterine growth of twins.²⁷

Size for gestational age was not determined until after the neonatal assessment. Raters at the later ages were blind to the infant's size for gestational age at birth. Mean birth weight was 2684 g (SD = 444 g) for AGA twins and 2159 g (SD = 296 g) for SGA twins, $F(1,42) = 21.33$, $P < 0.0001$. Mean gestational age at birth was 38.0 weeks (SD = 1.4 weeks), with a range of 35 to 40 weeks.

There were four pairs of monozygotic (MZ) male twins, four pairs of dizygotic (DZ) male twins, seven pairs of MZ female twins, and six pairs of DZ female twins. Zygosity was unknown for one pair of female twins. Zygosity was determined by bloodtyping on 22 or more red cell antigens.²⁸ Twins were classified as MZ if the results were concordant for all anti-serum tests, and DZ if the results were discordant for any test. All infants were assessed before zygosity was established. The small sample size precluded separate data analyses by zygosity.

Procedure

Neonatal assessment The neonatal reactivity assessment was conducted midway between two

feeding periods by a member of the research staff, while the infant was in an awake state, as part of a larger comprehensive assessment of behavior.^{29,30} All but two AGA neonates were tested in the first week (days 2 to 7) of life (those two were tested on days 9 and 15), and all but five SGA neonates were tested in the first week of life (those five were tested on days 8, 12, 14, 15 and 21).

Ratings were made of visual and auditory orienting responses to a bull's-eye, rattle, bell, voice, and face plus voice combined. Positioning of the infants for each test item was as follows. For the bull's-eye, infants were held in an upright position with the head and back supported, the infant 'seated' on the examiner's lap. For the rattle and bell, infants were supported in a semi-supine position on the examiner's lap. For voice and face plus voice, infants were held under the arms in an upright position. The infant's head was placed in the midline before each trial. Presentation of the items was randomized to prevent habituation to any individual item. The items, adapted from the Neonatal Neurobehavioral Assessment Scale³¹ were as follows:

1. **Bull's-eye.** Mean score of eight trials of response to a black and white bull's-eye presented at the midline, 15 cm in front of the infant's face. If the infant fixated, the bull's-eye was moved 90° to one side and then 90° to the other side. The initial movement was made to the right two times and to the left two times. Possible responses were: (1) no following response; (2) fixation, brief transient following; (3) fixation, intermittent good following; (4) sustained fixation, steady following with head and eyes.
2. **Rattle.** Mean score of six trials of response to a 5 s presentation of a standard rattle from the Bayley Scales of Infant Development.³² The rattle was presented three times 30 cm to the right side of the infant's head and out of view, and three times to the left. Possible responses were: (1) no orienting response; (2) quieting, eyes brightening and widening; blink, no eye movement; (3) quieting, eyes brightening and widening, some searching movements with eyes only; (4) eyes brightening and searching with head turning to side of sound.
3. **Bell.** A standard bell from the Bayley Scales of Infant Development³² was used. Presentation and scoring were the same as for the rattle.
4. **Voice.** For this item, the examiner spoke to the infant, saying 'Hi, baby', 'Hi, (baby's name)', and so on. Presentation and scoring was the same as for the rattle.

5. Face plus voice combined. Mean score of eight trials of response to a face plus voice. For this item, the examiner held the infant in an upright position, with the infant's face approximately 15 cm from the examiner's. The examiner attempted to capture the infant's visual fixation; if successful, the examiner slowly moved 90° to one side of the infant, then back across the midline 90° to the other side, smiling and talking to the infant the entire time. The initial movement was made to the right two times and to the left two times. Possible responses were: (1) no fixation on face; (2) fixation, brief transient following; (3) fixation, intermittent good following; (4) sustained fixation, steady following with head and eyes.
6. Alertness. Summary of the infant's 'responsive ability' or 'willingness to respond'; that is, how hard does the examiner have to work to get the baby to respond. And, how well does the infant maintain an alert state with the periodic presentation of external stimulation. Possible scores were: (1) poor; (2) fair; (3) moderate; (4) good; (5) excellent.

Interrater reliabilities, determined by intraclass correlations for exact agreement on raw scores, ranged from 0.90 to 0.97. The scores from the neonatal assessment were combined to create one composite score: reactivity. Epstein has indicated that an aggregate of several measures is more reliable and a better indicant of the behavior than single measures.³³

Longitudinal assessment At 12, 18, and 24 months of age the infants were engaged in a standardized series of age-appropriate vignettes in the laboratory^{34,35} using a structured sequence of play activities and interactions. Each twin was tested separately, with neither the co-twin nor a parent present. The activities were videotaped according to a pre-established schedule. Ratings of temperament were made from the videotape.

As illustration, one vignette used at each age is described below in the following:

12 months: visible barrier The infant was seated at a low table and given a small toy. When the infant played with the toy, the toy was taken from the infant and moved away from the infant, but within the infant's reach. As the infant reached for the toy, a transparent plexiglass screen was placed upright between the infant and the toy. If the infant did not try to get the toy, the screen was removed and the same or another toy was given to the infant.

18 months: puppet The examiner put on a hand puppet out of the infant's view. After gaining the infant's attention, the examiner revealed the puppet. The examiner described the puppet, then attempted to initiate interaction between the infant and puppet. The examiner encouraged the infant to work the puppet if the infant was willing.

24 months: mechanical toy A battery-powered dog that barks and moves was placed in front of the infant. The controlling mechanism, connected to the dog by a long wire, was held by the examiner who activated the dog and showed the infant how the toy works. The infant was offered the control and encouraged to make the dog bark and move.

After the visit was completed, the infant's behavior was rated for each successive 2-minute episode on the videotape. The ratings then were summed into one composite score for each rating scale. No rater scored the episodes for which she was the principal interactionist with the infant.

The following behaviors were rated on 9-point scales.

1. Emotional tone refers to the principal emotional state exhibited during the rating period, ranging from extreme distress to animated laughter.
2. Activity refers to body motion with or without locomotion; may involve whole or partial body movements.
3. Attentiveness refers to the degree to which an infant was alert to and maintained attention toward objects and events.
4. Social orientation to staff refers to the positive and negative aspects of social orientation of the infant in relation to others.

Interrater reliabilities, based on 15 infants whose videotapes were completely rescored by separate examiners, were determined by intraclass correlations.³⁶ They were: Emotional tone, $r = 0.91$; activity, $r = 0.89$; attentiveness, $r = 0.91$; and social orientation to staff, $r = 0.72$.

The scoring was designed so that higher ratings on these scales indicated

- (a) for emotional tone: more positive mood;
- (b) for activity: a higher level of activity;
- (c) for attentiveness: more focused or sustained attention; and
- (d) for social orientation to staff: more approachful and person-oriented.

Results

AGA/SGA scores on neonatal and 12-, 18-, and 24-month variables

The mean scores and standard deviations for the neonatal and 12-, 18-, and 24-month variables are presented in Table 1. A comparison of the mean scores for the AGA and SGA infants by Welch and Brown-Forsythe Equality of Means Tests in which variances are not assumed to be equal indicated that there were no significant differences between the AGA and SGA infants on the neonatal reactivity ratings or on the laboratory temperament ratings at 12, 18, or 24 months of age.

Predictive relations

To determine if there were predictive relations between neonatal reactivity and laboratory temperament ratings, correlations were computed between neonatal reactivity and 12-, 18-, and 24-month ratings of temperament. Separate correlations were computed for the AGA and SGA infants. The results are presented in Table 2.

For the AGA twins, neonates with higher reactivity scores were likely to be rated as more negative in emotional tone at 12 and 18 months of age, less active at 12, 18, and 24 months of age, less attentive at 12 and 18 months of age, and less approachful and oriented to the staff at 18 months of age when compared with neonates with lower reactivity scores. Thus, neonatal reactivity was predictive of several components of temperament at 12 and 18

Table 1 Means and standard deviations for neonatal reactivity and 12-, 18-, and 24-month temperament variables for AGA and SGA twins

	AGA		SGA	
	Mean	SD	Mean	SD
Neonatal reactivity	2.89	0.84	3.01	0.60
12 months				
Emotional tone	4.50	1.38	4.53	1.33
Activity	4.69	0.74	4.90	0.99
Attentiveness	3.91	0.70	3.74	0.51
Social orientation	6.18	0.75	5.98	0.67
18 months				
Emotional tone	4.51	1.32	4.78	1.33
Activity	4.88	0.69	4.98	0.72
Attentiveness	3.82	0.73	4.01	0.73
Social orientation	5.84	0.89	6.18	0.54
24 months				
Emotional tone	4.77	1.72	5.06	0.96
Activity	4.91	0.73	5.01	0.71
Attentiveness	4.01	0.89	4.27	0.68
Social orientation	6.04	1.46	6.14	0.80

Table 2 Predictive relations between neonatal reactivity and 12-, 18-, and 24-month laboratory temperament

	Emotional tone	Activity	Attentiveness	Social orientation
AGA				
12 Months	-0.58 ^b	-0.71 ^b	-0.49 ^a	0.14
18 Months	-0.56 ^a	-0.51 ^a	-0.76 ^b	-0.52 ^a
24 Months	-0.39	-0.56 ^a	-0.39	-0.28
SGA				
12 Months	-0.26	-0.27	-0.13	-0.16
18 Months	-0.48 ^a	-0.50 ^a	-0.08	-0.68 ^b
24 Months	-0.53 ^a	-0.51 ^a	-0.35	-0.73 ^b

^a $P < 0.05$; ^b $P < 0.01$.

months of age, and one component of temperament at 24 months of age. These results indicate that the neonate's reactivity and alertness are meaningful for later infant temperament. These findings also suggest that, with maturation past two years of age, the significance of the neonatal behavior for temperament development is lessened.

For the SGA twins, there were no significant relations between neonatal reactivity ratings and 12-month temperament ratings. SGA twins who received higher neonatal reactivity scores were likely to be rated as more negative in emotional tone at 18 and 24 months of age, less active at 18 and 24 months of age, and less approachful and oriented to the staff at 18 and 24 months of age when compared with neonates with lower reactivity scores. In contrast to the findings for the AGA twins, there were no predictive relations between neonatal reactivity and later attentiveness for the SGA group.

To determine if there were significant group differences in the predictive relations, the correlation coefficients were transformed to z scores, and statistical analyses were performed between the z coefficients.³⁷ These analyses were computed for those predictive relations that appeared to differentiate between the AGA and SGA twins; specifically, neonatal reactivity with 12-month emotional tone, activity, and attentiveness; 18-month attentiveness; and 24-month social orientation to staff. The results of these analyses indicated that there were three statistically significant differences between the groups in the longitudinal correlations: the relation between neonatal reactivity and

- (a) 12-month activity (CR = 1.78, $p < .05$);
- (b) 18-month attentiveness (CR = 2.60, $p < .01$); and
- (c) 24-month social orientation to staff (CR = 1.75, $p < .05$).

This is a relatively small sample, and it may be that, considering the magnitude of the differences between the other correlations, significant differences between the groups might have been observed for a larger sample if similar correlations had been obtained.

The results indicated, therefore, that neonatal reactivity and alertness are meaningful for later temperament for the SGA twins. Taking sample size into consideration, and acknowledging the lack of statistical significance between groups for some longitudinal relations, these findings suggest, however, that the intrauterine growth retardation may have depressed the longitudinal associations at the early age. Furthermore, there were differences in the patterns of predictive relations for the AGA and SGA groups.

Discussion

A pattern of predictive relations between neonatal reactivity and laboratory-assessed temperament at 12, 18, and 24 months of age has been demonstrated for the AGA twin. These findings suggest that there is an underlying process in neonatal reactivity that is meaningful for infant temperament. The same pattern of predictive associations between the neonatal period and 12, 18, and 24 months of age was not observed for SGA twins. Finding that size for gestational age did not affect ratings of neonatal reactivity or 12- to 24-month temperament, but did affect the stability of individual differences in behavior, suggests that differences in rates of maturation associated with constitutional variables play an important role in temperament development. A caveat is in order, however, when considering these conclusions, because statistically significant group differences were not observed for all of the relevant predictive relations. The statistically significant longitudinal correlations, however, do suggest differences in the meaningfulness of these early variables for the AGA and SGA co-twins.

A similar set of results had been obtained previously in a study looking at the relation between neonatal temperament and temperament questionnaire ratings completed by mothers of AGA/SGA twin pairs.²² Specifically, stronger consistency in temperament relations were observed between the neonatal period and 6–30 months of age for AGA twins than for SGA twins. Moreover, the changing patterns of temperament prediction from neonatal reactivity are similar to those observed between neonatal temperament and later temperament for full-term infants. Maturation processes and transactions with the environment influence the sig-

nificance of the neonatal variables for later development.^{22,38} These studies suggest that there are differences between AGA and SGA twins in central nervous system integrity as related to these behaviors. The literature suggests a biobehavioral component for temperament development, and these findings indicate that the stresses associated with intrauterine growth retardation interfere with this development.

The direction of the predictive associations is interesting for interpreting the significance of the behaviors. Previous research had indicated that full-term neonates receive higher scores on the reactivity items than pre-term infants, indicating that maturity at birth and low risk status are related to higher scores on these variables. The association between higher neonatal reactivity scores and negative temperament ratings in later infancy in this study indicate that the well-integrated infant is likely to express a certain amount of autonomy by displaying more negative emotional tone and more shifting attention when in a strange play setting. Additionally, the better integrated infant with higher neonatal reactivity scores will be less active at later ages. The SGA twin does not display these behavioral associations as early in development, or as consistently, as the AGA twin.

For twin pairs, the infant who is responsive to environmental stimuli and expresses behavior associated with more autonomous actions will evoke a different reaction from parents than the infant who is responsive to environmental stimuli yet does not express as high a degree of autonomy during early maturation. Although neither pattern may be characterized as good or bad, clearly the pattern of behavior for the more well-integrated twin is one of earlier expression of autonomy. This twin will be likely to create more situations in which parents will interact with that infant rather than with the co-twin. Thus, there is potential for the environment and constitutional variables (specifically, intrauterine growth retardation) to influence the early development of AGA and SGA co-twins differentially.

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