Neonatal behavior of infants at familial risk for ADHD

Judith G. Auerbach a,*, Rivka Landau a, Andrea Berger a, Shoshana Arbelle b, Michal Farøy a, Michael Karplus c

a Department of Behavioral Sciences, Ben-Gurion University, Beer Sheva 84105, Israel
b Division of Psychiatry, Faculty of Health Sciences, Ben-Gurion University, Beer Sheva 84105, Israel
c Department of Neonatology, Faculty of Health Sciences, Ben-Gurion University, Beer Sheva 84105, Israel

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Abstract

The neonatal behavior of male infants at familial risk for ADHD was compared to infants not at risk for the disorder. The ADHD risk group showed significantly more state organization difficulties and neurodevelopmental immaturity than the comparison group.

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One of the most common disorders of childhood is attention deficit hyperactivity disorder (ADHD) with a prevalence of 3–5% (American Psychiatric Association, 1994). Surprisingly, possible early developmental precursors of this disorder have been relatively uninvestigated. ADHD is a developmental disorder with both genetic and environmental underpinnings (Cunningham & Barkley, 1979; Woodward, Taylor, & Dowdney, 1998) making it an ideal candidate for a comprehensive longitudinal investigation of its possible developmental pathway(s). In this paper, we report findings from a neonatal assessment of infants participating in a longitudinal project of familial risk for ADHD.

Although ADHD is diagnosed on the basis of child behavior in various settings, it is assumed that the underlying mechanism is neurodevelopmental (Taylor, 1999). Various conceptual approaches have been advanced to elucidate the core deficit(s) underlying ADHD but two approaches are particularly relevant for...
examining possible precursors of the disorder in early infancy. One approach relates to inborn differences in temperament and the other relates to neurodevelopmental immaturity. The first approach conceptualizes the behaviors defining ADHD as falling within the realm of temperament albeit at the extreme edge of a continuum of temperament traits seen throughout the population (Taylor, 1999). Emotionality, activity, and attention/orienting are included under the rubric of temperament and individual differences in their expression can be seen early in life (Goldsmith & Campos, 1982; Rothbart, 1989). Difficulties in the regulation of the expression of these traits have been reported for children with ADHD and regulatory difficulties in infancy have been found to be predictive of behavioral difficulties, including hyperactivity and short attention span, at age 4 (Degangi, Porges, Sickal, & Greenspan, 1993). The second approach conceptualizes ADHD symptomatology as reflecting neurodevelopmental immaturity. Kinsbourne (1973) suggests that children with ADHD suffer from a delay in neurological maturation resulting in behaviors considered deviant for their chronological age. In the neonate, the domains of motor organization and autonomic nervous system stability would seem to reflect most directly neurodevelopmental maturation. Difficulties in motor organization are not considered a defining feature of ADHD but they might be a sign of neurodevelopmental immaturity, and therefore, be an early index of vulnerability to ADHD.

The aim of this longitudinal study is to examine the development of infants at familial risk for ADHD. The first assessment of the infants was during the neonatal period. The theoretical conceptualization mentioned above led to the prediction that neonates at risk for ADHD would show more signs of neurodevelopmental immaturity, higher levels of activity, difficulties in state organization, and either hypo- or hyper-reactivity to sensory stimulation.

The neonatal sample consisted of 158 male infants born with no history of prenatal, perinatal, or postnatal complications. Infants with these complications were excluded because some of these complications, such as low birthweight and prematurity, are associated with increased risk for ADHD (Bhutta, Cleves, Casey, & Cradock, 2002; Mick, Biederman, Prince, Fischer, & Faraone, 2002). The study sample is limited to boys because the ratio of boys to girls with ADHD ranges from 4:1 to 9:1 (American Psychiatric Association, 1994).

Recruitment took place in the maternity ward of a large local hospital. At the hospital, 900 fathers completed a questionnaire assessing ADHD DSM-IV symptomatology (American Psychiatric Association, 1994). The Cronbach alpha for ADHD symptom items was .80. For the total number of questionnaires completed, the mean, standard deviation, and median of total ADHD symptom items were 4.16, 3.73, and 3.00, respectively.

Entry into the study was based on the number of positive responses (yes-no format) fathers made to the ADHD items. Criteria for recruitment into the ADHD risk group was a score ≥7 and recruitment into the comparison group was based on a score ≤3 with sociodemographic characteristics (parental age, education, and occupation) similar to the risk group. Of total sample, 52.56% received scores of ≤3 and 19.11% received scores of ≥7. Of 900 fathers who completed the questionnaire, 311 met criteria for participation and these families were approached to participate in the study. Of these families, 187 agreed to participate.

1 A cutoff score of at least seven symptoms for the risk group was chosen because it was high enough above the mean to indicate moderate symptomatology and low enough to ensure a large enough risk group to follow longitudinally. In order to optimize the probability that there would eventually be enough boys in the study with a diagnosis of ADHD, more risk families than comparison families were recruited into the study.
Table 1

<table>
<thead>
<tr>
<th>Measures</th>
<th>ADHD risk group</th>
<th>Comparison group</th>
</tr>
</thead>
<tbody>
<tr>
<td>NBAS</td>
<td>M</td>
<td>S.D.</td>
</tr>
<tr>
<td>Stimulus responsivity</td>
<td>6.20</td>
<td>1.54</td>
</tr>
<tr>
<td>Auditory responsivity</td>
<td>5.88</td>
<td>1.05</td>
</tr>
<tr>
<td>State organization difficulties</td>
<td>3.95</td>
<td>1.70</td>
</tr>
<tr>
<td>Neurodevelopmental immaturity</td>
<td>3.75</td>
<td>1.02</td>
</tr>
<tr>
<td>Activity level item</td>
<td>5.02</td>
<td>1.20</td>
</tr>
</tbody>
</table>

NBAS: N ranges from 90 to 92 for the ADHD risk group and 65–66 for the comparison group.

The infants were assessed with the Neonatal Behavioral Assessment Scales (Brazelton & Nugent, 1995). Principal Components Analysis with Varimax rotation was used to reduce the NBAS data to a smaller number of components. A five factor extraction yielded the most interpretable solution and explained 56.88% of the variance. Items with factor loading ≥ .40 were used to define the factors. The first factor Stimulus Responsivity (20.9% of the variance) consisted of items assessing responsivity to visual and visual-auditory stimulation and alerting (Cronbach alpa .90). The second factor State Organization Difficulties (15.5% of the variance) had items assessing various aspects of irritability, state lability, and self-quieting ability (Cronbach alpha .84). Auditory responsivity items loaded on the third factor Auditory (8% of the variance) together with cuddliness; the Cronbach alpa was .48. The fourth factor Neurodevelopmental Immaturity (6.8% of the variance) included items measuring motor maturity, autonomic stability, activity, and hand-to-mouth behavior. The Cronbach alpha was .41. The three items loading on the fifth factor Tonus (5.8% of the variance) primarily tapped motor tonus with a Cronbach alpha of .27. This factor was dropped from the analyses because of its low Cronbach alpha.

One hundred and fifty-eight infants of 187 families in the research were examined neonatally during a home visit. The NBAS was administered midway between feedings. Twenty-nine infants were not examined because the home visit could not be arranged during the neonatal period (20), seven were more than 8 weeks old at the time of the home visit, three mothers refused to have the infant examined, and six infants could either not be aroused from sleep or were too irritable to examine.

The NBAS was administered by graduate students in developmental psychology who were trained to a reliability criterion of at least 92% by the first author. The examiners were blind as to group placement of the families.

NBAS descriptive statistics by group appear in Table 1. The groups did not differ by birthweight or parental demographic characteristics. There were significant differences between the groups on the State Organization Difficulties factor (t [153] = 1.78, p < .05; d = .29) and the Neurodevelopmental Immaturity factor (t [156] = 1.67, p < .05; d = .28) in the hypothesized direction. The ADHD risk group received higher scores than the comparison group on both of these factors. The groups also marginally differed in the

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2 Given that our sample was selected to examine possible early markers of ADHD, we thought that the intercorrelations among the NBAS items might reflect something about the nature of the sample. Therefore, we decided to factor analyze the data rather than using factors from other NBAS studies. The five items measuring habituation to stimulation during sleep were not included in the factor analysis because most infants were awake when the examination began. In addition two other items were dropped from analyses: lability of skin color because of too little variation in scores and consolability because of a high percentage of missing data. An item measuring general irritability was included.
predicted direction for Activity Level ($t = 1.39, p = .09; d = .23$). There were no group differences on the Stimulus Responsivity or Auditory Responsivity factors.

Correlations among the measures for each group separately revealed a marginal association between State Organization Difficulties and Neurodevelopmental Immaturity ($r = .20, p < .06$) for the ADHD risk group; those infants who had more difficulty with state organization tended also to show more signs of neurodevelopmental immaturity. For the comparison group, Stimulus Responsivity and Auditory Responsivity were significantly correlated ($r = .47, p < .001$) as were State Organization Difficulties and Neurodevelopmental Immaturity ($r = .25, p < .05$).

It is clear that as a group infants at familial risk for ADHD are at most exhibiting subtle signs of vulnerability in the neonatal period. Difficulties in state organization and regulation were more apparent in the ADHD risk group than in the comparison group. Negative emotionality, which is an indication of difficulties with state organization, has been linked in several studies, but not all, to later attentional problems and hyperactivity (Degangi, Porges, Sickal, & Greenspan, 1993; Jacobvitz & Sroufe, 1987; Wolke et al., 2002). The predictive value of state organization difficulties may to some extent be a function of the caretaking environment. In certain caretaking environments, these difficulties could evolve into a regulatory disorder, thereby, putting the child at increased risk to develop ADHD or some other externalizing disorder.

The ADHD risk group scored less optimally on the Neurodevelopmental Immaturity factor which consists of items measuring both motor maturity and autonomic stability. This finding is consistent with those of the Minnesota High Risk Study (Jacobvitz & Sroufe, 1987), who found that low scores on their NBAS Motor Maturity factor differentiated hyperactive from non-hyperactive kindergartners. The non-optimal performance of the ADHD risk group and of the hyperactive kindergartners in the Minnesota High Risk Study may reflect a specific neurodevelopmental immaturity which is compatible with Kinsbourne’s contention that the behavior of children with ADHD is indicative of a delay in neurological maturation.

There was a marginal difference for activity level; the ADHD risk group showed a higher level of activity than the comparison group. This difference may become stronger as the infants enter their second year and are more fully mobile. In fact, at the 7-month assessment of 66 of these infants, there was a significant group difference on mother-reported infant activity level; higher levels were reported for the ADHD risk group. In addition, neonatal activity was positively correlated with 7-month activity level (Auerbach, Atzaba-Poria, Berger, & Landau, 2004). If activity level continues to be stable and more importantly predictive of activity level and attentional functioning at later ages as has been found in other studies (Buss, Block, & Block, 1980; Campbell, Pierce, March, Ewing, & Szumowski, 1994), then neonatal activity level may be an important early marker of risk for ADHD.

Although PCA with varimax rotation optimizes an orthogonal solution, it is interesting that the ADHD risk group showed a somewhat different correlational pattern than the comparison group. These correlational differences give further support our conclusion that as a group neonates at risk for ADHD already are exhibiting behaviors that mark them as different from a group of infants not at familial risk for ADHD.

The findings of the present study suggest that behavioral markers of vulnerability to ADHD may be present in the neonatal period. There is also the possibility that these markers are nonspecific, that is, they are indicative of risk for psychopathology, but which type of pathology will be primarily determined by the caretaking environment. A more comprehensive picture of the specificity, stability and predictive value of these potential markers will be obtained as we follow these infants and their families through later infancy and childhood.
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References


