Neuromotor Precursors of Schizophrenia

by Elaine F. Walker, Tammy Savole, and Dana Davis

Abstract

Previous research suggests that in addition to being a characteristic of schizophrenia, neuromotor dysfunction also predates the onset of the syndrome. The research reported here was intended to examine further the neuromotor development of children with preschizophrenia traits. This study is part of a larger "archival-observational" project that uses childhood home movies to explore the developmental precursors of schizophrenia. Group comparisons revealed a higher rate of neuromotor abnormalities in the preschizophrenia children when compared to their healthy siblings, preaffective disorder subjects, the healthy siblings of patients with affective disorder, and subjects from families with no mental illness. The preschizophrenia subjects also showed poorer motor skills when compared to their healthy siblings and preaffective disorder subjects. When diagnostic group comparisons were made within age spans, the group differences were significant only in the first 2 years of life. Post hoc analyses also revealed that the preschizophrenia subjects' neuromotor abnormalities occurred primarily on the left side of the body. The abnormalities included choreoathetoid movements and posturing of the upper limbs, similar to the motor signs described in earlier reports on diagnosed schizophrenia patients. The findings are discussed in light of their implications for the developmental origins of schizophrenia. Limitations of the study, including problems with sample representativeness and the reliance on observational data, are also discussed.


Several reports have documented the presence of neuromotor abnormalities in patients with schizophrenia, including patients who have never received neuroleptic medication (Reiter 1926; Hertzig and Birch 1968; Yarden and Discipio 1971; Casey and Hansen 1984). However, research on motor dysfunction in schizophrenia is not currently one of the major lines of investigation in the field. This is at least partially attributable to the complexities of differentiating neuroleptic side effects from the syndrome's motoric features. Yet, as Meehl (1989) and others have noted, even subtle neuromotor abnormalities may hold important clues about etiology: "Research should concentrate on soft neuropsychology and psychophysiology as indicators being closer in the causal chain to the schizogene than psychometric, social, or high-level cognitive processes" (Meehl 1989, p. 935).

Evidence that childhood neuromotor abnormalities precede the clinical onset of schizophrenia has gradually accumulated over the past two decades. High-risk infant offspring of parents with schizophrenia have been found to show developmental delays in motor functions (see Walker and Emory 1983; Hans and Marcus 1991; Fish et al. 1992). Similarly, child and adolescent offspring of schizophrenia parents manifest greater deficits than children of normal and affective-disordered parents on

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measures of motor proficiency and neurologic soft signs (Marcus 1974; Reider and Nichols 1979; Erlenmeyer-Kimling et al. 1984; Marcus et al. 1985a, 1985b). However, because most research projects on high risk for schizophrenia that were initiated when subjects were infants have not yet conducted assessments of adult psychiatric outcome, they have not established a link between early childhood neuromotor dysfunction and adult-onset schizophrenia (Watt et al. 1984; Walker 1991).

One notable exception is Fish's seminal study of high-risk infants (Fish 1984; Fish et al. 1992). She conducted multiple assessments of the infants, then followed them into the adult risk period for schizophrenia. One of the 12 high-risk subjects developed schizophrenic, and 6 showed schizotypal or paranoid personality disorder. These ill subjects showed what Fish has described as "pandysmaturation" in infancy, including transient retardation in motor development during the first 2 years of life.

The demonstration of links between childhood characteristics and schizophrenic outcome in adulthood has significant implications for our conceptualization of the disorder. Early signs of dysfunction in preschizophrenia subjects lend support to the assumption that constitutional vulnerability is present at birth and that developmental processes moderate its expression (Benes et al. 1986; Mirsky and Duncan 1986; Weinberger 1987). The primary aim of the research reported here is to explore further the qualitative aspects of neuromotor development in preschizophrenia children. The study is part of a larger project that uses an "archival-observational" approach in which home movies are the source of data on developmental precursors. In this investigation, the neuromotor development of preschizophrenia subjects is compared with that of healthy controls, as well as with subjects who later manifest affective disorder. It was predicted that the preschizophrenia children would manifest more neuromotor dysfunction than subjects in the comparison groups.

In a preliminary study from this project, clinicians blind to psychiatric outcome viewed sets of films featuring one preschizophrenia child and his or her healthy siblings (Walker and Lewine 1990). Even without specific criteria or guidelines, the viewers were able to identify the preschizophrenia children younger than 8 years of age at above-chance levels. The clinicians' impressionistic comments indicated that various aspects of the children's motoric and affective behavior influenced their judgments. Confirming these subjective impressions, a subsequent study of facial expressions of emotion found that the preschizophrenia children differed from their healthy siblings (Walker et al. 1993). Compared to same-sex controls, preschizophrenia females showed a reduction in positive facial expressions that began in infancy and extended into adolescence. Both preschizophrenia males and females showed greater negative emotion than controls. These findings support the validity of the archival-observational approach and also point to the importance of more intensive study of the early developmental precursors of schizophrenia.

Methods

Subjects. Subjects were recruited through announcements sent to all local inpatient and outpatient psychiatric treatment facilities and to the Georgia Alliance for the Mentally III. The inclusion criteria, stated in the announcement, were that the prospective subjects have a diagnosis of schizophrenia or major affective disorder and that childhood home movies of the subject be available for study. All but six of the respondents to the announcement were enrolled in the study. Three were not enrolled because they had other major childhood medical conditions (e.g., physical handicap, neurologic disorder), and three did not follow through with submitting films.

As expected, the requirement for access to childhood home movies resulted in a sample of subjects from families in which the parents were of high mean education and occupational status. Mean years of education for fathers was 16 years (standard deviation [SD] = 2.90) and 15.5 years (SD = 2.42) for schizophrenia and affective patients, respectively. In both patient groups, 75 percent of the fathers were in professional occupations. The comparison group of subjects from families with no mental illness (recruited through newspaper announcements) was composed of subjects from families of comparable socioeconomic status (mean paternal education, 17 years [SD = 3.87] and 81% were professionals). There were no significant group differences in parental education or occupational status. Similarly, as shown in table 1, the healthy siblings of patients and the subjects from families with no mental illness showed comparable levels of educational attainment. A total of 121 subjects were entered into the study. The present 112 subjects is composed of those whose diagnostic data are complete and whose...
Table 1. Characteristics of the sample

<table>
<thead>
<tr>
<th>Group</th>
<th>Current age</th>
<th>Education level</th>
<th>Age at diagnosis</th>
<th>Age at 1st hospitalization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schizophrenia patients, n = 30</td>
<td>35.44 (6.32)</td>
<td>13.77 (2.22)</td>
<td>20.31 (4.28)</td>
<td>21.55 (5.41)</td>
</tr>
<tr>
<td>Healthy siblings of schizophrenia patients, n = 28</td>
<td>34.10 (5.80)</td>
<td>14.80 (2.14)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Affective disorder patients, n = 19</td>
<td>39.60 (10.17)</td>
<td>14.44 (2.18)</td>
<td>24.56 (8.21)</td>
<td>23.67 (6.30)</td>
</tr>
<tr>
<td>Healthy siblings of affective patients, n = 14</td>
<td>37.85 (9.30)</td>
<td>14.90 (1.60)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Subjects from families with no mental illness, n = 21</td>
<td>31.36 (7.77)</td>
<td>14.75 (2.07)</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

Note.—M = male; F = female; SD = standard deviation.

films contained a sufficient amount of observable motor behavior to permit coding.

Participants in this research provided informed consent after the nature and goals of the research were explained. The subjects of this study are 30 schizophrenia patients, 28 healthy siblings of the schizophrenia patients, 19 patients with affective disorders (16 with bipolar disorder and 3 with major depression), 14 healthy siblings of the affective patients, and 21 subjects from families with no mental illness in first-degree relatives. Developmental history questionnaires completed by parents indicated that only one of the affective patients, two of the siblings of affective patients, and two of the siblings of schizophrenia patients were left-handed.

All patients were diagnosed according to DSM-III-R (American Psychiatric Association 1987). For most of the patients, these diagnoses were based on the Schedule for Affective Disorders and Schizophrenia (SADS; Spitzer and Endicott 1979), symptom ratings from the Schedule for the Assessment of Positive Symptoms (Andreasen 1984b) and the Schedule for the Assessment of Negative Symptoms (Andreasen 1984a), and an interview with the parent. Two of the patients are deceased, and two were inaccessible; diagnostic and medical history information on their illnesses was obtained from medical records and from interviews with parents and other family members.

Demographic characteristics of the sample are listed in table 1. None of the schizophrenia patients had been evaluated or treated for any psychiatric condition before the age of 10 years, and none had received a diagnosis of schizophrenia before 16 years. Of the 30 schizophrenia patients in this study, only three manifested psychiatric symptoms before the age of 17: one female patient was treated for an adjustment disorder at age 13, one male was evaluated at age 10, and one male at age 16. Only one of the patients with affective disorder underwent evaluation for a psychiatric disorder before age 17. None of the patients in this study has ever been evaluated or treated for a neurologic disorder.

The parents of subjects were interviewed about their own psychiatric history and that of their offspring and biological relatives using the Family History-Research Diagnostic Criteria (Andreasen et al. 1977). All biological parents were free of major psychiatric illness (i.e., schizophrenia, bipolar disorder, and major depressive disorder with psychotic features). However, 8 schizophrenia and 10 affective patients have a parent who was treated for depression (dysthymia or a depressive episode). The onset of the parents' symptoms was associated with their child's illness in six cases.
(three parents of schizophrenia patients and three parents of affective patients).

Family studies indicate that approximately 6 percent of biological parents of schizophrenia probands are diagnosed with schizophrenia (Gottesman 1991). The absence of major psychiatric disorder in the biological parents of the patients in this study is probably attributable to the requirements for participation. Parents had to have made home movies and also had to agree to complete extensive questionnaires and interviews about their children's developmental and medical histories. Consequently, these parents are not representative of the general population of parents of probands with major psychiatric disorder.

The nearest-in-age, same-sex, healthy (i.e., no history of psychiatric symptoms) sibling of each patient was selected as the control. In cases where there was no same-sex sibling, the nearest-in-age, opposite-sex sibling was selected. Two of the patients had no siblings, four had no sibling whose psychiatric history could be clearly established, and one had no sibling on whom films appropriate for coding were available. None of the sibling controls had ever been evaluated or treated for a neurolologic or psychiatric condition. One family had two female offspring with schizophrenia and one healthy female sibling. Both affected females were included in the patient sample. In the remaining families of schizophrenia patients, only one member of the sibship had a diagnosis of schizophrenia.

The comparison group of subjects from families with no mental illness (NMI) was screened with the Family History–Research Diagnostic Criteria to verify the absence of psychopathology in them and all their first-degree relatives. It was also established that none of these subjects suffered from any neurologic condition.

It should be noted that the use of healthy siblings as comparison subjects offers several advantages over the use of unrelated subjects. It allows some control for group differences in the shared environmental effects of the family, such that any diagnostic group differences are not easily attributed to parental child-rearing practices. This approach also provides some control for hereditary influences on normative developmental trends. Finally, the use of siblings as a comparison group provides greater control for contextual factors because they are filmed in the same physical and social settings as the patient subjects.

**Materials.** Parents of subjects submitted all available 8-mm or 16-mm home movies featuring their offspring. The films spanned infancy through age 15, although the age periods represented varied among subjects. The films were transferred in chronological order to videotape, and elapsed time (tenths of a second) was inscribed on the lower right-hand corner. The mean duration of total footage on each subject was 80 minutes (SD = ±73.97). Group comparisons revealed no differences among the groups in the mean duration of total footage or in the mean duration of footage at each year of age.

**Measure.** The Neuromotor Rating Scale (table 2) used in the present study was designed to assess the presence of neuromotor abnormalities and to document the

### Table 2. Neuromotor Rating Scale

<table>
<thead>
<tr>
<th>Neuromotor Abnormalities (NA)</th>
<th>Sx</th>
<th>SxS</th>
<th>Aff</th>
<th>AffS</th>
<th>NMI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abnormal hand posture</td>
<td>19</td>
<td>5</td>
<td>11</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Abnormal oral/facial movements</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Associated reactions</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Bradykinesia</td>
<td>7</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Choreoathetoid movements</td>
<td>7</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Dysmetria</td>
<td>7</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Hypertonicity</td>
<td>6</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Hypotonicity</td>
<td>11</td>
<td>7</td>
<td>4</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Intention tremors</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
Table 2. Neuromotor Rating Scale—Continued

<table>
<thead>
<tr>
<th>Condition</th>
<th>AffS = 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mirror movements</td>
<td></td>
</tr>
<tr>
<td>Musculoskeletal abnormalities</td>
<td></td>
</tr>
<tr>
<td>Sx = 7, SxS = 3, Aff = 2, AffS = 1, NMI = 2</td>
<td></td>
</tr>
<tr>
<td>Postural abnormality of trunk or legs</td>
<td></td>
</tr>
<tr>
<td>Sx = 18, SxS = 11, Aff = 10, AffS = 8, NMI = 7</td>
<td></td>
</tr>
<tr>
<td>Repetitive movements</td>
<td></td>
</tr>
<tr>
<td>Sx = 1</td>
<td></td>
</tr>
<tr>
<td>Rest tremors</td>
<td></td>
</tr>
<tr>
<td>Sx = 2, SxS = 3, Aff = 1, AffS = 2, NMI = 4</td>
<td></td>
</tr>
<tr>
<td>Retained primitive reflexes</td>
<td></td>
</tr>
<tr>
<td>Sx = 3, SxS = 1, NMI = 1</td>
<td></td>
</tr>
<tr>
<td>Spastic movements</td>
<td></td>
</tr>
<tr>
<td>Sx = 11, SxS = 8, Aff = 7, AffS = 2, NMI = 7</td>
<td></td>
</tr>
<tr>
<td>Tics</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>

**Motor Skills (MS)**

- Alignment
- Dissociation of movement
- Gait
- Protective extension
- Righting reactions
- Shoulder and pelvic stability
- Smoothness of transitional movement
- Standing posture
- Weight shift

**Infant Motor Skills (IMS)**

- Crawling
- Grasp
- Head control
- Manual manipulation
- Sitting
- Walking

The Neuromotor Rating Scale has two components: neuromotor abnormalities (NA) and motor skills (MS). The NA scale focuses on soft signs of neurologic dysfunction as well as movement abnormalities. The MS scale rates the general quality of movement and motor skills.

All items in the NA subscale are rated as present or absent. The age at occurrence of each abnormality as well as the side(s) (right, left, or both) of occurrence of limb abnormalities is also recorded. The MS subscale items are rated on a scale ranging from below average (1) to above average (5). The age at occurrence of below-average functioning is also recorded. A subset of the motor skills items (infant motor skills; IMS) that are rated only in the first 2 years of life constitutes a separate subscale. Films for the total sample began before 2 years of age for 81 subjects. The IMS items were rated for the subset of this group (n = 76) for whom adequate observational data during this age period were available. There was no evidence of any differences between the subgroup with IMS scores and the remainder of the sample with respect to sex or diagnostic group. The number of subjects with IMS scores in each group appears in table 3.

Procedure. The neuromotor coding was done by two raters: one a neurodevelopmental specialist with

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1The numbers of subjects, by diagnostic group, showing each sign are listed. Zero values are not included. Sx = preschizophrenia subjects; SxS = siblings of schizophrenia patients; Aff = preaffective disorder; AffS = siblings of affective patients; NMI = no mental illness (comparison group).
Table 3. Mean scores (adjusted for covariate) for neuromotor abnormalities (NA), motor skills (MS), and infant motor skills (IMS) by diagnostic group

<table>
<thead>
<tr>
<th>Groups</th>
<th>NA(^1) Mean (SD)</th>
<th>MS(^2) Mean (SD)</th>
<th>IMS(^2) Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schizophrenia patients</td>
<td>3.28 (2.32)</td>
<td>2.71 (0.63)</td>
<td>2.67 (0.63)</td>
</tr>
<tr>
<td>Healthy siblings of schizophrenia patients</td>
<td>1.67 (2.04)</td>
<td>3.12 (0.37)</td>
<td>3.10 (0.87)</td>
</tr>
<tr>
<td>Affective disorder patients</td>
<td>2.27 (1.53)</td>
<td>2.99 (0.47)</td>
<td>3.11 (0.75)</td>
</tr>
<tr>
<td>Healthy siblings of affective disorder patients</td>
<td>2.03 (1.83)</td>
<td>2.95 (0.41)</td>
<td>3.02 (0.59)</td>
</tr>
<tr>
<td>Subjects from families with no mental illness</td>
<td>2.07 (1.84)</td>
<td>2.96 (0.65)</td>
<td>3.07 (0.67)</td>
</tr>
</tbody>
</table>

\(^1\)Higher scores indicate more abnormalities.  
\(^2\)Higher scores indicate better functioning.

A degree in pediatric physical therapy and the other a Ph.D. neuropsychologist with expertise in developmental assessment. Both raters had formal training in motor development and clinical experience in the assessment of motor functions in children. The raters had no prior exposure to the videotapes or to previous study findings, and they were blind to the diagnostic outcome of the subjects. In rating the NA items, they were instructed to record all instances of abnormality, even subtle and nonpersistent occurrences. The raters viewed all of the videotape on each subject they rated. They were provided with a chronological index for each videotape, which listed the age of the subject (in months for the first 2 years and in years up to age 15) and was keyed to the elapsed time inscribed on the videotape. To determine the level of interrater agreement, a subset of subjects (n = 8) was evaluated separately by two raters. The average Cohen’s kappa for the Neuromotor Rating Scale was 0.76 (range = 0.68-0.82).

Results

NA and MS scores were computed on the basis of total ratings across all age periods (maximum = 15 years) observed for each subject. The NA score is the total number of neuromotor abnormalities recorded. The MS and IMS scores are the mean ratings across all items for each subject (1 = below average, 2 = slightly below average, 3 = average, 4 = slightly above average, 5 = above average). The mean NA, MS, and IMS scores by diagnostic group are given in table 3.

Because the diagnostic groups differed in sex ratio, t tests were conducted to test for sex differences in the NA, MS, and IMS scores, both within and across the diagnostic groups. Although these analyses revealed no significant sex differences (smallest p > 0.16), subsequent analyses were conducted with sex as a covariate to control for any effects it might have on diagnostic group differences. The mean NA, MS, and IMS scores, adjusted for group differences in sex, are presented in table 2.

Analysis of covariance (ANCOVA) revealed significant diagnostic group differences in the NA scores (F = 2.51, df = 5,106, p = 0.04), a trend toward differences in the MS scores (F = 2.18, df = 5,106, p = 0.07), but no trend toward differences in the IMS score (F = 1.24, df = 5,70, p = 0.30). (It should be noted that there was less statistical power for detecting group differences in the IMS score because of the smaller number of subjects.)

Group comparisons, which were also controlled for sex, were conducted to test our a priori prediction that preschizophrenia subjects would show higher NA and lower MS scores compared to the other groups. The preschizophrenia subjects showed significantly higher NA scores than their healthy siblings (F = 8.92, p = 0.004), the siblings of affective patients (F = 2.99, p = 0.04), the NMI subjects (F = 3.70, p = 0.03), and the pre-affective disorder subjects (F = 4.95, p = 0.01). On the MS scale, the preschizophrenia subjects scored significantly lower than their sibling controls (F = 10.25, p = 0.001) and the affective subjects (F = 3.42, p = 0.04). There were nonsignificant trends toward greater deficits among the preschizophrenia subjects when they were compared to the siblings of affective patients (F = 1.68, p = 0.10) and the NMI group (F = 1.55, p = 0.11).
Although the pattern of group differences for the NA and MS scores was similar, this does not appear to be a function of a high correlation between the two dependent measures \( r = -0.20, p < 0.05 \). Thus, they appear to be tapping partially independent motor functions.

**Post Hoc Analyses.** Past research has revealed a variety of asymmetries in motor functions and brain morphology in schizophrenia. To examine asymmetries with the present data, a multivariate ANCOVA was conducted on the number of NA items that were scored for only the right side, only the left side, or for both sides. The multivariate effect for diagnostic group was highly significant (Wilks \( F = 2.33, p = 0.007 \)). Univariate tests revealed no diagnostic group effect for the number of NA items scored for the right side or both sides, but there was a highly significant difference among the diagnostic groups for signs on the left side (\( F = 5.12, df = 5.106, p < 0.001 \)). Means for the groups, adjusted for the covariate, are as follows: preschizophrenia subjects, 1.32 (SD = 1.80); siblings of schizophrenia subjects, 0.34 (SD = 0.19); affective patients, 0.53 (SD = 1.24); siblings of affective patients, 0.35 (SD = 0.63); and the NMI group, 0.24 (SD = 0.63). Group comparisons (two-tailed), controlled for sex, revealed that preschizophrenia subjects showed significantly more left-sided abnormalities than their siblings (\( F = 11.95, p < 0.001 \)) and the NMI subjects (\( F = 5.10, p = 0.03 \)). The majority of these abnormalities were in the left hand and arm.

As mentioned, the codable films for the total sample of subjects, began before age 2 for 81 subjects. Fish and colleagues (1992) have suggested that this period may be a critical one for the manifestation of neuromotor dysfunction in preschizophrenia children. Thus, separate group comparisons were conducted to test for group differences during the first 2 years of life versus three subsequent age periods. ANCOVAs were conducted on the numbers of NA items coded that were present during the age ranges of birth to 2 years, 2 to 4 years, 4 to 10 years, and 10 through 15 years. These analyses revealed a significant effect of diagnostic group for the birth-to-2-year range (\( F = 3.17, df = 5.75, p = 0.02 \)), but not for the other age periods. Means for the groups, adjusted for the covariate, are as follows: preschizophrenia subjects, 4.13 (SD = 2.51); siblings of schizophrenia subjects, 1.82 (SD = 2.37); preaffective patients, 2.95 (SD = 2.78); affective patients' siblings, 2.97 (SD = 2.06); and the NMI group, 2.04 (SD = 2.23). Again, preschizophrenia subjects showed more abnormalities than their siblings (\( F = 8.68, p = 0.006 \)) and a nonsignificant trend toward more abnormalities than the NMI group (\( F = 3.02, p = 0.09 \)). Analyses to test for age effects within group revealed significant declines in abnormalities between the first and all subsequent age periods in all groups (all \( p's < 0.05 \)).

It should be mentioned that the relation between age period and rate of neuromotor abnormalities was not attributable to differences in the duration of videotape or the number of subjects as a function of age; there was no relation between duration of film for the four age periods and NA score. Moreover, because more subjects (\( n = 111 \)) had film during the 4-to-10-year range than the other age periods, statistical power for detecting group differences was greatest for this period, not for birth to 2 years.

MS scores were derived separately for these age periods by computing the total number of below average ratings at each age period, not including the IMS items. As with the NA scores, analysis of variance revealed a significant effect of group for the birth to 2-year period (\( F = 3.08, df = 5.75, p = 0.02 \)); the preschizophrenia children were scored below average more frequently than their siblings (\( F = 7.53, p = 0.009 \)) and the NMI group (\( F = 7.70, p = 0.009 \)). Means for the groups, adjusted for the covariate, are as follows: preschizophrenia subjects, 5.32 (SD = 4.80); siblings of schizophrenia subjects, 1.75 (SD = 3.08); affective patients, 2.73 (SD = 3.84); affective patients' siblings, 2.56 (SD = 3.28); and the NMI group, 1.66 (SD = 1.68). The group differences were not significant at the other age periods. As with the NA scores, all groups showed significant improvement between the first and subsequent age periods (all \( p's < 0.05 \)).

To explore the nature of the neuromotor abnormalities observed in the preschizophrenia subjects, post hoc chi-square analyses were conducted to determine which items on the NA scale significantly differentiated the preschizophrenia subjects from their healthy siblings. The frequencies of occurrence of each sign, by group, are listed in table 2. Chi-square tests were conducted on the items that were observed with sufficient frequency across the two groups (i.e., in at least four subjects) to detect group differences at the 0.05 level of significance. This resulted in nine
chi-square tests, three of which reached significance. Associated reactions ($\chi^2 = 6.24$, $df = 1$, $p = 0.01$), postural abnormalities of the hand ($\chi^2 = 12.34$, $df = 1$, $p = 0.0004$), and choreoathetoid movements ($\chi^2 = 5.31$, $df = 1$, $p = 0.02$) occurred with greater frequency in the preschizophrenia subjects. Applying the Bonferroni correction, a significance level of $p < 0.005$ is needed. Using this criterion, the group difference in postural abnormalities of the hand remains significant.

**Discussion**

The results of this study lend further support to the assumption that childhood neuromotor dysfunction precedes the onset of schizophrenia. And, as suggested by the previous findings of Fish et al. (1992), this dysfunction is most apparent during the developmental period when motor abilities are in greatest ascendance, namely the first 2 years of life. This study also revealed limb posture and movement abnormalities and a trend toward hypotonicity in the preschizophrenia infants. Similar findings, namely postural abnormalities and hypotonicity of limbs, have been reported in infant offspring of schizophrenia mothers (Fish 1957; Fish and Alpert 1963). Although we are not aware of any previous reports of choreoathetoid movements in preschizophrenia children, earlier studies of unmedicated schizophrenia patients have revealed choreoathetoid movements and postural abnormalities of the upper limbs (Reiter 1926; Hertzig and Birch 1968; Yarden and Discipio 1971; Casey and Hansen 1984).

While the presence of neuromotor dysfunction in preschizophrenia infants suggests congenital vulnerability, such dysfunction is not unique to schizophrenia. The literature on motor development indicates that neuromotor abnormalities and skills deficits are generally more prevalent in children who are suspected of having sustained central nervous system insult, although they are not uncommon in normal children (Pasamanick and Knobloch 1966; Knobloch and Pasamanick 1974; Rie et al. 1978; Saint-Anne Dargassies 1982; Wolf et al. 1983; Rie 1987). Also, for both normal and clinical samples, there is a significant diminution in motor dysfunction with age. The present findings are consistent with this developmental trend, in that all of the diagnostic groups showed reductions in neuromotor abnormalities and skills deficits after the first 2 years of life.

We also find that the critical period from birth to 2 years is the only period during which there is a significant differentiation among the diagnostic groups with respect to motor skills and neuromotor abnormalities. Because basic human motor abilities, such as manual manipulation and locomotion, are in rapid ascendance in the first 2 years, it is not surprising that group differences in motor skills are most easily detected during this critical period. Comparisons of learning disabled and normal children reveal that group differences in motor skills decrease with age (Rie et al. 1978; Rie 1987). Further, consistent with our findings, there is evidence of a decrease in group differences in movement abnormalities with age (Rie et al. 1978; Rie 1987). Dramatic amelioration of limb posture and movement abnormalities has even been observed in some infants who manifest clinical signs of neurologic impairment. For example, Willems (1986) reports on four subjects who showed significant hypotonicity and debilitating unilateral posture and movement abnormalities in the first year of life, but who were free of clinical abnormality by age 5. Given the fact that none of the preschizophrenia subjects in the present study was characterized by motor dysfunction of sufficient severity to warrant neurologic evaluation, a decrease in their neurologic signs with age would be expected.

Some have suggested that the gradual activation of cortical regions may underlie the diminution of neuromotor abnormalities with age (Knobloch and Pasamanick 1974; Saint-Anne Dargassies 1982; Chugani et al. 1987). Specifically, it has been proposed that with maturation, subcortical influences on motor functions decline as the cortex assumes greater control. Abnormalities in subcortical regions may, therefore, have decreasing significance for motor functions as the child matures.

The present discussion should not be taken to imply that motor dysfunction is restricted to the early childhood period in schizophrenia. Previous research has revealed motor dysfunction across the lifespan in schizophrenia subjects (Reiter 1926; Hertzig and Birch 1968; Yarden and Discipio 1971; Marcus 1974; Casey and Hansen 1984; Manschreck 1986; Johnstone et al. 1990). Our failure to detect significant diagnostic group differences beyond the first 2 years of life is probably attributable to the limited sensitivity of our measure which was, by necessity, restricted to observable, spontaneous behaviors. Most studies that have revealed motor dysfunction in elementary-school-aged and
adolescent high-risk children and in schizophrenia adults have directly assessed the subjects with standardized and/or systematic tests of motor function. Thus, there is reason to conclude that neuromotor deficits characterize schizophrenia across the lifespan, although the present findings indicate that they are more apparent in the first 2 years of life.

The absence of differences between the siblings of schizophrenia subjects and the NMI group is of interest in light of a previous study that showed an elevated rate of neurologic soft signs in adult first-degree relatives of schizophrenia patients (Kinney et al. 1986; Woods et al. 1986). However, in that study, the investigators intentionally selected relatives from families "with a high concentration of schizophrenia or schizotypal personality disorder" (Kinney et al. 1986, p. 666). Of the 21 relatives they studied, 19 came from families with two affected members. Further, 9 of the 21 relatives met DSM-III (American Psychiatric Association 1980) criteria for psychiatric disorder. In contrast, none of the sibling controls in the present study met DSM-III criteria for any disorder, and only four of the schizophrenia patients had first-degree relatives who met DSM-III criteria. In light of these facts, it is not surprising that the siblings of patients were similar to the subjects in the NMI group with respect to educational attainment and neuromotor scores. (Although the use of sibling controls who are screened for mental illness enhances the potential for detecting precursors in the patients, it does not permit the identification of childhood risk factors for "spectrum" disorders.)

It is also of interest to note that the preschizophrenia subjects performed more poorly than the preaffective subjects on the global NA and MS items, although these groups were not significantly different during the first 2 years of life. Further, the preaffective patients did not differ from their siblings or from the NMI group. Thus, consistent with previous research on neurologic soft signs in psychiatric patients (Woods et al. 1986), premorbid neuromotor dysfunction appears to be more pronounced in schizophrenia than in affective disorders.

The predominance of neuromotor abnormalities on the left side in the preschizophrenia subjects raises intriguing questions. Because unilateral motor dysfunction is typically associated with contralateral brain damage, these findings suggest right hemisphere dysfunction in schizophrenia. However, theories of hemispheric dysfunction in schizophrenia have typically focused on the left hemisphere (see Walker and McGuire 1982), although some have argued that there is greater evidence of right hemisphere impairment (Cutting 1985). A critical discussion of the literature on lateralized dysfunction in schizophrenia is beyond the scope of this article. Further, although there is a body of literature on handedness that indicates no difference between schizophrenia subjects and normals (Taylor 1987), we are not aware of any studies of lateralization of motor abnormalities in nonmedicated schizophrenia patients or high-risk subjects. Thus, additional research on asymmetries in neuromotor abnormalities is needed to shed further light on our findings.

Some limitations of the present study should be mentioned. First, the psychiatric patients in this sample are not representative in that they tend to come from middle- to upper middle-class backgrounds and virtually all have had continuous access to good medical care. Yet, the patients are not atypical with respect to the age at onset or the course of their illness. Most of the schizophrenia patients are unemployed (n = 29), unmarried (n = 29), and on maintenance doses of medication (n = 28) (two patients refuse medication). Second, because the amount of observational data varied among subjects, we cannot use these findings to estimate the proportion of schizophrenia patients who show early neuromotor abnormalities. It is possible that these abnormalities characterize the majority of preschizophrenia children but that our procedures did not detect them. A related problem is the variability in the physical and social contexts in which subjects appear. Because siblings tend to appear in the same behavioral contexts in home movies (Litter and Walker 1993), differences between them may be more readily apparent. This may account for our detection of more pronounced differences in neuromotor functions between the preschizophrenia subjects and their siblings, relative to the other group comparisons. Also, the comparison with healthy siblings may afford greater control for genetically determined variability within the normal range. Finally, not all of the comparison subjects have passed through the adult risk period for schizophrenia, so it is possible that some will eventually develop psychiatric illnesses. However, the number of such subjects would probably be small and unlikely to alter the pattern of results.

In summary, the finding that
preschizophrenia subjects show neuromotor deficits as early as the first 2 years of life is consistent with the assumption that schizophrenia involves a neuropathologic process that can originate in a congenital central nervous system impairment. The onset of clinical symptoms in late adolescence/early adulthood might, therefore, be viewed as a unique point in the developmentally moderated expression of the neuropathology.

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Acknowledgments

This work was supported in part by USPHS research grant MH-46496 and a Research Scientist Development Award MH-00876 to Elaine Walker from the National Institute of Mental Health. Support was also provided by the National Alliance for Research on Schizophrenia and Depression.

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