Early Childhood IQ Trajectories in Individuals Later Developing Schizophrenia and Affective Psychoses in the New England Family Studies

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Individuals who develop schizophrenia in adulthood exhibit, on average, deficits in childhood cognition relative to healthy controls. However, it remains unclear when in childhood such deficits emerge and whether they are stable across childhood or change (increase or decrease) across development. Importantly, whether the trajectory of childhood cognition differs among youth who later develop affective psychoses (AP) vs schizophrenia as adults remains unresolved. Subjects in the Collaborative Perinatal Project were administered the Stanford-Binet IQ test at age 4 and the Wechsler Intelligence Scale for Children at age 7. A total of 9809 (54.7%) participants in the New England Study sites were tested at both ages, including 37 who later developed schizophrenia spectrum psychoses (SSP) and 39 who later developed AP. Logistic regression models examined the association of level of and change in childhood IQ and later SSP or AP. Lower overall childhood IQ was associated with higher risk of SSP. Additionally, there was a small mean increase in IQ in the SSP group relative to a mean decrease in the control group from age 4 to 7 such that positive change in IQ was significantly associated with a higher risk of SSP. Neither overall level nor change in IQ was associated with risk of AP. The results are consistent with neurocognitive impairment throughout early childhood specifically for children who later develop schizophrenia, affirming the theory of atypical neurodevelopment in premorbid schizophrenia.

Key words: IQ/cognition/schizophrenia/affective psychosis/cognitive development

Introduction

Neurodevelopmental models of schizophrenia postulate that the disorder has roots in the pre- and perinatal period and may be associated with subtle neurobehavioral signs beginning in early childhood long before illness onset.1–4 Individuals who later develop schizophrenia have been shown to exhibit problems with motor, behavioral, and cognitive development in childhood5–9 and manifest lower childhood IQ, by approximately half a SD compared with controls.10,11

A central question regarding premorbid cognition in schizophrenia is when and how does it change? Reichenberg et al.12 have shown that impairments are relatively stable in crystallized verbal intelligence, but show a developmental lag in fluid intelligence from ages 7 to 13 in children who later develop schizophrenia. Studies examining cognition in teen years among individuals who later develop schizophrenia have also identified an increasing lag in cognitive functioning behind healthy comparison subjects especially for verbal ability.13,14 This adolescent cognitive decline relative to peers has been postulated by some to be even more central to the initial presentation of schizophrenia onset than psychotic symptoms.15 However, whether similar changes in cognition are apparent during younger childhood has been less well explored.

Additionally, whether such deficits and/or lags are present in both schizophrenia and affective psychoses (AP) is not clear. The evidence to date suggests that premorbid cognitive deficits in AP are less than those observed in...
premorbid schizophrenia.\textsuperscript{5,6} There are few studies that have examined cognition in premorbid schizophrenia and AP at multiple time points, and none that we are aware of in early childhood.\textsuperscript{5,6,17}

The goals of this study were to: (1) clarify the course of cognitive functioning in premorbid schizophrenia, and (2) compare the course of premorbid cognitive functioning of schizophrenia to AP in early childhood to determine the specificity of impairments over time. There are several possible trajectories that may characterize early childhood cognitive development among these children. Future cases may exhibit a static deficit in childhood with relative declines not beginning until adolescence; alternatively, cognition may begin to decline relative to peers in early childhood and continue to do so through adolescence.\textsuperscript{18} Or, based on some models of premorbid schizophrenia, such as the pandysmaturational hypothesis of Fish,\textsuperscript{19} there may be abnormal variability in cognitive development in premorbid schizophrenia, including improvement as well as decline.

Methods

Study Population

The Collaborative Perinatal Project (CPP) was established over 50 years ago to study the pre- and perinatal origins of disease and followed women during prenatal visits, and their offspring at ages 4, 8, and 12 months, and 4 and 7 years.\textsuperscript{20}

The New England Family Studies (NEFS) includes the Boston, Massachusetts and Providence, Rhode Island CPP study sites and comprises approximately 17,000 births. In total, 54.7\% ($N = 9809$) of subjects in NEFS completed IQ testing at both ages 4 and 7. Participants who did not have IQ measured at both ages were of higher socioeconomic status (SES) at birth (6.14 vs 5.58, $P < .001$), had mothers with more education (11.8 vs 11.1 years, $P < .001$), and were less likely to have mothers who were non-white (12.9\% vs 14.8\%, $P < .001$); gender distribution did not differ.

Ascertainment and Assessment of Adult Psychosis Cases

Cohort members with possible psychosis were identified from 1996 to 2007 through a systematic follow-up of the entire NEFS cohort that included: (1) record linkages with public hospitals, mental health clinics, and the Massachusetts and Rhode Island Departments of Mental Health; (2) nested follow-up and case-control studies, including interviews with approximately 20\% of the cohort; and (3) reports from participants in follow-up studies of a family member also in the CPP with a history of psychosis. A total of 249 individuals with possible psychotic illness were identified through this systematic follow-up and were subsequently diagnosed through administration of the Structured Clinical Interview for DSM-IV (SCID, First et al\textsuperscript{21}) ($N = 173$) or review of medical case notes alone ($N = 76$); based on these interviews and record reviews, trained diagnosticians completed best-estimate consensus diagnoses using DSM-IV criteria.\textsuperscript{22}

A total of 114 subjects were found to have a nonorganic psychotic disorder, including schizophrenia spectrum psychoses (SSP) or AP. Age 7 cognitive data for this sample have been reported previously by Seidman et al\textsuperscript{16}. In total, 37 subjects with SSP (schizophrenia [$N = 33$] and schizoaffective depressed type [$N = 4$]) and 39 subjects with AP (schizoaffective bipolar type [$N = 11$], bipolar disorder with psychotic features [$N = 21$], and major depressive disorder with psychosis [$N = 7$]) had data available on full scale IQ (FSIQ) at both age 4 and age 7. Schizoaffective disorder, depressed type was grouped with SSP, and schizoaffective disorder, bipolar type, with AP based on past literature on familial transmission of SSP and AP.\textsuperscript{23-26} A small number of participants ($N = 9$) with other nonaffective psychotic disorders (eg, brief psychosis, delusional disorder) were not included in analyses. The age 4 data have not previously been published for the full psychotic sample; information on a small subgroup (<25\%) of persons with later psychotic symptoms and controls has previously been published.\textsuperscript{16} Human subjects approval was granted by Institutional Review Boards at Harvard University, Brown University, and local psychiatric facilities; written consent was obtained from all interviewed participants.

Ascertainment and Assessment of Controls

Controls in primary analyses include all study subjects with data available on IQ at age 4 and age 7 who were not identified as psychosis cases through the follow-up procedures ($N = 9724$). Due to concerns that this nondiagnosed control group could contain some false negatives (individuals with psychosis not identified through case ascertainment procedures), an alternative control group ($N = 1315$) that received a brief screener for psychotic symptoms in adulthood was used in sensitivity analyses (supplementary appendix 1) (screening questions included whether the participant had ever: (1) heard voices or seen visions others could not see or hear, or (2) believed someone was plotting against them).

Demographics

SES in the CPP is an index including education and occupation of the head of household, and total family income (scale ranges from 0 to 9.5).\textsuperscript{27} Demographic variables such as mother’s education and ethnicity were assessed prior to the participant’s birth. Additionally, covariates were included for whether the subject was seen at 8-month and 1-year follow-up appointments, as continued involvement in the study may be related to the probability of being identified as a case in adulthood.

Neurocognitive Measures at Age 4 and Age 7

At age 4, the assessment battery for general intellectual ability included the Stanford-Binet Intelligence Scales.\textsuperscript{28,29} At
age 7, seven subtests from the Wechsler Intelligence Scale for Children (WISC, Wechsler) were used to derive an IQ estimate. The test-retest correlations of IQ from the Stanford-Binet \( (r = .83) \) and WISC \( (r = .85) \) in the CPP were high.\(^20\)

**Statistical Analyses**

The primary goal of this analysis was to determine whether level of IQ and/or a change in IQ was related to SSP and AP in adulthood. Level of IQ was operationalized in regression models by averaging IQ at ages 4 and 7; change in IQ was operationalized by subtracting age 4 from age 7 IQ. Logistic regression models simultaneously included level of and change in IQ at ages 4 and 7 to examine the relation between these factors and adult diagnosis. Multivariable models were adjusted for SES at birth, maternal race (white or non-white), years of maternal education, gender, and the subject’s presence at 8-month and 1-year NEFS visits. Models were also adjusted for intrafamilial correlation, using “robust” or empirical SE to account for the presence of siblings. Multiple imputation was used to impute missing information on sociodemographic covariates using IVEware\(^31\) and results were combined and analyzed with the SAS MIANALYZE procedure.\(^32\)

**Results**

Table 1 presents subject characteristics for controls, SSP cases, and AP cases. Compared with controls, SSP cases were less likely to be female (24.3% vs 49.1%, \( P < .01 \)) and had less educated mothers (10.3 vs 11.1 y of education, \( P < .05 \)), but were otherwise demographically comparable. Cases of AP did not show any significant demographic differences from controls.

IQ at age 4 and age 7 was significantly lower among future SSP cases vs controls; IQ of future AP cases was lower than controls, but not significantly, at both ages (table 1). The SSP group also had a preponderance of subjects in the lowest quartile of IQ at ages 4 and 7, with the percentage of SSP subjects decreasing as IQ quartile increased; this was significant at age 4 \( (P = .003) \), but only a trend at age 7 \( (P = .08) \). The AP group showed a similar, but less pronounced quartile trend that was not significant at either age.

Figures 1a and 1b depict the distribution of IQ scores at ages 4 and 7 by study group. The graphs show that the entire distribution of childhood IQ scores among SSP cases is shifted toward lower scores, suggesting that lower mean IQ among cases is not driven by a particularly poorly performing subgroup. Additionally, while mean IQ at age 4 and age 7 is lower among future SSP than controls, there is significant overlap in the distributions of IQ between these groups.

Figure 2 shows the average IQ scores at ages 4 and 7 among the 3 groups. Among controls, average scores at age 7 on the WISC are lower than scores on the Stanford-Binet at age 4 (a result that has been found previously).\(^33–35\)

| Table 1. Demographics and Age 4 and Age 7 Cognitive Performance Among Nondiagnosed Study Population Controls (N = 9724), Premorbid Schizophrenia Spectrum Psychoses (SSP) (N = 37), and Premorbid Affective Psychoses (AP) (N = 39) Subjects |
|-----------------|----------------|----------------|
|                 | Nondiagnosed Study Pop. Controls | SSP Cases | AP Cases |
|                 | N = 9724 | N = 37 | N = 39 |
| Female gender, N (%) | 4765 (49.1) | 9 (24.3) | 21 (53.9) |
| Non-white maternal race, N (%) | 1429 (14.7) | 8 (21.6) | 6 (15.4) |
| Present at age 8 mo exam, N (%) | 9206 (94.8) | 33 (92.3) | 36 (92.3) |
| Present at 1 y exam, N (%) | 9222 (95.0) | 34 (91.9) | 37 (94.9) |
| SES at birth, mean (SD) | 5.6 (1.9) | 5.2 (2.2) | 5.9 (1.7) |
| Mother’s education, mean (SD) | 11.1 (2.3) | 10.3 (2.3) | 11.0 (1.8) |
| Age 4 FSIQ, mean (SD) | 105.4 (16.1) | 94.8 (15.3) | 102.5 (15.5) |
| Age 4 FSIQ quartile*, N (%) | | | |
| 1st | 2406 (24.8) | 19 (51.4) | 15 (38.5) |
| 2nd | 2660 (27.4) | 9 (24.3) | 8 (20.5) |
| 3rd | 2350 (24.2) | 7 (18.9) | 8 (20.5) |
| 4th | 2296 (23.6) | 2 (5.4) | 8 (20.5) |
| Age 7 FSIQ, mean (SD) | 101.7 (13.4) | 97.2 (14.5) | 99.8 (13.1) |
| Age 7 FSIQ quartile*, N (%) | | | |
| 1st | 2544 (26.2) | 15 (40.5) | 13 (33.3) |
| 2nd | 2500 (25.7) | 9 (24.3) | 8 (20.5) |
| 3rd | 2309 (23.8) | 7 (18.9) | 10 (25.6) |
| 4th | 2359 (24.3) | 6 (16.2) | 8 (20.5) |

**Note**: SSP include schizophrenia and schizoaffective depressed type; AP include schizoaffective bipolar type, bipolar disorder with psychotic features, and major depressive disorder with psychosis. FSIQ, full scale IQ; SES, socioeconomic status.

*Quartiles defined by distribution of FSIQ scores in entire study population (N = 9809); the first quartile includes the lowest FSIQ scores and the fourth quartile the highest FSIQ scores.
Among future SSP cases, average IQ is slightly higher at age 7 than age 4. AP cases perform at a level intermediate between future SSP cases and controls. Table 2 provides results of models examining level of and change in childhood IQ in relation to the odds of SSP and AP. ORs are scaled to a half SD of IQ (7.5 points). In the unadjusted model, both the overall level and change in IQ are associated with the odds of SSP. After adjustment for multiple covariates, lower average IQ in childhood remains significantly related to higher risk of SSP (OR = 1.23, 95% CI: 1.03, 1.48, P < .05), and a slight increase in IQ from age 4 to 7, relative to a small decrease in controls, is associated with higher risk of SSP (OR = 1.22, 95% CI: 1.01, 1.48, P < .05); male gender is also significantly predictive of SSP. Other sociodemographic covariates, such as maternal education and SES at birth, were not statistically significant in the multivariable model. Among analyses examining AP, neither level of IQ nor change in IQ, were significantly associated with elevated risk.

In sensitivity analyses in which the control group was defined as those responding negatively on the psychosis screening questions, results were in a similar direction, but of somewhat different magnitude: the effect for level of IQ and risk of SSP was stronger (OR = 1.23 with unscreened controls, OR = 1.46 with screened controls); the result for change in IQ and risk of SSP was of smaller magnitude (OR = 1.22 with unscreened controls, OR = 1.16 with screened controls) and the results for change in IQ did not reach statistical significance with screened controls. Results for AP were similar across control types, but of stronger magnitude and reached statistical significance for level of IQ.

**Discussion**

We found that individuals with SSP had, on average, a lower level of IQ in childhood compared with nonpsychotic controls, consistent with the neurodevelopmental deficit model. A small mean increase in IQ from age 4 to 7 in the SSP group, combined with a mean decrease among controls, led to a significant association of premorbid IQ change with higher risk of SSP. Individuals who later developed AP did not show statistically lower IQ scores at ages 4 or 7, nor did they show any significantly greater decrease or increase in IQ from age 4 to 7 compared with controls.

Few studies have prospectively measured IQ in childhood among future psychosis cases, but there are several studies that bear on the question of whether future SSP or AP cases exhibit decreasing, increasing, or stable deficits in IQ in childhood. A preponderance of research to date supports our finding that a lower overall level of early childhood IQ (rather than its decline) is associated with later schizophrenia.5,10,17 A study in the Dunedin Multidisciplinary Health and Development Study cohort described results of cognitive testing from ages 3 to 11 among individuals who later developed schizophreniform disorder and found IQ was significantly lower at each age among future cases, without evidence of a significant decline.5 Similarly, a study in the Philadelphia cohort of the CPP demonstrated lower IQ at ages 4 to 7 among later schizophrenia cases with no significant intraindividual decline,36 and a British birth cohort study found consistently lower, but not declining, scores at older ages (7, 11, and 16 y) among individuals who later developed schizophrenia.17

**Fig. 1.** (a) Distribution of full scale IQ (FSIQ) at age 4 of premorbid schizophrenia spectrum psychoses (SSP) cases (N = 37), premorbid affective psychoses (AP) cases (N = 39), and nondiagnosed population controls (N = 9724). (b) Distribution of FSIQ at age 7 among premorbid SSP cases (N = 37), premorbid AP cases (N = 39), and nondiagnosed population controls (N = 9724).

**Fig. 2.** Means and SD of full scale IQ (FSIQ) among premorbid schizophrenia spectrum psychoses (SSP) cases (N = 37), premorbid affective psychoses (AP) cases (N = 39), and nondiagnosed population controls (N = 9725) at ages 4 and 7.

Among future SSP cases, average IQ is slightly higher at age 7 than age 4. AP cases perform at a level intermediate between future SSP cases and controls.

Table 2 provides results of models examining level of and change in childhood IQ in relation to the odds of SSP and AP. ORs are scaled to a half SD of IQ (7.5 points). In the unadjusted model, both the overall level and change in IQ are associated with the odds of SSP. After adjustment for multiple covariates, lower average IQ in childhood remains significantly related to higher risk of SSP (OR = 1.23, 95% CI: 1.03, 1.48, P < .05), and a slight increase in IQ from age 4 to 7, relative to a small decrease in controls, is associated with higher risk of SSP (OR = 1.22, 95% CI: 1.01, 1.48, P < .05); male gender is also significantly predictive of SSP. Other sociodemographic covariates, such as maternal education and SES at birth, were not statistically significant in the multivariable model. Among analyses examining AP, neither level of IQ nor change in IQ, were significantly associated with elevated risk.

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Table 2. Unadjusted and Multivariable-Adjusted Models of Level of and Change in FSIQ Among Premorbid Schizophrenia Cases (N = 37), Premorbid Affective Psychoses Cases (N = 39), and Nondiagnosed Population Controls (N = 9724)

<table>
<thead>
<tr>
<th></th>
<th>Schizophrenia Spectrum Psychoses (SSP) (N = 37)</th>
<th>Affective Psychoses (AP) (N = 39)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unadjusted</td>
<td>Adjusteda</td>
</tr>
<tr>
<td>Level of FSIQ</td>
<td>1.29** (1.10, 1.51)</td>
<td>1.23* (1.03, 1.48)</td>
</tr>
<tr>
<td>Change in FSIQ</td>
<td>1.25* (1.04, 1.53)</td>
<td>1.22* (1.01, 1.48)</td>
</tr>
<tr>
<td>Male gender</td>
<td>—</td>
<td>2.64* (1.24, 5.65)</td>
</tr>
</tbody>
</table>

Note: SSP include schizophrenia and schizoaffective depressed type; AP include schizoaffective bipolar type, bipolar disorder with psychotic features, and major depressive disorder with psychosis.

*Adjusted models include gender, SES at birth, maternal education, maternal race, presence of subject at 8 mo exam and presence of subject at 1 y exam.

*P < .05, **P < .01.

Most evidence pointing to a premorbid decline in cognition relative to peers among later schizophrenia cases comes from studies including IQ testing in later childhood/adolescence. The National Survey of Health and Development tested participants at ages 8, 11, and 15 and found that differences in IQ between schizophrenia cases and controls were larger as the age at testing increased.6 A study from the Dunedin cohort fit growth-curve models to cognitive test scores at ages 7, 9, 11, and 13 and found stable deficits in verbal and visual knowledge reasoning, acquisition, and conceptualization, and a developmental lag on tests of visual-spatial problem solving and freedom from distractability.12 Premorbid schizophrenia cases in a longitudinal Swedish cohort study exhibited relative declines, most pronounced in areas of verbal ability, from ages 13 to 18.14 A retrospective study of school records of individuals who later developed schizophrenia showed no significant change in cognitive test scores from grades 4 to 8, but a significant decline in scores from grades 8 to 11 compared with state norms.13 Additionally, studies of cognition among adolescents at clinical high risk for psychosis (who later transitioned to psychosis) show a larger effect size for IQ differences compared with controls (~3/4 SD) than the effect size observed in childhood prior to the onset of attenuated psychotic symptoms (~1/2 SD), consistent with the idea that deviation in cognition from peers increases in the period closer to onset of psychosis.15 Thus, if a lag occurs, it may typically appear by early teen years and be observed best with individual tests rather than FSIQ overall.

A secondary finding was that the control group had lower mean IQ scores at age 7 than at age 4 while, on average, IQ scores were slightly higher at age 7 than age 4 in the SSP group. This finding of a relative increase, rather than decrease, in IQ from ages 4 to 7 associated with higher risk of SSP was unexpected and did not support a smaller pilot study that found a decline in childhood cognition associated with psychotic symptoms.16 The current study offers several advantages compared with this earlier pilot study, including a longer period of follow-up (39 vs 23 y) and a larger sample size with more definitive disorders (76 individuals with SSP or AP compared with the earlier 18 individuals with psychotic symptoms). Prior evidence that relates to the current finding of a subtle, relative increase in IQ in childhood associated with later schizophrenia is limited. Results from the Philadelphia cohort of the CPP parallel the current results in a demographically quite different population with a differing IQ range: future cases of schizophrenia showed a slight increase in IQ from age 4 to 7, while controls showed an average decrease in IQ from ages 4 to 7.36

There are a number of possible interpretations of this result. First, this may be a methodological artifact of using different IQ tests at the 2 different time points. If our finding is a true estimate of cognitive development, it could be conceptualized as reflecting increased variability in IQ, consistent with the “pandysmaturation” model, as described by Fish.3,19 While the current study was not designed to examine this hypothesis, our data suggest a narrowing gap in cognitive performance between cases and controls that could be consistent with Fish’s concept of transient deficits in development which are followed by an “acceleration in the rate of development….”19 Our findings could also reflect the idea that the cognitive performance of children at risk for schizophrenia benefits from the structure of early schooling. However, we are limited in our ability to examine this question by having IQ assessments at only 2 time points using different tests. Further research with cognitive assessments at more time points is necessary to determine whether this relative, subtle increase in IQ from age 4 to 7 is a methodological artifact, is indicative of a true improvement in cognition across childhood, or reflects a higher overall variability (both increases and decreases in IQ) among individuals who later develop schizophrenia.
Studies of childhood cognition among individuals who later develop affective disorders have generally identified some impairment in childhood (but typically less than what has been shown among future schizophrenia cases) or no childhood cognitive deficits compared with controls. However, less research has been done examining childhood cognition among individuals with AP. Our finding that future AP cases performed more poorly than controls (but not significantly so) and better than later schizophrenia cases is consistent with an earlier study from this cohort that examined cognitive performance at age 7 only. This conclusion is strengthened in the current study by including results from 2 time points in childhood, and the additional finding that AP is not associated with a significant increase or decrease in IQ from ages 4 to 7. Despite AP cases sharing some psychotic symptoms with SSP as adults, it appears that childhood premorbid IQ deficits are primarily associated with later development of SSP. These data are consistent with the idea that additional risk factors, such as a higher loading of genetic risk or obstetric complications, could contribute to the premorbid cognitive impairment that is more evident in SSP compared with AP.

There are several limitations of the current study. First, we examined IQ at only 2 time points and therefore cannot extend our analyses to growth-curve models that can examine in a more detailed way the slope of change in cognition. Additionally, because different IQ tests were administered (the Stanford-Binet at age 4 and the WISC at age 7), differences in performance across the 2 ages could be related to differences in the IQ batteries. However, because both case groups and comparisons were administered the same tests, we are able to compare performance between cases and controls. Moreover, our primary definition of “controls” included all individuals in the cohort not identified as having a diagnosis of psychotic disorder in adulthood. It is therefore possible that our control group included false negatives. However, we think this is unlikely to have greatly influenced our results as sensitivity analyses comparing psychosis cases to screened controls showed results similar to our primary analysis.

Another important limitation is that a large proportion of the original NEFS cohort did not have information on IQ at both testing ages and were therefore excluded from the present study. However, we found that sociodemographic factors associated with study dropout (higher maternal education, SES and Caucasian race) were not associated with risk of adult psychosis in this sample, and that controlling for these variables, dropout was not associated with adult case status. Additionally, there are other aspects of cognitive performance not captured by IQ testing (such as declarative memory or executive functioning) that could be related to risk of adult psychotic disorder that were not assessed in this study. Finally, results for subtle changes in IQ should be interpreted with caution, as point estimates of IQ may be inherently unstable in small samples of slightly impaired individuals.

This study also has several strengths. First, it is one of the few to examine the trajectory of childhood cognitive development at younger ages (4 and 7 y), providing an earlier-life complement to studies assessing cognition from later childhood into adolescence. Second, we are able to disaggregate the outcome of psychotic disorder into SSP and AP. Finally, our study drew from a general population birth cohort, so results are more representative of the general population of individuals with SSP and AP than those from studies of individuals at genetic high risk for psychosis.

In conclusion, we found that individuals who later develop SSP show a deficit in IQ in early childhood across 2 time points relative to nonpsychotic controls; these effects were not observed in individuals who later develop AP. The absence of IQ decline in early childhood suggests that the relative cognitive decline associated with schizophrenia does not emerge until the teenage years. Subtle greater variability in IQ over time among later SSP cases compared with controls is suggestive of atypical, unusually variable neurodevelopment in premorbid schizophrenia and requires further testing. Future research could elucidate the brain mechanisms and psychosocial factors underlying these deficits in cognition in early childhood found among individuals who later develop schizophrenia, and potential ways in which these deficits may be remediated.

Supplementary Material
Supplementary material is available at http://schizophreniabulletin.oxfordjournals.org.

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