Published in final edited form as:
Psychiatry Res. 2010 June 30; 178(1): 23–26. doi:10.1016/j.psychres.2010.03.016.

Premorbid IQ and adult schizophrenia spectrum disorder: Verbal and performance subtests

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Abstract

The present prospective high-risk study examined associations between childhood scores on five WISC subtests (Vocabulary, Similarities, Block Design, Object Assembly, and Mazes) and later development of schizophrenia-spectrum disorders (SSD). The sample comprised 244 high-risk or control children who were administered the WISC subtests at age 10 to 13 years in 1972. Adult psychiatric data were gathered from psychiatric interviews in 1992-93 and from the Danish Psychiatric Central Register in 2007. Thirty-two participants had developed SSD, 79 other psychiatric disorders (OPD), and 133 had no diagnosis (ND). The SSD group obtained lower scores than the ND group on all subtests and IQs, but when adjusted for sex and parental social status only significantly lower scores on similarities, object assembly, mazes, and total IQ. Compared with the ND group, the OPD group obtained significantly lower scores on similarities, vocabulary, verbal IQ, and total IQ. The only significant difference between the SSD and OPD groups were on object assembly (OPD performed at the level of ND). The results suggest a premorbid deficit in general intelligence in individuals who later develop SSD. The results for the OPD group support recent studies demonstrating that premorbid IQ deficits may characterize a wide range of psychiatric disorders.

Keywords

Premorbid Intelligence; WISC; schizophrenia; schizophrenia spectrum disorder; psychiatric disorders; pre-schizophrenia

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1. Introduction

For decades, schizophrenia researchers have sought to establish whether general intelligence or specific aspects of intelligence are related to schizophrenia. Most of this research has been conducted on the relationship between general intelligence and later schizophrenia. A recent meta-analytic review has concluded that years before the onset of psychotic symptoms, individuals with schizophrenia, as a group, demonstrate mean IQ scores approximately one half of a standard deviation below that of healthy comparison subjects (Woodberry et al., 2008). Although it is now well established that an association between low IQ and schizophrenia exists, the relationship seems to have low specificity as a number of studies have shown that low premorbid IQ is also linked to several other psychiatric disorders than schizophrenia (Zammit et al., 2004; Mortensen et al., 2005; Koenen et al., 2009; Urfer-Parnas et al., 2010).

For the Wechsler IQ scales, it is not firmly established whether total IQ or specific subtests have the strongest association with later schizophrenia (Aylward et al., 1984). Only a few prospective studies have shed light on this question. A trend towards lower Performance IQ among pre-psychotic individuals was reported in The New York High-Risk Project (Ott et al., 1998). In an analysis based on the US National Collaborative Perinatal Project, Niendam et al. (2003) evaluated childhood cognitive functioning in individuals who later developed schizophrenia and in their unaffected siblings. Pre-schizophrenic children and their unaffected siblings obtained lower scores on picture arrangement, vocabulary, and coding than healthy controls, but differed from each other only on the coding subtest. In line with this finding, an analysis based on the Copenhagen High Risk Project showed that individuals destined to develop a disorder within the schizophrenia spectrum differed from controls on the coding subtest (Sorensen et al., 2006).

Psychiatric follow-up studies of young individuals at genetic high risk for schizophrenia could play an important role in elucidating how total IQ or specific IQ subtests relate to schizophrenia. To further examine the premorbid IQ subtest performance in schizophrenia and related disorders we initiated an analysis based on a high-risk sample drawn from the Copenhagen Perinatal Cohort. This high-risk sample, which was extensively examined (Mednick et al., 1971), including IQ testing in 1972 represents individuals at different genetic risk for schizophrenia (Schiffman et al., 2009) and comprised 265 participants in 1972. By May 2007, the cohort members were 47-48 years old and were likely to have passed the risk period for schizophrenia.

2. Methods

2.1. Subjects

The data collection and results of previous analyses of this Danish high-risk sample have been described elsewhere (Mednick et al., 1971; Marcus et al., 1985; Schiffman et al., 2009). In brief, high-risk children were originally identified in 1969 on the basis of their parental record of psychiatric admissions. Subjects were drawn from the Copenhagen Perinatal Cohort consisting of all children born between September 1, 1959, and December 31, 1961, at Rigshospitalet in Copenhagen (Zachau-Christiansen and Ross, 1975). In 1972, a sample of 265 10–13 year old children from this cohort was intensively examined (Mednick et al., 1971). Psychiatric follow-up data were available for 244 (92%) of the original 265 cohort members, and these 244 individuals constitute the present study sample.

2.2. The 1972 IQ Examination

The original 265 children were thoroughly examined between the ages of 10 and 13. None had a psychiatric diagnosis at the time. Along with a battery of other tests, the children were

all administered 2 verbal and 3 nonverbal subtests of the Wechsler Intelligence Scale for Children (WISC) at the mean age of 12.1 years (Wechsler, 1955). The included subtests were vocabulary, similarities, block design, mazes, and object assembly. In addition total IQ, verbal IQ and performance IQ were derived. The tests were administered by a team of trained psychologists.

2.3. Psychiatric outcome assessments

Two adult psychiatric follow-ups have been conducted. The first took place in 1992-93, when the subjects were between 31 and 33 years of age, and comprised a semi-structured interview (SCID-II, Spitzer et al., 1987) and the psychosis section of the Present State Examination (Wing et al., 1974). Two psychiatrists (ME and HS) also systematically assessed all available psychiatric hospital records. On the basis of the interviews and/or hospital records, adult DSM-IIIR diagnostic outcomes were obtained for the 244 subjects in the study sample. In 1992-93, a registry-based and interview-based diagnostic follow-up was also carried out amongst the parents, and for those with a psychiatric hospitalization history we obtained DSM-III-R and ICD diagnoses from the hospital records.

The second psychiatric follow up was entirely registry-based and was carried out in May 2007. The Danish Psychiatric Central Register has been computerized since April 1, 1969. The register contains data on all admissions to Danish psychiatric inpatient facilities. Until 1994, diagnoses were coded according to the International Classification of Diseases, 8th Revision (ICD-8), and since 1994 according to ICD-10 criteria. The 244 subjects and their parents were classified into three diagnostic groups: 1) Schizophrenia spectrum disorders (SSD), 2) Other psychiatric disorders (OPD), and 3) No psychiatric diagnosis (ND). Schizophrenia spectrum disorders included the following diagnoses: schizophrenia according to either DSM-III-R or ICD-10 (F20), schizotypal personality disorder, any delusional disorder, or paranoid personality disorder according to DSM-III-R, schizotypal disorder (F21), paranoid psychosis including, simple paranoia (F22), acute transitory psychosis (F23), schizoaffective psychosis (F25), non-organic psychosis (F28 and F29) according to ICD-10. All individuals with any of these diagnoses were categorized in the SSD group. Previous research has demonstrated high reliability of the clinical diagnoses within the schizophrenia spectrum in the Danish Psychiatric Central Register (Jakobsen et al., 2005). The category OPD comprised any registration with a psychiatric diagnosis or any interview-based diagnosis outside the schizophrenia spectrum.

Based on the first diagnostic assessment we identified 26 subjects within the schizophrenia spectrum by the age of 32-33 years. The 2007 diagnostic assessment identified 6 additional subjects who met the ICD-10 criteria for schizophrenia, schizotypal disorder, paranoid psychosis or delusional disorder. Thus, the total number of subjects with a lifetime disorder within the schizophrenia-spectrum (SSD) was 32 by May 2007. The total number of subjects with a lifetime diagnosis in the OPD group was 79, whereas there were 133 subjects with no psychiatric diagnosis (ND). To investigate possible differences among OPD diagnostic subgroups a hierarchical diagnostic approach was used to classify the OPD group into affective- and anxiety disorders (n = 27), alcohol and drug related disorders (n = 34) and non-spectrum personality disorders (n = 18).

2.4. Covariates

We used the most updated psychiatric registry information about the parents to describe parental psychiatric status by May 2007. Of the 244 cohort members, 94 had a mother or a father who had been hospitalized with or received an interview-based diagnosis of schizophrenia, 84 had a parent with a diagnosis other than schizophrenia, and 66 cohort members had parents without any psychiatric diagnosis.

Information about parental social status was obtained from an interview with the mother when the child was 1 year old (Zachau-Christiansen & Ross, 1975). The social status classification was based on information about breadwinner's occupation, breadwinner's education, type of income, and quality of housing. Parental social status was coded on a 1-8 point scale with high scores indicating high social status. For this variable, data were missing for 42 (15.9%) of the subjects, and in these cases the EM Algorithm was used to impute data (Schafer, 1997).

2.5. Data analysis

To enable comparisons among WISC subtests and age adjustments of test scores, scaled scores were preferred to subtest raw scores and analyzed together with IQs (preliminary analyses showed that age was not significantly associated with any scaled score or IQ). ANOVA and ANCOVA were used to compare subtests and IQs in the 3 diagnostic categories (SSD, OPD and ND). The main ANCOVA model included gender and parental social status as covariates. In addition, regression analyses were conducted to evaluate possible main effects of parental psychiatric status on offspring WISC scores and to evaluate potential interactions between parental psychiatric status and offspring diagnostic category with respect to offspring WISC performance. Finally, in an exploratory analysis multinomial logistic regression was conducted to evaluate WISC total IQ as a predictor of both SSD and OPD status. Statistical significance was set at $p<0.05$.

3. Results

Preliminary analyses showed that the relationship between parental social status and all WISC scores was linear, and sex and parental social status were included as covariates in a model testing the main effects of parental psychiatric status and offspring diagnostic outcome and the interaction between these two factors. For parental psychiatric status this analysis showed no significant main effect or interaction with offspring diagnostic category, and consequently no further analyses were conducted on this variable.

Table 1 shows mean test scores and standard deviations in the SSD, ND and OPD offspring diagnostic outcome groups. ANOVA showed significant mean differences in the verbal and total IQ and in the similarities, vocabulary, mazes, and object assembly subtests. After ANCOVA adjustment for gender and parental social status, the adjusted p values remained significant, except for vocabulary.

Table 2 shows the adjusted differences between the three offspring diagnostic outcome groups. Comparison of the SSD and ND groups showed that the SSD group obtained lower scores on all subtests and IQs than the control group without psychiatric diagnoses. The adjusted difference in mean test scores was significant for performance and total IQ and for similarities, mazes, and object assembly.

Columns 3 and 4 in table 2 show that the SSD and OPD groups performed at similar levels in most tests, and that the only significant difference in adjusted mean performance was in object assembly where the OPD groups obtained a significantly higher mean score than the SSD group. Columns 5 and 6 of the table show that the OPD group performed at the level of the ND group in object assembly, but obtained significantly lower adjusted mean scores in verbal and total IQs, similarities, vocabulary, and mazes.

The OPD group is diagnostically heterogeneous, but ANCOVA adjusting for sex and parental social status did not reveal any significant differences among the three OPD diagnostic subgroups with respect to WISC IQs and subtest scores.

As might be expected, multinomial logistic regression showed that WISC total IQ was a significant predictor of both SSD and OPD status. For a one unit increase in IQ, the relative risk of developing either SSD or OPD was close to 0.97. When evaluating the relative risk, it should be born in mind that one unit on the IQ scale corresponds to 1/15 of the theoretical IQ standard deviation of 15.

4. Discussion

The main finding from this longitudinal high-risk study was that children who developed SSD obtained significantly lower total IQ than children who did not develop a psychiatric diagnosis (ND), but not significantly lower than children who developed other psychiatric disorders (OPD). The SSD obtained lower scores than the ND group on all IQs and subtests, and although not all differences in mean test scores were significant, the consistent lower performance in the SSD group suggests a premorbid deficit in general intelligence. This deficit is not specific to schizophrenia spectrum disorders since the test scores of the OPD group were similar to the scores obtained by the SSD group. The OPD group performed at the level of the ND group in object assembly and significantly better than the SSD group, but the overall pattern of test scores in the OPD group is also consistent with a premorbid deficit in general intelligence.

It is a methodological advantage of this high-risk study that data on a number of potential confounding factors had been collected independently of the study outcome. We observed that statistical control for sex and parental social status did not substantially attenuate the differences in mean test scores between the ND controls and the SSD and OPD diagnostic outcome groups.

The overall findings of this longitudinal high-risk study extend and corroborate some of the published findings on the relationship between IQ and later schizophrenia based on prospective studies (Jones et al., 1994; Zammit et al., 2004; Mortensen et al., 2005; Koenen et al., 2009; Urfer-Parnas et., 2010) and meta-analyses (Aylward et al.,1984; Woodberry et al., 2008). Thus, it is consistent with many previous findings that the SSD group performed approximately one half of a standard deviation below the ND group in this study.

Although the overall premorbid intellectual deficit between those who do and do not develop schizophrenia is well documented, there is still need for further clarification of deficits within specific domains (Woodberry et al., 2008). In the present study, five WISC subtests were administered and significant differences between the SSD and ND groups were observed on similarities, mazes, and object assembly, but not on block design or vocabulary. These results can be viewed within the context of several previous studies, all with similar findings. In the US National Collaborative Perinatal Project, only some of the WISC subtests were administered. Children who developed schizophrenia and their siblings obtained lower scores than controls on picture arrangement, vocabulary and coding, while a significant difference between pre-schizophrenic and healthy siblings was only observed on the coding subtest (Niendam et al., 2003). In the Copenhagen High Risk Study, all subtests from WISC were administered, but low performance on the coding subtest was the only significant difference between the SSD and the ND groups (Sorensen et al., 2006).

From a methodological viewpoint, the current study resembles the Copenhagen High Risk Study since both studies used a high-risk design and made use of The Danish Psychiatric Central Register as part of the psychiatric follow-up. It is therefore remarkable that one study found evidence of a relatively specific dysfunction on the coding subtest (Sorensen et al., 2006), while the results of the present study suggest a premorbid deficit in general intelligence (in the Copenhagen High Risk Study the difference between SSD and controls

was 1.7 IQ points). In the New York high-risk study, nonverbal IQ subtests were more strongly associated with schizophrenia-related psychosis than verbal IQ (Ott et al., 1998; Amminger et al., 2000), while in our study the association with later schizophrenia was similar for the verbal and the performance IQs. Thus, our results suggest deficits in general intelligence and are in line with a recent study using structural equation modelling to evaluate the relative importance of generalized and specific cognitive deficits in schizophrenia (Dickinson et al., 2008).

This study suffers from some notable limitations. Despite a relatively high number of individuals who developed a schizophrenia-spectrum disorder, the raw number of people in this group limits statistical power. Thus, the risk of type II errors should be kept in mind when interpreting some of the insignificant results with respect to subtests. The possibility of type I error should also be kept in mind, particularly when interpreting the significant differences between the SSD and the OPD groups with respect to object assembly, since the relatively high scores of the OPD group on this task may have been a chance finding.

The decision to collapse various diagnostic categories within the schizophrenia spectrum into one SSD group was pragmatic (to increase analytic power in this quite small sample), but evidence from a previous high-risk study actually suggests similar premorbid IQ subtest-profiles in subjects who develop a psychotic disorder within the schizophrenia spectrum and in subjects with a non-psychotic schizophrenia spectrum disorder (i.e. mainly schizotypal disorder) (Sorensen et al., 2006).

A concern shared by all high-risk research is the issue of generalizability to individuals who develop a spectrum disorder but who do not have a parent with schizophrenia, although it is likely that genetic influences play a role in most cases of schizophrenia, even if the parents fail to manifest the disorder phenotypically (Cannon et al., 1999). In the present study, the effect of offspring diagnostic outcome on offspring intellectual function was not modified by parental psychiatric status. Although our study obviously had limited statistical power to detect an interaction between parental psychiatric status and offspring psychiatric outcome, our results suggest that the association between premorbid intelligence and schizophrenia spectrum disorder is similar in high and low risk individuals. The literature contains a number of studies suggesting differences between first degree relatives of individuals with schizophrenia and controls (e.g., Byrne et al., 1999; Cannon et al., 2000; Niendam et al., 2003; Whyte et al., 2006), but what is needed are studies comparing intelligence in schizophrenic individuals with and without first degree relatives with the disease.

An additional limitation is that the premorbid IQ assessment for this study was conducted at one time point only. As a result, we were unable to contribute to the understanding of the stable versus progressively deteriorating nature of premorbid IQ deficits among individuals who later go on to develop schizophrenia (e.g., Reichenberg et al., 2005). Since the mean age of our sample was about 12 when intelligence was assessed, it remains an open question whether significant intellectual decline already had affected future schizophrenic participants at the time of assessment (Kremen et. al., 1998). Although premorbid deficits were clearly identifiable prior to psychotic symptoms at the time of assessment, the limitation of only one premorbid assessment prohibits speculation about the developmental trajectory of the deficits.

In conclusion, the present study provides evidence of a premorbid deficit in general intelligence in individuals who later develop schizophrenia. A comparable premorbid deficit in general intelligence was observed in individuals who later developed other psychiatric diseases, and the intelligence deficit appears not to be specific for schizophrenia or schizophrenia spectrum disorders. Thus, our results support recent studies demonstrating

that premorbid IQ deficits may characterize a wide range of psychiatric disorders (Zammit et al., 2004; Mortensen et al., 2005; Koenen et al., 2008, Urfer-Parnas, 2010).

Acknowledgments

This work was supported by Sygekassernes Helsefond (Health Insurance Foundation), by grant 9700093 from the Danish Research Council, and by grant R03MH076846 from the National Institute of Mental Health. Thanks are due to Vibeke Munk for help with the manuscript and critical comments.

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Psychiatry Res. Author manuscript; available in PMC 2013 August 01.

Table 1

Observed and adjusted means in three diagnostic outcome categories[1]. The p values are for the overall F in ANOVA and ANCOVA[2]

	SSD (n=32)	OPD (n=79)	ND (n=133)	P for overall F	Adjusted SSD mean	Adjusted OPD mean	Adjusted ND mean	Adjusted p-value
Total IQ	102.8 (18.2)	104.2 (15.1)	109.4 (13.9)	0.013	103.2	104.6	109.3	0.017
Verbal IQ	100.0 (16.4)	99.6 (15.8)	105.8 (14.8)	0.010	100.5	100.3	105.5	0.020
Performance IQ	105.1 (20.8)	108.4 (16.3)	111.7 (14.9)	0.079	105.4	108.5	111.8	0.083
Similarities	9.6 (2.7)	9.9 (2.4)	10.8 (2.2)	0.005	9.7	10.0	10.7	0.011
Vocabulary	10.3 (3.1)	9.9 (3.1)	11.0 (3.1)	0.048	10.4	10.0	10.9	0.083
Block design	11.7 (3.5)	11.4 (3.2)	12.1 (2.8)	0.331	11.7	11.5	12.1	0.370
Mazes	9.1 (2.9)	9.6 (2.8)	10.4 (2.7)	0.019	9.2	9.6	10.4	0.026
Object assembly	11.1 (3.7)	12.6 (2.8)	12.5 (2.9)	0.042	11.1	12.6	12.5	0.042

[1]SSD = schizophrenia-spectrum, OPD = other psychiatric disorder and ND = no psychiatric disorder

[2]Adjusted for gender and parental social status.

Table 2

Adjusted mean differences between the three offspring diagnostic outcome categories[1,2]

	SSD vs. OPD Adjusted mean difference	SSD vs. OPD P	SSD vs. ND Adjusted mean difference	SSD vs. ND P	OPD vs. ND Adjusted mean difference	OPD vs. ND P
Total IQ	−1.37 (−7.04 – 4.29)	0.633	−6.05 (−11.39 – −0.71)	0.027	−4.68 (−8.57 – −0.79)	0.019
Verbal IQ	0.20 (−5.62 – 6.03)	0.945	−5.03 (−10.52 – 0.45)	0.072	−5.24 (−9.23 – −1.24)	0.010
Performance IQ	−3.08 (−9.54 – 3.39)	0.349	−6.32 (−12.41 – −0.23)	0.042	−3.25 (−7.68 – 1.19)	0.150
Similarities	−0.32 (−1.24 – 0.60)	0.492	−1.08 (−1.94 – −0.22)	0.014	−0.76 (−1.39 – −0.14)	0.017
Vocabulary	0.42 (−0.75 – 1.59)	0.483	−0.49 (−1.59 – 0.61)	0.381	−0.91 (−1.71 –−0.10)	0.027
Block design	0.26 (−0.96 – 1.47)	0.675	−0.33 (−1.48 – 0.81)	0.566	−0.59 (−1.43 – 0.24)	0.163
Mazes	0.45 (−1.58 – 0.67)	0.426	−1.24 (−2.30 – −0.19)	0.021	−0.79 (−1.56 – −0.02)	0.044
Object assembly	−1.44 (−2.65 – 0.24)	0.019	−1.37 (−2.51 – −0.24)	0.018	0.07 (−0.75 – 0.90)	0.861

[1]SSD = schizophrenia-spectrum, OPD = other psychiatric disorder and ND = no psychiatric disorder

[2]Adjusted for gender and parental social status