The role of cognitive functioning in the outcome of those at clinical high risk for developing psychosis

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Although it is well established that cognitive impairment is a common feature of schizophrenia, only recently has cognitive functioning been prospectively studied in individuals at clinical high risk (CHR) for developing psychosis. To date, both cross-sectional and longitudinal studies have been conducted in the CHR population and in the context of later conversion to psychosis. A comprehensive review of the literature suggests that CHR individuals have general and specific baseline cognitive deficits compared to healthy controls. As a group, their cognitive course, tends to remain stable over time and in this way does not differ from healthy controls. For those who go on to develop a full-blown psychotic illness compared to those who do not convert, there appeared to be minimal differences at baseline with respect to cognition, although over time the converters may show deterioration in certain cognitive abilities compared to the non-converters. However, for many cognitive domains results are mixed, and may result from methodological limitations.

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Key words: Cognition, high risk, prodrome, psychosis, schizophrenia.

Introduction

Cognitive deficits are considered to be a core symptom of schizophrenia in that they precede the presentation of clinical symptoms (Reichenberg, 2010), and can impact functioning (Green et al. 2004). Cognition tends to remain relatively stable over the course of the illness, at most improving modestly, with those at the first episode exhibiting impairment of a similar severity to those with a more chronic course of illness (Mesholam-Gately et al. 2009).

It is possible that some of the cognitive impairment that occurs in schizophrenia is already present before the first episode (Jones et al. 1994). The increase in prospective research (Addington & Heinssen, 2012) which examines individuals who are at clinical high risk (CHR) for developing psychosis, offers an excellent opportunity to determine whether there is evidence of cognitive impairment prior to the onset of fully blown psychosis. In an earlier comprehensive review of 17 studies, Brewer and colleagues (Brewer et al. 2006) reported that the association between cognition and emerging psychosis was not well understood. These authors highlighted a lack of consistency in the literature, with contrasting results about the putatively impaired cognitive domains. However, they did conclude that general cognitive ability appeared to remain intact and was a poor predictor of developing psychosis. We have updated Brewer’s review of 2006 to determine the impact of the increased attention to cognition for those at CHR of psychosis to determine whether we have an increased understanding of the role of cognition on outcome for these young CHR individuals.

Methods

Cognitive studies in CHR populations were identified through computerized searches of Pubmed, Medline and PsychINFO bibliographic databases. The terms searched included combinations of: prodromal, prodrome, ultra high risk, clinical high risk, neurocognition, cognition, neurocognitive, cognitive, neuropsychological and neuropsychology. Since the Brewer review was published in 2006 (Brewer et al. 2006), we have only included studies published between June 2006 and December 2011. Studies were included if participants were identified as being at CHR, UHR or prodromal, if they had evidence of basic symptoms, or if specific criteria or measures were used and described to make this diagnosis. Acceptable criteria and measures included: the Criteria of Prodromal Syndromes (COPS) criteria based on the Structured Interview for Prodromal Syndromes (McGlashan et al. 2010), the Personal Assessment and...
Crisis Evaluation (PACE) criteria based on the Comprehensive Assessment of an At Risk Mental State (CAARMS) (Yung et al. 1998), the Basel Screening Instrument for Psychosis (BSIP) (Riecher-Rossler et al. 2007)/ Brief Psychiatric Rating Scale (BPRS) (Ventura et al. 1993), specific DSM-III-R prodromal symptoms (Jackson et al. 1995), the Bonn Scale for the Assessment of Basic Symptoms (BSABS) (Vollmer-Larsen et al. 2007), the Schizophrenia Prediction Instrument-Adult Version (SPI-A) (Klosterkotter et al. 2001), the Early Recognition Inventory/Interview for the Retrospective Assessment of the Onset of Schizophrenia (ERI-Iraos) (Hafner et al. 2004) and the Cognitive Assessment and Risk Evaluation (CARE) program criteria (Eastvold et al. 2007). Studies were excluded if they included frankly psychotic or genetic high-risk participants (without clinical symptoms or functional decline) mixed into their CHR, UHR or prodromal sample (Cosway et al. 2000; Myles-Worsley et al. 2007).

Results

The literature search yielded 23 publications that were deemed appropriate for review. These are presented in Table 1. Some studies are cross-sectional, whereas others are longitudinal. Some studies compared the performance of the CHR group with that of healthy controls, whereas others compared the performance of CHR individuals who later converted to psychosis to that of CHR individuals who did not convert.

In a few of these publications, the CHR group was divided into two groups, usually on the basis of the severity of symptoms. The less severe group typically met what are known as basic symptoms while the more severe group met criteria for either an Attenuated Positive Symptom Syndrome or a Brief Intermittent Psychotic Syndrome. In such cases only data from the more severe group, i.e., those meeting the more typical criteria were considered in the review. The summary of the results presented below are based on the 23 studies reviewed and listed in Table 1.

Comparison of CHR individuals with healthy controls

There is increasing evidence from the studies reviewed that compared to healthy controls CHR individuals are significantly impaired in cognition when a composite cognitive score is considered. Otherwise, there is some evidence suggesting impairment in specific domains of cognition but for most domains of cognition results are mixed. For example about half of the studies we reviewed that assessed intelligence reported significant impairment in verbal intelligence in the CHR group, while the remainder found no difference. However, there was less evidence of non-verbal IQ impairment in this population.

Impaired verbal memory was reported in eight studies using a range of tasks such as list learning and the Wechsler Memory Scale Logical Memory subtest, but five studies did not support this finding. Interestingly, the majority of studies do not support a difference in visual memory (Nienad et al. 2006, 2007; Pukrop et al. 2006; Becker et al. 2010b; Lindgren et al. 2010). Both verbal and visuo-spatial working-memory deficits have frequently been reported in the CHR population (Brewer et al. 2006); however, recent results are inconsistent with four to five studies demonstrating working-memory deficits and the same number reporting no differences. Similar results are observed for processing speed, sustained attention, executive functioning and fine motor function with several studies reporting impairment in the CHR group and several failing to highlight a difference between CHR and healthy control groups. The one exception was verbal fluency for which impairment has been consistently observed.

Thus, the results from a comprehensive selection of studies comparing CHR individuals with healthy controls on the majority of cognitive tasks are consistently contradictory. It is possible that the inconsistency can be accounted for by the use of different tasks across different studies; for example, tests such as digit symbol coding are known to be sensitive for the detection of subtle impairment, while others may have limited sensitivity. Nonetheless, this is not always the case as contrasting results often come from studies that used the same measure.

Conversion to psychosis

One of the important aims of CHR research is to discover predictors of developing psychosis. Several studies compared baseline scores of those CHR participants who went on to develop psychosis to those who did not. Unfortunately, once again consistent results are rare. There are reports that those who converted were significantly impaired on a composite score of cognition or had lower verbal IQ but in each case there are contradictory studies. There is support for poorer performance on tests of verbal memory, verbal fluency and processing speed for those who converted, but this was not consistently supported. However, results supporting a lack of significant difference in visual memory, verbal or spatial working memory, executive functioning, attention or finger tapping between the converters and non-converters are consistently reported. Studies are limited but there is
Table 1. Studies of cognition in individuals at CHR for psychosis

<table>
<thead>
<tr>
<th>Study</th>
<th>Participants</th>
<th>Mean age</th>
<th>Tasks</th>
<th>Follow-up (months)</th>
<th>Rate of conversion</th>
<th>Anti-psychotic use</th>
<th>Clinical tool</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastvold et al. (2007)</td>
<td>40 CHR</td>
<td>21</td>
<td>Vocabulary, block design, Stroop colour-word, numeric attention, letter number sequencing, spatial span, HVLT, WCST</td>
<td>12</td>
<td>17%</td>
<td>NA</td>
<td>SIPS/SOPS</td>
</tr>
<tr>
<td>Frommann et al. (2010)</td>
<td>89 CHR</td>
<td>25</td>
<td>MWT-B, RAVLT, self-ordered pointing task, trails A and B, digit symbol coding, letter fluency, CPT, letter number sequencing</td>
<td>–</td>
<td>–</td>
<td>Yes (10%)</td>
<td>ERIraos</td>
</tr>
<tr>
<td>Pflueger et al. (2007)</td>
<td>54 CHR</td>
<td>27</td>
<td>MWT-A and LPS scale 3, tower of Hanoi, WCST, TAP (go/no go, working memory), CPT-OX</td>
<td>–</td>
<td>–</td>
<td>Yes (7%)</td>
<td>BSIP/BPRS</td>
</tr>
<tr>
<td>Pukrop et al. (2006)</td>
<td>90 CHR</td>
<td>25</td>
<td>MWT-B, visual backwards masking, CPT-IP, spatial working memory task (dot location), RAVLT, Rey–Osterrieth complex figure test, category and letter fluency, WCST</td>
<td>–</td>
<td>–</td>
<td>No</td>
<td>SIPS/SOPS</td>
</tr>
<tr>
<td>Simon et al. (2007)</td>
<td>69 CHR</td>
<td>20</td>
<td>MWT-B, letter number sequencing, trails A and B, category and letter fluency, WCST, RAVLT, TAP (sustained attention, alertness)</td>
<td>–</td>
<td>–</td>
<td>No</td>
<td>SIPS/SOPS</td>
</tr>
<tr>
<td>Jahan et al. (2010)*</td>
<td>48 CHR</td>
<td>19</td>
<td>Vocabulary, block design, WCST, Stroop colour-word, numeric attention, letter number sequencing, HVLT, letter number sequencing, spatial span</td>
<td>6</td>
<td>12.5%</td>
<td>Yes (21%)</td>
<td>SIPS/SOPS</td>
</tr>
<tr>
<td>Koepe et al. (2006)*</td>
<td>37 CHR</td>
<td>21</td>
<td>Premorbid IQ (NART), category and letter fluency, CPT-IP, CVLT, digit symbol coding, spatial working memory task (dot location), letter number sequencing, finger tapping</td>
<td>12</td>
<td>39%</td>
<td>No</td>
<td>SIPS/SOPS</td>
</tr>
<tr>
<td>Seidman et al. (2010)</td>
<td>304 CHR</td>
<td>18</td>
<td>Vocabulary, block design, digit symbol coding, trails B, letter fluency, WCST, stories/logical memory, list learning, CPT-IP</td>
<td>30</td>
<td>29%</td>
<td>NA</td>
<td>SIPS/SOPS</td>
</tr>
<tr>
<td>Woodberry et al. (2010)</td>
<td>73 CHR</td>
<td>16</td>
<td>Premorbid IQ (WRAT), vocabulary, block design, similarities, matrix reasoning, CPT-IP, CVLT, stories/logical memory, category fluency, trails 4, WCST, letter number sequencing, finger tapping, B-SIT</td>
<td>24</td>
<td>50%</td>
<td>Yes</td>
<td>SIPS/SOPS</td>
</tr>
<tr>
<td>Lindgren et al. (2010)</td>
<td>62 CHR</td>
<td>16</td>
<td>Vocabulary, block design, reaction time, category and letter fluency, trails A, B, and C, digit symbol coding, CVLT, prose learning, visual reproductions, digit span, visual span, similarities, matrix reasoning, dot cancellation, counting backwards, dual task numbers, dual task dots, Purdue pegboard, spatial tapping</td>
<td>–</td>
<td>–</td>
<td>NA</td>
<td>SIPS/SOPS</td>
</tr>
</tbody>
</table>

Continued
<table>
<thead>
<tr>
<th>Study</th>
<th>Participants</th>
<th>Mean age</th>
<th>Tasks</th>
<th>Follow-up (months)</th>
<th>Rate of conversion</th>
<th>Anti-psychotic use</th>
<th>Clinical tool</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ozgurdal et al. (2009)</td>
<td>54 CHR</td>
<td>25</td>
<td>MWT-B, LPS section UT3, category and letter fluency, trails B, Stroop colour-word, CPT-IP, AVLT (German version), WCST</td>
<td>–</td>
<td>–</td>
<td>Yes (31%)</td>
<td>SIPS/SOPS and BSABS</td>
</tr>
<tr>
<td>Hurlemann et al. (2008)</td>
<td>16 CHR</td>
<td>27</td>
<td>MWT-B, RAVLT</td>
<td>18</td>
<td>31%</td>
<td>No</td>
<td>ERiras</td>
</tr>
<tr>
<td>Niendam et al. (2006)</td>
<td>45 CHR</td>
<td>18</td>
<td>Full scale WISC/WAIS current IQ, trails A and B, digit symbol coding, category and letter fluency, matrix reasoning, visual reproductions, digit span, CVLT, stories/logical memory, finger tapping</td>
<td>–</td>
<td>–</td>
<td>Yes (42%)</td>
<td>SIPS/SOPS</td>
</tr>
<tr>
<td>Niendam et al. (2007)*</td>
<td>35 CHR</td>
<td>17</td>
<td>WASI IQ, trails A and B, digit symbol coding, letter fluency, matrix reasoning, visual reproductions, digit span, CVLT, stories/logical memory, finger tapping</td>
<td>8</td>
<td>25%</td>
<td>Yes (50%)</td>
<td>SIPS/SOPS</td>
</tr>
<tr>
<td>Becker et al. (2010b)*</td>
<td>40 CHR</td>
<td>20</td>
<td>Premorbid IQ (NART), CVLT, category and letter fluency, CPT, finger tapping, spatial working memory test (dot location), complex figure of Rey</td>
<td>18</td>
<td>41%</td>
<td>NA</td>
<td>SIPS/SOPS and BSABS</td>
</tr>
<tr>
<td>Pukrop et al. (2007)</td>
<td>83 CHR</td>
<td>24</td>
<td>MWT-B, visual backwards masking, CPT-IP, dual tasking test, letter number sequencing, subject ordered pointing task, spatial working memory task (dot location), RAVLT, Rey-Osterrieth complex figure task, digit symbol coding, trails A and B, WCST, category and letter fluency</td>
<td>At least 12</td>
<td>53%</td>
<td>No</td>
<td>SIPS/SOPS</td>
</tr>
<tr>
<td>Fusar-Poli et al. (2010)*</td>
<td>15 CHR</td>
<td>25</td>
<td>Premorbid IQ (NART), paired associate learning</td>
<td>12</td>
<td>13%</td>
<td>No</td>
<td>CAARMS</td>
</tr>
<tr>
<td>Becker et al. (2010a)</td>
<td>47 CHR</td>
<td>21</td>
<td>Category and letter fluency</td>
<td>24</td>
<td>38%</td>
<td>Yes (25%)</td>
<td>SIPS/SOPS and BSABS</td>
</tr>
<tr>
<td>Magaud et al. (2010)</td>
<td>77 CHR</td>
<td>21</td>
<td>Category and letter fluency</td>
<td>–</td>
<td>–</td>
<td>Yes (13%)</td>
<td>CAARMS</td>
</tr>
<tr>
<td>Hawkins et al. (2008)*</td>
<td>60 CHR</td>
<td>18</td>
<td>Vocabulary, block design, information, finger tapping, CPT-IP, VIDA, letter number sequencing, Ruff figural fluency, Benton line orientation, CVLT, visual reproductions, digit symbol coding, Stroop colour and word, trails A and B, category and letter fluency, WCST</td>
<td>12</td>
<td>35%</td>
<td>Yes (50%)</td>
<td>SIPS/SOPS</td>
</tr>
</tbody>
</table>
indication that converters are more impaired in olfaction (Woodberry et al. 2010). Thus, it may be that, in general, those who convert do have more cognitive impairment but this is not always reported and not for specific tasks. One possibility is that, although, in several studies there is little to differentiate converters from non-converters, at baseline those who convert tend to have lower verbal IQ, verbal memory, verbal fluency and speed of processing. Results comparing the longitudinal course of cognitive functioning between converters who convert and those who do not are inconsistent. However, longitudinal studies of cognitive functioning appears to suggest a decline. Indeed, with regard to conversion, there do not seem to be any tasks that consistently differentiate the converters from the non-converters, although those who convert seem to be more dependent on verbal fluency and speed of processing. Results comparing the longitudinal course of cognitive functioning between those who convert and those who do not are inconsistent.

In this article, we drew our conclusions from the review of 23 recent studies published in the last 6 years that assessed cognition in individuals at CHR for developing psychosis. Some general conclusions for developing psychosis can be drawn from the studies reviewed in Table 1. First, individuals at CHR for psychosis, as a group, demonstrate impairment in cognition relative to healthy controls when a composite score created by factor analysis is used as well as on a few individual cognitive tasks, specifically verbal fluency and olfaction. Second, from the longitudinal studies that exist cognitive functioning appears to remain stable over time for some aspects but to date there is not a great deal of evidence to suggest a decline. Indeed, with regard to conversion, there do not seem to be any tasks that consistently differentiate the converters from the non-converters, although those who convert seem to be more dependent on verbal fluency and speed of processing. Results comparing the longitudinal course of cognitive functioning between those who convert and those who do not are inconsistent. However, longitudinal studies of cognitive functioning appears to suggest a decline. Indeed, with regard to conversion, there do not seem to be any tasks that consistently differentiate the converters from the non-converters, although those who convert seem to be more dependent on verbal fluency and speed of processing.
since our review, there has been published in 2012 two meta-analyses (Giuliano et al. 2012; Fusar-Poli et al. 2012a). The first meta-analysis (Giuliano et al. 2012) suggests small-to-medium impairments across nine of ten cognitive domains. Furthermore, for those who developed psychosis their baseline performance was generally more impaired than those who did not convert. The more specific results of the paper by Giuliano et al. may be due to a narrower selection of studies, i.e., only 14 studies that appear to be with samples that met the criteria based on the SIPS or CAARMS and to the fact that cognitive tasks were grouped into cognitive domains. The second meta-analysis by Fusar-Poli et al. (2012a) using 18 studies (although three of the studies only contained measures of social cognition) suggests that CHR participants were impaired on tests of general intelligence, executive functioning, verbal and visual memory, attention and working memory. Later, transition to psychosis was associated with poorer verbal fluency and memory. Unlike the earlier meta-analysis, papers with participants meeting the basic symptom criteria were included. This paper focused mainly on cross-sectional studies but did investigate moderators. They found no effect for year of publication, exposure to antipsychotics, age and sex.

Taken together these results offer some preliminary insights into the neurodevelopmental trajectory of psychosis. The finding that CHR individuals present in many studies with cognitive impairment suggests that these young individuals may already exhibit neural abnormalities, possibly in the prefrontal cortex given its association with most of the discussed cognitive abilities (Fuster, 2001). Moreover, functional imaging studies have consistently found prefrontal cortical dysfunction during cognitive tasks in CHR individuals (Benetti et al. 2009; Broome et al. 2009; Crossley et al. 2009). Although not consistently demonstrated, there is evidence of greater impairment for those who go on to develop psychosis compared with those who do not.

Some of the inconsistency may result from several limitations. Firstly, sample sizes tended to be relatively small, especially for longitudinal studies, although the meta-analysis with larger samples was more supportive of the results of our review. Secondly, some of the longitudinal studies had somewhat short follow-up periods, typically ranging from 6 to 18 months, which certainly at the lower end may not be long enough to determine conversions. This is particularly relevant since the risk of transition to psychosis seems to increase with the duration of the follow-up period (Fusar-Poli et al. 2012b). Thirdly, the rate of participant drop out is relatively high, and it may be that those who drop out may experience a different clinical or cognitive course. Fourthly, a variable rate of participants medicated with antipsychotics was reported in some studies.

However, this did not seem to account for the inconsistent results as in most of these studies additional analyses were conducted to exclude any correlation between cognitive performance and the use of antipsychotics, with only one study reporting an influence of olanzapine on visual memory (Hawkins et al. 2008).

Fifthly, there is a wide variation in tasks used across the different studies, with some being potentially more sensitive for detection of subtle impairment. It is also possible that low performance in cognitive tests may reflect an impairment in general intellectual ability more than deficits in specific domains (Abubaker et al. 2008). Moreover, as Brewer et al. (2006) pointed out, some cognitive domains are neuropsychologically complex, each including discrete sub-processes which may be compromised in a different way, and therefore further examination of the sub-processes involved in each task is still needed.

Finally, the lack of homogeneity within the CHR group may partially explain this pattern of results. In fact, outcomes from recent studies with longer follow-up periods (at least 2 years) suggest that help-seeking individuals who meet CHR criteria cluster into several groups, some of them developing a psychiatric illness, others remitting from their symptoms, others improving modestly, (Addington et al. 2011), and that at least one-third of individuals identified as CHR are likely to represent false positives (Schlosser et al. 2011).

In summary, given the limited nature of the current available results, further research is required before the role of cognition in the prediction of psychosis can be well understood. Future studies need to attend to the increasing use of antipsychotics in CHR populations, greater matching of controls on premorbid IQ, more understanding of the potential of moderator variables, longer follow-up periods and specifically selected cognitive tasks. More recent studies such as the ongoing North American Longitudinal Prodromal Study are using batteries such as the MATRICS that have been well-established in samples with schizophrenia. The definition of conversion may also be important. In these high-risk studies, definitions of conversion range from schizophrenia to a diagnosis of schizophrenia or other psychotic disorders or in some studies the attenuated symptoms reached a psychotic intensity over a given period of time. As Brewer et al. (2003) demonstrated in an examination of olfaction, lower cognition at initial assessment in those who convert may be limited to those whose end diagnosis is schizophrenia.

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