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Neuropsychological Deficits in Participants at Clinical High-Risk for Psychosis Recruited from the Community: Relationships to Functioning and Clinical Symptoms

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Abstract

Background—The current study examined the pattern of neurocognitive impairments in a community-recruited sample of clinical high-risk (CHR) participants and established relationships with psychosocial functioning.

Methods—CHR-participants (n = 108), participants who did not fulfil CHR-criteria (CHR-negatives) (n = 42) as well as a group of healthy controls (HCs) (n = 55) were recruited. CHR-status was assessed using the Comprehensive Assessment of At-Risk Mental State (CAARMS) and the Schizophrenia Proneness Interview, Adult Version (SPI-A). The Brief Assessment of Cognition in Schizophrenia Battery (BACS) as well as tests for emotion recognition, working memory and attention were administered. In addition, role and social functioning as well as premorbid adjustment were assessed.

Results—CHR-participants were significantly impaired on the Symbol-Coding and Token-Motor task and showed a reduction in total BACS-scores. Moreover, CHR-participants were characterized by prolonged reactions times (RTs) in emotion recognition as well by reductions in both social and role functioning, GAF and premorbid adjustments compared to HCs. Neurocognitive impairments in emotion recognition accuracy, emotion recognition RT, processing speed and motor speed were associated with several aspects of functioning explaining between 4-12% of the variance.

Conclusion—The current data obtained from a community sample of CHR-participants highlight the importance of dysfunctions in motor and processing speed and emotion recognition

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RT. Moreover, these deficits were found to be related to global, social and role functioning, suggesting that neurocognitive impairments are an important aspect of sub-threshold psychotic experiences and a possible target for therapeutic interventions.

Keywords

Clinical High-Risk; Psychosis; Neurocognition; Functioning; Prevention

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Background

Cognitive deficits are a core feature of schizophrenia (ScZ) and have been found in the domains of working memory (WM), verbal learning, motor abilities, attention, processing speed and social cognition (Green et al., 2004). There is substantial evidence that neuro-cognitive and social cognitive impairments in ScZ are associated with poor occupational and social outcomes (Green et al., 2000; Hooker & Park, 2002; Fett et al., 2011), making them a potential target for therapeutic interventions.

More recently, one focus has been the identification of neurocognitive impairments in participants meeting clinical high-risk criteria (CHR) for the development of psychosis (Klosterkötter et al., 2001; Yung et al., 2005). These include ultra-high risk (UHR) criteria that involve the presence of attenuated, psychotic symptoms (Miller et al, 2003; Yung et al., 2005). Moreover, UHR-criteria instruments include a genetic risk plus functional deterioration syndrome as well as brief limited intermittent psychotic symptoms (BLIPs).

In addition, CHR-criteria have been developed based on the basic symptom (BS) concept proposed by Huber and colleagues (Schultze-Lutter, et al., 2010). BS involve the presence of self-experienced perceptual and cognitive anomalies that are thought to represent the earliest manifestation of psychosis risk (Schultze-Lutter, et al., 2010). CHR-criteria confer a 10-30% risk of developing ScZ within a 2-5 year period (Fusar-Poli et al., 2013; Fusar-Poli et al., 2015). More recent studies have shown that the combined presence of both BS- and UHR-criteria increases the predictive power significantly (Schultze-Lutter, et al., 2014).

There is extensive evidence on the presence of neurocognitive deficits in CHR-populations across a range of domains that mirror observations in established ScZ, including impairments in working memory, attention, speed of processing, verbal memory, verbal fluency, executive functions and motor speed with small to medium effect sizes (Fusar-Poli et al., 2012; Giuliano et al., 2012; Bora et al, 2014). Follow-up studies have suggested that certain deficits may indicate stable vulnerability markers, e.g. sustained attention (Francey et al., 2005), whereas others may be predictive of transition to psychosis, such as verbal IQ, processing speed, verbal memory and WM (Brewer et al., 2005; Lencz et al., 2006; Pukrop, & Klosterkötter, 2010; Seidman et al., 2010; Michel et al., 2014).

Moreover, previous studies have found deficits in emotion recognition, theory of mind and social perception in CHR-participants (Thompson et al., 2011) in agreement with extensive evidence for dysfunctions in social cognition in ScZ-patients (Green et al., 2015). More specifically, impaired facial emotion recognition in CHR-groups has been reported in several studies (Addington, et al., 2008a; van Rijn et al., 2011; Amminger et al., 2012a; Amminger

et al., 2012b), suggesting that emotion recognition deficits may emerge before the onset of psychosis.

The current study aimed to extend these findings by examining the relationship between neurocognition, social cognition and current psychosocial functioning in a CHR-sample recruited from the general community. The large majority of studies investigating neurocognition in CHR-populations involve participants who are help-seeking and recruited through clinical pathways. Accordingly, it is unclear to what extent neurocognitive deficits generalize to more representative samples recruited outside clinical pathways. This is potentially an important question as there may be differences between clinically-referred vs. community CHR-samples, for example, regarding transition rates (Fusar-Poli et al., 2015).

To address this issue, we recruited a sample of n = 108 CHR-participants through an online-screening platform (McDonald et al., 2018) as well as a group of n = 42 participants who did not fulfil CHR-criteria (CHR-negatives) but were characterised by psychiatric comorbidities, such as affective disorders and substance abuse, and a group of n = 55 healthy controls (HCs). Neurocognition was assessed with the Brief Assessment of Cognition in Schizophrenia Battery (BACS) (Keefe et al., 2004) as well as tasks from the Penn Computerized Neurocognitive Battery (CNB) (Moore et al., 2015). The Global Assessment of Functioning (GAF) as well as scales for role (GF: Role) and social (GF: Social) functioning (Cornblatt et al., 2007) were used to assess psychosocial functioning.

A secondary objective was to examine the relationship between neurocognitive deficits and social and occupational functioning in community-recruited CHR-participants. Previous studies reported conflicting findings on this relationship in CHR-participants recruited from clinical pathways. Niendam et al. (2006) reported that impairments in verbal learning and memory were associated with current social functioning. A follow-up study found that improvements in social functioning predicted gains in processing speed and visual learning and memory (Niendam et al., 2007). Similar findings were reported by Lin et al. (2011). However, findings by Jahshan et al. (2010) indicated that improvements in neurocognitive performance were not significantly associated with functioning as measured by the GAF scale. Finally, Carrión et al. (2011) examined impairments in both social and role functioning in relation to neurocognitive performance and found that speed of processing was predictive of poorer social and role functioning.

Methods

Recruitment and Participants

The YouR-Study is a longitudinal study to identify neurobiological and psychological mechanisms and predictors of psychosis-risk (Uhlhaas et al., 2017) and is funded by the Medical Research Council (MRC).

CHR-participants were recruited through an online-screening approach (see http://www.your-study.org.uk) that identified CHR-participants from the general population through email-invitations, posters and flyers over a 4-year period (see McDonald et al., 2018). Specifically, email invitations were sent out to colleges and universities in Glasgow

and Edinburgh through which the majority of study participants were identified. It is estimated that ~100000 participants were invited to the study.

Approximately 2800 participants filled out the online-versions of the a) the 16-item Prodromal Questionnaire (PQ-16) (Ising et al., 2012) and b) a 9-item scale of perceptual and cognitive anomalies (PCA) that was developed to assess BS. Participants were invited for clinical interviews if they positively endorsed 6 or more items on the PQ-16 or 3 or more on the PCA.

Previous analysis (McDonald et al., 2018) had shown that ~ 50% participants fulfilled the PQ-16 cut-off criteria while ~70% met criteria for the PCA. Out of the ~ 2800 of participants who met online cut-offs, ~20% took part in clinical assessments. Moreover, an additional sample of n = 21 participants meeting first-episode criteria were identified.

To establish CHR-criteria, the positive scale of the Comprehensive Assessment of At-Risk Mental States (CAARMS) (Yung et al., 2005) and items of the Schizophrenia Proneness Instrument (SPI-A) (Schultze-Lutter, et al., 2007) as defined by Cognitive-Perceptive Basic Symptoms (COPER) and Cognitive Disturbances (COGDIS) were administered through trained research assistants and MS.c./Ph.D. level-researchers. Inter-rater reliability (IRR) of CHR-status as determined by the CAARMS and SPI-A ratings was assessed over 18 sessions, reaching good to excellent reliability (CAARMS: 92%; SPI-A: 95.7%).

CHR-participants were excluded for current or past diagnosis with Axis I psychotic disorders. Other co-morbid Axis I diagnoses, such as mood or anxiety disorders, were not exclusionary and all participants were between 16-35 years of age (for more details, see Uhlhaas et al., 2017).

Participants were recruited into the CHR-group if they met a) SPI-A COGDIS/COPER-criteria b) CAARMS criteria for the attenuated psychosis group (subthreshold psychotic syndrome present in the last year without a decline in functioning) c) CAARMS criteria for genetic risk plus functional deterioration (family history of psychosis plus a 30 % drop in GAF) and d) CAARMS criteria for the BLIPs-group (brief limited intermittent *psychotic* symptoms).

Moreover, the M.I.N.I. International Neuropsychiatric Interview (M.I.N.I. 6.0) (Sheehan et al., 1998), the scales for premorbid adjustment (Cannon-Spoor et al., 1982) and social and functional role scales (Cornblatt, et al, 2007) were administered. Neuropsychological assessment consisted of the BACS (Keefe et al., 2004) as well as three tasks from the CNB battery (Moore et al., 2015): a) the Continuous Performance Test b) the N-Back Task and c) the Emotion Recognition Task.

In addition to CHR-participants, two samples were recruited consisting of 1) participants who entered the study similar to CHR-participants but who did not meet CHR-criteria (CHR-negative). This group was included to assess the impact of psychiatric comorbidity, such as affective disorders and substance abuse, on neurocognitive parameters and 2) a group of HCs without an Axis I diagnosis or family history of psychotic disorders.

Statistical Analyses

All statistical analyses were performed using SPSS version 24. BACS and CNB raw test scores for each neurocognitive domain were standardized by creating z-scores using the means and standard deviations of HCs. BACS raw scores were additionally corrected for gender. When the homogeneity of variances assumption was violated in one-way ANOVA analyses, Welch's F was reported. Since the one-way ANOVA is considered a robust test against the normality assumption, no alternative tests were applied. The Hochberg's GT2 test was used as a post hoc test for ANOVA analyses whereas the Games-Howell test was used as a post hoc test for Welch analyses. For Kruskal-Wallis H tests, Dunn's pairwise tests were carried out post hoc.

All BACS and CNB neurocognitive domains were entered into stepwise multiple linear regressions in order to assess the relationship between functioning, neurocognition and psychopathology in the CHR group.

Results

Sample Characteristics

Baseline demographic and clinical characteristics of the three groups are summarized in Table 1.

CHRs, CHR-negatives and HCs did not differ significantly on age, gender or years of education. The CHR-group had significantly higher CAARMS-positive severity scores, poorer premorbid adjustment, lower GAF scores as well as reduced role and social functioning compared to HCs and CHR-negatives. Significant differences between groups were also found for medication status with 49.1% of CHR-participants receiving current medication. The CHR-group was also characterized by extensive psychiatric comorbidity, in particular with affective disorders. Moreover, differences in CHR-subgroups (UHR (n = 34), BS (n = 29), UHR/BS (n = 45)) were explored (Supplementary Table 1). The BS group had significantly higher GAF scores and lower CAARMS-positive severity scores than the UHR/BS group.

Neuropsychology

Table 2 summarizes the neurocognitive performance for CHRs, CHR-negatives and HCs. Due to incorrect task performance, one CHR participant was removed from the CNB WM accuracy and WM RT analysis, and one CHR-negative participant was removed from the CNB attention accuracy analysis.

Significant group effects were demonstrated for motor speed ($F(2,202) = 8.48$, $p < 0.001$), BACS composite ($F(2, 105) = 3.44$, $p < 0.05$), emotion recognition RT ($F(2,105) = 3.74$, $p < 0.05$) and processing speed ($F(2,202) = 4.23$, $p < 0.05$). These effects were observed between CHRs and controls for all domains apart from processing speed where CHRs significantly differed only from CHR-negatives. Figure 1 displays the effect sizes for each neurocognitive domain for both CHRs and CHR-negatives.

In the CHR-group, motor speed had the largest effect size (Cohen's d = 0.63). A small to medium effect size was found for emotion recognition RT (d = 0.37), processing speed (d = 0.35), BACS composite (d = 0.35), attention accuracy (d = 0.28) and working memory accuracy (d = 0.23). In the CHR-negative group, a small to medium effect size was found for motor speed (d = 0.43), verbal fluency (d = 0.29) and attention RT (d = 0.24).

Furthermore, analysis was carried out to explore recognition of specific emotion categories (Supplementary Table 2). CHR-participants were significantly slower in their response times compared to HCs for recognizing happy faces ($F(2,102) = 6.90$, $p < 0.01$; d = 0.46). No additional emotion recognition deficits emerged.

We also examined differences in neurocognition in relation to CHR-subgroups (Supplementary Table 1). There was a significant difference between groups on motor speed ($F(3, 159) = 5.47$, $p < 0.01$), while a trend was observed for emotion recognition RT ($F(3, 74) = 2.72$, $p = 0.05$), BACS composite ($F(3, 72) = 2.30$, $p = 0.09$) and attention RT ($F(3, 159) = 2.28$, $p = 0.08$). CHR-participants in the UHR and UHR/BS groups had significantly slower motor speed than HCs. Individuals in the UHR/BS groups had also significantly slower emotion recognition RTs than HCs (p=0.046). No post-hoc differences were found for BACS composite or attention RT. CHR subgroup effect sizes for each neurocognitive domain are reported in Supplementary Figure 1.

Cognition, Psychopathology and Functioning—Stepwise multiple linear regressions were performed to assess the relationship between functioning, neurocognition and psychopathology in the CHR-group (Tables 3-4). All BACS and CNB neurocognitive domains were included in the regression. Motor speed significantly predicted GAF, accounting for 4% of the variance while emotion recognition RT explained 5% of the variance in CAARMS-positive severity scores. Emotion recognition RT together with emotion recognition accuracy and processing speed significantly predicted social functioning, accounting for 11% of the variance while processing speed alone significantly predicted role functioning, explaining 5% of the variance.

Fear RT was found to be a significant predictor for both GAF and social functioning, accounting for 4% and 10% of the variance respectively and together with anger RT, fear RT significantly predicted role functioning, accounting for 12% of the variance. Happy RT significantly predicted CAARMS-positive severity scores, accounting for 10% of the variance.

Discussion

The current study examined neurocognition and its relationship to functioning in a sample of CHR-participants recruited from the general community. Deficits in neurocognition are a hallmark of ScZ (Heinrichs & Zakzanis, 1998; Rajji et al., 2009) and have been observed in CHR-participants across a number of domains with small to medium effect sizes (Fusar-Poli et al., 2012; Giuliano et al., 2012; Bora et al., 2014). Importantly, there is evidence to suggest that impairments in neurocognition impact on psychosocial functioning in CHR-participants (Niendam et al., 2006; Niendam et al., 2007; Carrión et al., 2011; Lin, et al.,

2011). However, it is unclear to what extent these findings generalize to CHR-samples recruited from the general community.

Recent evidence has highlighted the importance of studying CHR-populations outside clinical referral pathways to identify the similarities and differences in clinical characteristics, demographic variables and neurocognition (Mills et al., 2017; Schultze-Lutter et al., 2018). Overall, our sample of CHR-participants recruited through a novel online-screening (McDonald et al, 2018) was characterized by similar levels of functioning and psychiatric comorbidity as previously observed in cohorts recruited through early intervention centres.

However, with regard to the pattern of neurocognitive deficits, there were differences and similarities with previous studies. We observed neurocognitive impairments that are consistent with a large body of work that has highlighted neurocognitive deficits in CHR-samples with mild to moderate effect sizes (Fusar-Poli et al., 2012; Giuliano et al., 2012; Bora & Murray, 2014). However, there were also certain differences to previous data, particularly with regard to the extent of dysfunctions in neuropsychological variables (see Supplementary Figure 2). Specifically, we observed that the neurocognitive domains that were most prominently impaired were processing and motor speed.

The symbol-coding task has been consistently shown to be impaired in ScZ-patients with large effect sizes (Dickinson, et al., 2007). Moreover, it discriminates between CHR and controls (Seidman, et al., 2010; Fusar-Poli et al., 2012) and predicts psychosis-onset in CHR-individuals (Pukrop & Klosterkötter, 2010; Michel et al., 2014). In the current study, we observed that CHR-participants showed a similar deficit that was associated with an effect size of d = .35. Interestingly, processing speed was largely intact in the CHR-negative group (effect size: d = < .1), highlighting that the symbol-coding task may delineate specific cognitive impairments associated with psychosis risk.

In addition, CHR-participants were characterized by pronounced impairments in motor speed. While abnormalities in the motor system that involve psychomotor slowing are considered a core feature of ScZ (Morrens, et al., 2006), alterations in the motor system in CHR-participants are only recently being investigated. Evidence suggests that youths who later develop a ScZ-spectrum disorder have been reported to show poorer motor function in childhood (Dickson, et al., 2012) and abnormal involuntary movements were linked to CHR symptoms in a child and adolescent community sample (Kindler et al., 2016). These findings are consistent with reduced motor speed, dexterity and movement abnormalities in CHR-populations (e.g. Niendam et al., 2006; Carrion et al., 2011; Fusar-Poli et al., 2012; Bora et al., 2014; Dean and Mittal, 2015; Dean et al., 2016). However, in contrast to the symbol-coding task, impairments in motor speed were also present in the CHR-negative group (effect size: d = .4), suggesting that psychomotor-slowing may be related to aspects of general psychopathology rather than psychosis-risk per se.

In addition to impaired motor and processing speed, we also observed slower RTs during emotion recognition, while the accuracy of emotion recognition was intact, highlighting the importance of reduced processing speed across different domains of functioning. Emotion

recognition deficits have been reported in some CHR studies (Addington, et al., 2008a; van Rijn et al., 2011; Amminger et al., 2012a; Amminger et al., 2012b) while others have found emotion recognition to be intact (Pinkham et al., 2007; Seiferth, et al., 2008; Gee, et al., 2012). There is also preliminary evidence for the possibility of emotion recognition deficits as a predictor for transition to psychosis (Allott, et al., 2014).

Interestingly, other domains of neurocognition that were found to be impaired in previous studies were not replicated in our community-recruited CHR-group. Verbal memory, for example, which has been associated with medium effect sizes in CHR-populations (Fusar-Poli et al., 2012), was relatively intact in the current study. Previous reports have found verbal fluency and memory to be associated with subsequent transition to psychosis (Fusar-Poli et al. 2012). Moreover, there is evidence to suggest that poorer verbal memory predicts more rapid transitioning (Seidman, et al., 2010).

The current study could not replicate impaired memory, executive function and attention in our CHR-group. Evidence is emerging of deficits in declarative memory in FEP (Mesholam-Gately et al., 2009) and in CHR populations (Seidman, et al., 2016). The domain of attention has been argued to represent a stable vulnerability marker in CHR-populations (e.g. Francey, et al., 2005). More recent data from the NAPLS-2 cohort have demonstrated impairments in working memory and attention in CHR-participants who later transitioned to psychosis relative to CHR-participants who did not transition (Seidman, et al., 2016).

Finally, executive functions have been found to be impaired in CHR samples (Lencz, et al., 2006; Carrión et al., 2011; Fusar-Poli et al., 2012; Seidman, et al., 2016). A meta-analysis found executive functioning, along with domains of memory and attention, to be the most consistently impairment and already established at the time of the FEP (Mesholam-Gately, et al., 2009).

Our data show that there are subtle differences between neurocognition and functioning levels in CHR-subgroups. Current evidence suggests that self-experienced BS represent the earliest manifestation of psychosis risk or an early prodromal state (EPS) while positive symptoms constitute coping mechanisms that emerge later during development (late prodromal state, LPS) (Fusar-Poli et al., 2013). Consistent with this notion, we observed that CHR-participants who met UHR-criteria and UHR/BS-criteria had more pronounced cognitive impairments, in particular in motor speed, compared to the BS only group. This is consistent with previous findings that neurocognitive impairments differentiate EPS from the LPS-participants. Frommann, et al. (2010) found individuals in LPS to be impaired across all domains whilst those in the EPS showed a specific deficit in the executive control/ processing speed domain, raising the question of potentially progressive impairments in cognition across the at-risk phase. Alternatively, it has been suggested that BS criteria help to identify a more homogenous group with respect to neurocognitive profiles (Simon et al., 2006).

Our data also support previous findings that deficits in neurocognition impact on functioning parameters in CHR-participants (Niendam et al., 2006; Niendam et al., 2007; Carrión et al., 2011; Lin, et al., 2011). Consistent with previous findings that highlighted that reduced

processing speed is an important determinant of functioning (Carrión et al., 2011), our data suggest that impaired processing speed significantly correlates with role and social functioning. Emotion recognition RT, emotion recognition accuracy and processing speed combined explained 11% of the variance in social functioning while processing speed alone accounted for 5% of the variance in role functioning in our CHR-sample. In addition, we found that emotion recognition RT explained 5% of the variance in CAARMS-positive severity scores, while motor speed alone explains 4% of the variance in global functioning.

While these data replicate previous findings (e.g. Carrion et al., 2011) and highlight the importance of processing speed for explaining psychosocial functioning, the relatively low amount of variance that is being accounted for also suggests that other factors are involved in contributing towards impaired functioning in CHR-participants. Given the importance of psychosocial functioning as an outcome parameter in CHR-populations, further studies need to address the contribution of other factors that could be potentially allow insights into origin and mechanism(s) of impaired role and social functioning in CHR-participants.

Limitations

The current study has several limitations. With regard to the sample characteristics, the number of female CHR-participants in the current study exceeded previous studies in the field. The reason of the higher number of self-referrals are not completely clear but may be in part explained by the greater willingness of female participants to engage in studies and perhaps increased awareness of mental health issues. If the latter is correct, different strategies may have to be employed to engage male participants in early intervention. Secondly, we did not assess negative symptoms in CHR-participants that have been shown to mediate the relationship between neurocognitive deficits and functioning in previous studies (Meyer et al., 2014; Glenthoj et al., 2017). Finally, it is currently unclear whether neurocognitive deficits in our community recruited CHR-sample are predictive for the persistence of sub-threshold psychosis symptoms and/or conversion to psychosis as has been suggested by previous findings (Seidmann et al., 2016; Lam et al., 2018).

Summary and Conclusions

The current data support the view that neurocognitive deficits are a core feature of the CHR-participants recruited from the general community, replicating previous findings from CHR-cohorts recruited from clinical referral pathways. This is also supported by the fact that cognitive impairments were largely specific to the CHR-group. Thus, participants who did not meet CHR-criteria but who were characterized by affective disorders and substance abuse did not show neurocognitive impairments, to the same extent as observed in the CHR-group, supporting the view that dysfunctional cognition is related to an extended psychosis phenotype.

Follow-up data need to confirm whether such deficits are also predictive for clinical outcomes and transitioning to psychosis in community-recruited CHR-participants. If this is the case, neurocognitive testing could potentially be used to stratify young people with subthreshold psychotic symptoms and support targeted interventions for improving cognitive

processes. This approach is furthermore motivated by the finding that neurocognitive deficits were related to aspects of psychosocial functioning, replicating existing data from clinically identified CHR-groups.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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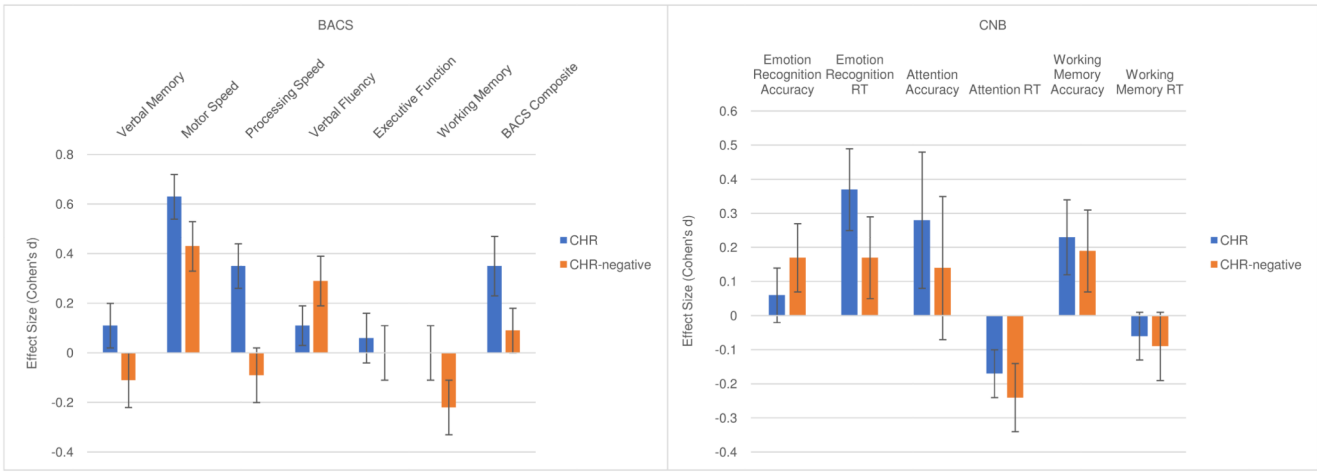

Figure 1.

CHR and CHR-negative Effect Sizes, as Measured by Cohen's d, for BACS and CNB Data: classified as small (0.2), medium (0.5), and large (0.8). Error bars indicate standard errors of the mean. Positive values indicate impaired performance while negative values indicate better performance compared to HCs.

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Table 1

Baseline Demographic and Clinical Characteristics of CHR, HC and CHR-Negative Participants

Characteristic	CHRs (N = 108)	HCs (N = 55)	CHR-Ns (N = 42)	df	F/ X^2/H	p	Post Hoc Contrasts
Age (years), M ± SD	21.85 ± 4.33	22.31 ± 3.39	23.24 ± 5.00	2, 97	F = 1.27	0.29	
Gender, N female (%)	82 (75.9)	37 (63.7)	28 (66.7)	2	X^2 = 2.01	0.37	
Years of education, M ± SD	15.50 ± 3.13	16.38 ± 2.84	16.57 ± 3.62	2, 202	F = 2.29	0.10	
GAF, median (range)	59.50 (21-95)	88 (67-97)	70 (43-94)	2	H = 105.13	<0.001	CHR vs CHR-N vs HC
CAARMS-Positive Severity, median (range)	28.50 (0-72)	0 (0-12)	5 (0-24)	2	H = 129.41	<0.001	CHR vs CHR-N vs HC
GF: Social, median (range)	8 (5-10)	9 (8-10)	8 (6-9)	2	H = 64.44	<0.001	CHR vs HC vs CHR-N
GF: Role, median (range)	8(5-9)	9 (5-9)	8 (5-9)	2	H = 45.05	<0.001	CHR vs HC vs CHR-N
PAS, median (range)							
Childhood	0.11 (0-0.57)	0.04 (0-0.21)	0.07 (0-0.46)	2	H = 25.92	<0.001	CHR vs HC
Early adolescence	0.17 (0-0.54)	0.06 (0-0.23)	0.11 (0-0.46)	2	H = 42.51	<0.001	HC vs CHR, CHR-N
Late adolescence	0.14 (0-0.57)	0.06 (0-0.29)	0.11 (0-0.71)	2	H = 27.41	<0.001	HC vs CHR,CHR-N
Medication, N (%)	53 (49.1)	1 (1.8)	19 (45.2)	10	X^2 = 45.49	<0.001	
Anti-psychotic	0 (0)	0 (0)	1 (2.4)				
Mood stabiliser	1 (0.9)	0 (0)	0 (0)				
Anti-depressant	23 (21.3)	0 (0)	10 (23.8)				
Other	13 (12.0)	1 (1.8)	6 (14.3)				
Multiple	16 (14.8)	0 (0)	2 (4.7)				
Diagnosis, N (%)	97 (89.8)	3 (5.45)	26 (61.9)	2	X^2 = 109.5	<0.001	
Anxiety disorders	80 (74.1)	0 (0)	19 (45.2)				
Mood disorders	67 (62.0)	0 (0)	12 (28.6)				
Eating disorders	11 (10.2)	0 (0)	1 (2.4)				
Suicide Risk	57 (52.8)	1 (1.8)	10 (23.8)				
Alcohol Dependence/Abuse	31 (28.7)	2 (3.6)	9 (21.4)				
Substance Dependence/Abuse	13 (12.0)	0 (0)	1 (2.4)				

Abbreviations: CHR, clinical high-risk; HC, healthy control; CHR-N, clinical high-risk-negative

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Table 2

Neurocognitive Performance of CHR, HC and CHR-N Participants

Domain	CHRs (N = 108)		HCs (N = 55)		CHR-Ns (N = 42)		df	F	p	Cohen's d	Post Hoc Contrasts
	M	SD	M	SD	M	SD					
BACS											
Verbal Memory	-0.07	1.19	0	1	0.18	1.07	2, 202	0.77	0.47	0.11	
Motor Speed	-0.71	1.13	0	1	-0.40	0.92	2, 202	8.48	< 0.001	0.63	HC vs CHR
Processing Speed	-0.39	1.11	0	1	0.11	1.16	2, 202	4.23	< 0.05	0.35	CHR vs CHR-N
Verbal Fluency	-0.11	0.96	0	1	-0.26	0.81	2, 202	0.94	0.39	0.11	
Executive Function	-0.07	1.26	0	1	-0.03	1.19	2, 202	0.05	0.95	0.06	
Working Memory	0.01	1.39	0	1	0.27	1.18	2, 105	0.73	0.48	0.00	
BACS Composite	-0.49	1.58	0	1	-0.05	1.33	2, 105	3.56	< 0.05	0.35	HC vs CHR
CNB											
Emotion Recognition Accuracy	-0.07	0.99	0	1	-0.16	0.94	2, 202	0.31	0.73	0.06	
Emotion Recognition RT	0.57	1.65	0	1	0.21	1.39	2, 105	3.74	< 0.05	0.37	HC vs CHR
Attention Accuracy	-0.69	2.83	0	1	-0.28	2.82	2, 201	1.50	0.23	0.28	
Attention RT	-0.16	0.84	0	1	-0.24	1.00	2, 202	0.90	0.41	0.17	
Working Memory Accuracy	-0.31	1.45	0	1	-0.21	1.28	2, 104	1.32	0.27	0.23	
Working Memory RT	-0.07	0.76	0	1	-0.09	1.03	2, 201	0.14	0.87	0.06	

RT (response times). CHR effect sizes, measured by Cohen's d, are classified as small (0.2), medium (0.5), and large (0.8).
Abbreviations: CHR, clinical high-risk; HC, healthy control; CHR-N, clinical high-risk-negative

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Table 3

Linear Regression Results for the Effects of Neurocognitive Performance on Clinical Characteristics at Baseline in CHR participants

Variable	B	SE	β	R^2	F	p
GAF						
Motor Speed	3.04	1.04	0.20	0.04	8.56	< 0.01
CAARMS-Positive Severity						
Emotion Recognition RT	2.74	0.86	0.22	0.05	10.10	< 0.01
Social Functioning						
Emotion Recognition RT	-0.14	0.05	-0.20			
Emotion Recognition Accuracy	0.14	0.07	0.13	0.11	8.38	< 0.001
Processing Speed	0.14	0.06	0.15			
Role Functioning						
Processing Speed	0.20	0.06	0.22	0.05	10.05	< 0.01

RT (response times).

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Table 4

Linear Regression Results for the Effects of Emotion Specific RTs on Clinical Characteristics at Baseline in CHR participants

Variable	B	SE	β	R^2	F	p
GAF						
Fear RT	-2.01	0.73	-0.19	0.04	7.68	< 0.01
CAARMS-Positive Severity						
Happy RT	4.24	0.92	0.31	0.10	21.38	< 0.001
Social Functioning						
Fear RT	-0.21	0.04	-0.32	0.10	23.55	< 0.001
Role Functioning						
Fear RT	-0.26	0.05	-0.40	0.12	13.31	< 0.001
Anger RT	0.18	0.07	0.19			

RT (response times).