Can Cognitive Deficits Facilitate Differential Diagnosis Between At Risk Mental State for Psychosis and Depressive Disorders?

Running head: Cognition in ARMS for Psychosis

Carla Schulze*, Ronan Zimmermann*, Ute Gschwandtner, Marlon O. Pflueger, Charlotte Rapp, Erich Studerus, Anita Riecher-Rössler

University Psychiatric Outpatient Department, Psychiatric University Clinics Basel

***equal contribution**

Corresponding author:

Prof. Dr. Anita Riecher-Rössler, MD
Psychiatric University Clinics Basel
Psychiatric University Outpatient Department
c/o University Hospital Basel
Petersgraben 4
CH-4031 Basel
Switzerland
Phone: +41 61 265 51 14
Fax: +41 61 265 45 99
E-mail: Anita.Riecher@upkbs.ch

Abstract

Aim: Many studies have provided evidence of cognitive deficits in individuals in an "At Risk Mental State" (ARMS) for psychosis, which makes neuropsychology potentially useful in the early detection of psychosis. As depression is an important differential diagnosis in prodromal states of psychosis, the specificity of neurocognitive deficits in ARMS individuals as compared to non-psychotic depressive disorders is investigated.

Method: Neurocognitive performance of four groups was analysed: 22 ARMS individuals with later transition to psychosis (ARMS-T), 25 ARMS individuals without later transition to psychosis (ARMS-NT), 34 controls with depressive disorders and 76 healthy controls. The subjects were assessed with a neurocognitive test battery covering the domains intelligence, executive function and attention/working memory. MANOVAs, ANOVAs and Tukey's tests were applied after adjustment for confounding factors.

Results: ARMS-T showed significant cognitive deficits in working memory and in certain executive function tasks compared to healthy controls as well as to controls with depression. Controls with depression were only impaired in time per move in the tower of Hanoi test when compared to healthy controls. ARMS-NT performed similar to ARMS-T, but additionally showed deficits in attention.

Conclusions:

The psychosis prodrome seems to be associated with cognitive deficits in the domains of working memory and executive function. In contrast, depressive patients showed no cognitive deficits but slowing in one executive function task. Neurocognitive testing

might therefore contribute to the differential diagnosis between prodromal psychosis and depressive disorders.

Key Words: psychosis, early detection, depression, neurocognition, working memory

Introduction

The diagnostic criteria for psychotic disorders are currently revised with the aim to base future classification systems on more objective signs and to incorporate individuals in an "At Risk Mental State" for psychosis (ARMS).[1] Possible approaches to detect ARMS individuals and to identify risk factors for the transition to psychosis are suggested by genetic, neuroimaging, neurophysiological and/or neuropsychological studies.[1-6] Among these methods, neurocognitive evaluation might be a useful approach, since many studies have provided evidence of neurocognitive deficits not only in chronic schizophrenia [7,8] and first episode psychosis [9,10] but and also in the prodromal phase of the disease.[11-18]

However, the specificity of the cognitive deficits in prodromal psychosis as compared to depression has – to our knowledge- not yet been investigated. This is surprising, as the question of differential diagnosis of depressive disorders and prodromal psychosis is of great clinical interest. Depression is one of the first and most frequent initial signs in the prodromal phase of schizophrenic psychosis [19-23] and classification into either ARMS state or depressive disorder is often difficult.

Other studies comparing the neurocognitive performance of ARMS individuals with non-psychotic psychiatric control groups showed heterogeneous results. Ilonen et al.[24] found no significant difference between the groups, while Lindgren et al.[25] found, that ARMS performed worse on visuospatial tasks than the psychiatric control group.

According to studies on cognitive deficits in frank psychosis versus affective disorders, cognitive impairment in non-psychotic depression is less severe than in psychotic depression [26-28] or schizophrenia [26,28-30]. Cognitive deficits in patients with psychosis

seem to be characterized by a distinct pattern of cognitive deficits which involves impairment in verbal memory, working memory, attention and executive functions [26,29,31-33], while cognitive deficits in depression follow a more variable pattern and studies show heterogeneous results most likely due to factors like different clinical subtypes, severity, age and medication.[34] Cognitive deficits in depression are more related to clinical symptoms, while cognitive deficits in psychosis are a more stable aspect of the disease and not related to psychotic symptoms.[35] The neuropsychological profile of major depression and psychosis may overlap, as deficits in psychomotor speed [34,36,37], processing speed [38], attention [36,37], memory [36,37,39] and executive function [34,36-40] were – even if not consistently- also reported in patients with major depression.

As there seem to be differences especially concerning the severity of cognitive deficits in frank psychosis versus major depression, the aim of the present study is to investigate if a neurocognitive evaluation may also help in the differential diagnosis of prodromal psychosis and depressive disorders.

We assessed neurocognitive baseline data of ARMS individuals, controls with depression (DC) and healthy controls (HC), using intelligence, executive functioning, attention and working memory tasks. ARMS individuals were further divided into two subgroups: ARMS-T who made a transition to manifest psychosis during follow-up and ARMS-NT without later transition.

According to the studies comparing patients with major depression and psychosis explained above, we expected ARMS-T to differentiate from DC in severity of the cognitive deficits and also in the pattern of the neuropsychological profile. As our DC group mainly consisted of individuals with a moderate depressive episode, we did not expect a severe cognitive impairment in this group. From previous studies in our

research project [14,41] and other groups (for review see [5,42]) we expected working memory, processing speed and executive function to be specifically impaired in ARMS-T patients.

Methods

Study design

The neurocognitive data analysed in this paper were collected within the ***FePsy*** (***F***rüh***e***rkennung von ***Psy***chosen; early detection of psychosis) study at the University Psychiatric Outpatient Department, Basel, Switzerland. It is an open, prospective clinical study of all consecutive referrals to our specialized clinic for the early detection of psychosis. The overall study and preliminary results have been described by Riecher-Rössler et al.[2,14]

Subjects

The sample of the present study consisted of 76 healthy controls (HC), 25 ARMS-NT, 22 ARMS-T and 34 DC. ARMS was assessed using the Basel Screening Instrument for Psychosis (BSIP), which is based on the DSM-III-R prodromal symptoms as well as other prodromes as derived from literature and four items of the Brief Psychiatric Rating Scale (BPRS[43]). All ARMS individuals included underwent an entry examination, which included BPRS, Scale for the Assessment of Negative Symptoms (SANS[44]) and the neurocognitive test battery. They were followed up at regular intervals for at least two years in order to evaluate transition to psychosis. The follow-up duration in the present study ranged from 2.3 to 11.1 years, with a mean of 9.3 years. Criteria for ARMS status and transition to psychosis in the follow-up can be seen in

Table 1 and are described in more detail by Riecher-Rössler et al.[14,45] The neurocognitive data analyzed in this paper were obtained at study entry.

--- Insert Table 1 about here ---

Exclusion criteria for ARMS individuals were: previous episode of schizophrenic psychosis (treated with major tranquillizers for more than 3 weeks), psychosis clearly due to organic reasons or substance abuse, or psychotic symptoms within a clearly diagnosed depression or borderline personality disorder. ARMS-NT were included if they had a follow-up period of at least two years.

DC were patients of the University Psychiatric Outpatient Department of Basel and were included if they fulfilled the criteria of a non-psychotic depressive disorder according to ICD-10.

HC were recruited from a commercial school, hospital staff, and through advertisements and were not included if they had a current or former psychiatric disorder or neurological disease, serious medical condition, substance abuse, or a family history of psychiatric disorder.

Exclusion criteria for all participants were: age younger than 18 years, insufficient knowledge of German or IQ <70 or substance abuse other than cannabis. After complete description of the study to the subjects, written informed consent was obtained from all participants. The study was approved by the Ethics Committee of Basel, Switzerland (EKBB).

Measures

The neurocognitive test battery used is mainly based on computer-tests and paper-pencil tests conducted by psychologists or trained students of psychology. To counteract the modulation of reaction time or performance due to strategic emphasis of either reaction time or performance (speed-accuracy trade-off), compound measures were applied in some variables, i.e. an average standard score (Z-Score) of both the error measures and the reaction times.[46] Neurocognitive tests were assigned to the neuropsychological domains general intelligence, attention/working memory and executive functions according to Riecher-Rössler et al.:[14]

- Intelligence: the "Mehrfachwortschatztest" (MWT-A[47]) assesses verbal abilities while the "Leistungsprüfsystem" (LPS-3[48]) assesses abstract thinking abilities. A verbal and a nonverbal IQ variable were derived from the tests.
- Executive function: Tower of Hanoi (ToH[49]) is a test that demands planning and goal-oriented behavior. This computerized test comprises a four- and a five-disc task. Outcome parameters were the number of moves (taking speed-accuracy trade-off into account) and time per move.

  The Wisconsin Card Sorting Test (WCST[50]) demands flexible shifts between three cognitive sets in order to avoid perseveration errors. Outcome parameters were number of perseveration errors and proportion of perseveration errors compared to overall errors (perseveration score).

  The Go/No-Go test (TAP, Testbatterie zur Aufmerksamkeitsprüfung[51]) demands the selective response to two out of five visually similar stimuli. Omissions and false alarms (both adjusted for speed-accuracy trade-off) were used as outcome parameters.

- Working memory and attention: The TAP working memory test forces the subject to match visually presented stimuli in terms of a 2-back task. This test demands the ability of a continuous control about the information flow in the short-term memory. Omissions and false alarms (both adjusted for speed-accuracy trade-off) were used as outcome parameters.

  The Continuous Performance task (CPT[52]) measures sustained visual attention. Four letters are consecutively shown in a randomized order. Whenever the letter O (prime) is followed by the letter X (target) the subject has to press the button as quickly as possible. False alarms and omissions (both adjusted for speed-accuracy trade-off) as well as slowing in the second half of the test compared to the first part were evaluated.

Statistical procedures

Statistical analyses were operated with the statistics program R (Version 2.9.0[53]). In order to prepare the neurocognitive data for further processing, Box-Cox [54], logarithmic and inverse tangent transformations were performed to ensure normal distribution and homoscedasticity. Demographic characteristics (age, gender, and education) were compared between groups using Chi-square, Kruskal-Wallis and Monte Carlo tests. Use of cannabis and medication (benzodiazepines, neuroleptics, antidepressants) were compared between the groups of patients with Monte Carlo tests. Neurocognitive variables were tested for influence of substance use and demographic characteristics and, if necessary, adjusted for this influence.

Multivariate analyses of variance (MANOVAs) were carried out to address the question whether there are differences in the neuropsychological domains executive function, attention/working memory and intelligence between the groups.

In case the MANOVA showed significant group differences in a neuropsychological domain, analysis of variance (ANOVA) were used to test overall group differences for single variables. Post-hoc analyses including 95% confidence intervals were calculated using Tukey's honest significance test.

Results

Sample characteristics and confounding factors

Table 2 summarizes the sample characteristics of all four groups. There were no significant differences between the groups regarding gender (p=.23) and age (p=.46). However, significant group differences were found concerning education (p<.01), use of neuroleptics (only chlorprothixene as a sedating low potency neuroleptic) (p=.06) and use of antidepressants (p=.02). As there could potentially be confounding of neurocognitive parameters by age, education or benzodiazepines we statistically adjusted for these influences.

---Insert Table 2 about here---

Table 3 indicates the severity of depression in the groups as ICD-10 codes. Depression in the groups was diagnosed by SKID-I interviews.[55] The most prevalent diagnosis in DC was moderate depressive episode (17/34). Further, 49% of the ARMS individuals were diagnosed with a depressive disorder as comorbidity.

---Insert Table 3 about here-----

Neurocognitive assessment

MANOVAs revealed significant differences between the four groups concerning the cognitive domains of executive function (ToH, Go/NoGo, WCST; Wilks-lambda=.63, p<.001) and attention/working memory (CPT, TAP Working Memory; Wilks lambda=.78, p<.01). No group differences were found in the domain of intelligence (MWT, LPS; Wilks lambda=.94, p=.20).

ANOVAs showed significant (p<.05) overall group differences for all parameters of the domains executive functions and attention/working memory except for the variable 'CPT slowing' (p=.44) (for details see Table 4 in the supplemental material). Results of post hoc analyses (Tukey's tests) are graphically represented in Figure 1, which shows group differences from HC in z-scores. Table 5 shows z-scores, 95% confidence interval and p-value of Tukey`s tests.

--- Insert Figure 1 and Table 5 about here ---

ARMS-T showed significant deficits in working memory and in most executive function tests compared to HC, namely in the TAP Go/NoGo paradigm and in the accuracy measure (number of moves) of the Tower of Hanoi.

DC were significantly slower in the Tower of Hanoi than HC but showed no deficits in accuracy in this task. No other statistically significant cognitive deficits were found in DC.

ARMS-NT as compared to HC showed a significantly increased number of perseveration errors ($p<.01$) and higher perseveration scores ($p=.02$) in the WCST as well as significant deficits in a parameter of working memory (omissions; $p=.01$) and in the attention task CPT (false alarm; $p<.01$).

The direct comparison of **ARMS-T and DC** (Table 5) showed that ARMS-T have specific deficits in working memory (both parameters), accuracy of Tower of Hanoi (number of moves, 4 discs) and the Go/NoGo paradigm (omissions).

The direct comparison of **DC and ARMS-NT** as well as the comparison between **ARMS-T and ARMS-NT** revealed no statistically significant differences (for details see Table 6 in the supplementary material).

Discussion

The main objective of the present study was to contribute to the differential diagnosis of the early prodromal states of psychosis versus depressive disorders. To this end, we tried to clarify the specificity of neurocognitive deficits in ARMS-T compared to DC. ARMS-T showed specific deficits in working memory and in certain executive function tasks when compared to HC and DC.

Cognitive deficits in ARMS-T versus DC

In our study, DC performed similar to HC – except from slowing in the Tower of Hanoi task. Therefore, both DC and ARMS-T showed impairment in the Tower of Hanoi test, but when analyzing it in more detail, the deficits apply to different areas of the task. DC advanced slowly in the task compared to HC, but the quality of the performance (i.e. number of disk moves to solve the problem) was comparable to HC. In contrast,

ARMS-T were significantly impaired in the quality of the performance in the Tower of Hanoi but not in speed. The Tower of Hanoi test demands strategical thinking and planning skills and not a quick reaction time. Therefore, we interpreted the reduced speed in the Tower of Hanoi test observed in the DC group as slow course of action probably best explained by the influence of emotional processes on decision making [56] and rumination [57,58] and as probably not related to predominant psychomotor slowing. This argument is also supported by the fact that DC were not impaired in reaction time tests such as the Go/NoGo and the CPT.

Cognitive deficits are a well established feature of depressive disorders, although the findings are heterogeneous (for review see[27,34,36,40]). One reason for our DC group to show few cognitive deficits and to perform similar to HC in most tests may be that few patients were suffering from a severe episode of depression and cognitive deficits in depression are closely related to severity of the episode.[59] Another reason could be that our DC group consisted of individuals with a non-psychotic depression. Studies show that patients suffering from affective disorders *with* psychotic symptoms show comparable [26,28,32] or similar but less pronounced [33] cognitive deficits when compared to patients with schizophrenia, while patients with affective disorders *without* psychotic symptoms- corresponding to the DC evaluated in the present study- showed less cognitive deficits [26-28].

The ARMS-T in our study were significantly more impaired than DC in working memory and certain executive function tasks. To our knowledge there are so far no other studies specifically comparing cognitive deficits in prodromal psychosis versus major depression. Hence, our results are difficult to compare to other studies in the literature.

Ilonen et al. [24] investigated neurocognitive functioning in ARMS individuals versus a psychotic and non-psychotic patient group. In contrast to our results, they found that ARMS did not differ from the non-psychotic group with respect to cognitive deficits. However, this study is not totally comparable to the present study, as the non-psychotic control group included several diagnostic entities according to DSM IV Axis I such as mood disorder, anxiety disorder and disorders usually first diagnosed in infancy, childhood, or adolescence. Another study [25] compared the neurocognitive performance of ARMS individuals to a non-psychotic psychiatric control group. They found that the ARMS group performed worse on visuospatial tasks than the control group.

Further, there are studies comparing cognitive deficits in patients with non-psychotic depression and schizophrenia showing that the patients with schizophrenia were more impaired than the controls with depression in psychomotor speed, attention, learning [28], working memory [29,30], executive function, visual and verbal memory [30].

Conceptualization of cognitive deficits in ARMS-T

Working memory such as formulated by Baddeley [60] might be an appropriate framework to consistently conceptualize cognitive deficits found in ARMS-T [11,41,61]. The observed deficits in the TAP Go/NoGo test, which first requires the successful memorization of visual patterns and then the selective response to 2 out of 5 of these patterns, might be related to deficits in spatial working memory also observed in other studies on subjects at ultra-high risk for psychosis [62]. Furthermore, planning deficits such as observed in the Tower of Hanoi have been related to working memory [63,64] and, thus, ARMS-T's deficits observed in the Tower of Hanoi might also be attributable to working memory dysfunction.

Cognitive deficits in ARMS-T versus ARMS-NT

The neurocognitive profile of ARMS-NT was similar to the profile of ARMS-T. This relative similarity might be due to a proportion of ARMS-NT who are bearing a true risk for developing psychosis but have not (yet) made the transition to psychosis. Alternatively, the described deficits in ARMS-NT might be related to the presence of attenuated psychotic symptoms and brief intermitted psychotic symptoms in these patients.

The differentiation of ARMS-T versus ARMS-NT evaluated in the present study showed stronger deficits in the ARMS-T than ARMS-NT, although the direct comparison of both ARMS groups revealed no statistically significant differences. But as our group has shown in a previous study [14] neurocognitive assessment can also help to predict transition to psychosis when combined with other assessment domains such as psychopathology. In this study, reduced speed of information processing combined with psychopathology was shown to be the measure that best predicted transition to psychosis.

In another study by our group, verbal episodic memory was found to be significantly impaired in ARMS-T individuals compared to HC but not significantly when compared to ARMS-NT (Zimmermann R et al., 2011, unpublished data). The domain of verbal memory was not assessed in the present study.

Other studies comparing ARMS who converted to psychosis during follow-up with those who did not, found reduced [13] or enhanced [15] speed of information processing, impaired IQ [13], executive function [13,16,18] attention [15], verbal memory [11-13,16] working memory [13,18] (not significant[62]), visual memory [18] and spatial memory [11] in psychosis-

converters. In one study, no significant differences were found between psychosis-converters and non-converters in attention [65] and in a study by Wood et al. [66] a decline of visual memory and attention over time predicted transition to psychosis. Seidman et al [17] found that psychosis-converters performed worse than non-converters in global neuropsychological functioning, but no neurocognitive variable predicted transition to psychosis beyond clinical variables. Reviews concluded that reduced procession speed, impaired verbal memory [5,42] and working memory [5] are the most frequently found neurocognitive parameters to predict transition to psychosis.

Limitations

Limitations of our study are the small group samples and that ARMS individuals in this study had a minimum follow-up period of only two years. While it has been shown that most ARMS individuals make the transition to psychosis within 12 months [14,67,68] it might be possible that a small percentage of ARMS individuals develop psychosis after the follow-up period.

Furthermore, groups differed significantly in education. The possible effect on the results was statistically controlled for. A natural matching of the groups in terms of education was not possible since ARMS individuals showed marked deficits in this area.

In conclusion, ARMS-T performed worse than DC in working memory and certain executive function tasks. The neurocognitive evaluation of tasks related to these domains might in the future be helpful in the differential diagnosis of ARMS individuals versus depressive disorders.

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Figure Legends

Figure 1 Differences in neurocognitive performance of the groups compared to healthy controls. Performance of healthy controls is represented by the baseline.
Groups: ARMS-T = At Risk Mental State individuals with later transition to psychosis, ARMS-NT = At Risk Mental State individuals without later transition, DC = controls with depression
Tests: ToH = Tower of Hanoi; WCST = Wisconsin Card Sorting Test; WM = TAP working memory; CPT = Continuous Performance Task

Table 1: Criteria for ARMS and transition to psychosis

	Clinical signs
At Risk Mental State (ARMS)	A) "Attenuated" psychotic symptoms: psychotic symptoms below the transition cut-off (BPRS scales: ratings of hallucinations at 2-3, unusual thought content 3-4, or suspiciousness 3-4) at least several times per week persisting for >1 week; OR B) Brief Limited Intermittent Psychotic Symptoms (BLIPS): psychotic symptoms over the transition cut-off (BPRS scales: hallucinations ≥4, unusual thought content ≥5, suspiciousness ≥5, conceptual disorganization ≥5), but each symptom lasting <1 week before resolving spontaneously C) Genetic risk category: first or second degree relative with psychotic disorder *and* at least two further risk factors according to the screening instrument. D) Precondition for all categories: criteria of transition to psychosis remain unfulfilled.
Transition to Psychosis	A) At least one of the following symptoms: • suspiciousness (BPRS ≥5): subject says others are maliciously talking about him/her, have negative intentions or may induce harm (incidents more than once a week OR partly delusional conviction). • unusual thought content (BPRS ≥5): full delusion(s) with some preoccupation OR some areas of functioning disrupted (*not only* ideas of reference/ persecution, unusual beliefs or bizarre ideas without fixed delusional conviction) • hallucinations (BPRS ≥4): occasional hallucinations OR visual illusions >2 week or with functional impairment (*not only* hearing of own name, non-verbal acoustic or formless visual hallucinations/illusions). • conceptual disorganization (BPRS ≥5): speech difficult to understand due to circumstantiality, tangentiality, neologisms, blockings or topic shifts (most of the time OR three to five instances of incoherent phrases). • Symptoms at least several times a week and change in mental state lasting for more than one week.

BPRS = Brief Psychiatric Rating Scale [43]; ARMS = at risk mental state for psychosis

Table 2: Socio-demographic and clinical data

	HC	DC	ARMS-NT	ARMS-T	Statistics
N	76	34	27	20	
Gender (m/f)	39/37	14/20	13/14	14/6	$^{\dagger}\chi^2 = 4.29$, df=3, p = 0.23
Age (*SD of years)	24.86 (±5.71)	26.24 (±5.85)	25.85 (±8.68)	26.55 (±6.96)	$^{\ddagger}\chi^2 = 2.56$, df = 3 p = 0.46
Education					
< 9 years	8	10	4	6	
9 - 11 years	25	13	11	7	$^{\S}p < 0.01$
12 - 13 years	35	3	5	6	
>14 years	7	7	6	1	
Substance use					
Neuroleptics (chlorprothixene)	0	0	4	3	$^{\S}p = 0.06$
Antidepressants	0	23	11	7	$^{\S}p = 0.02$
Benzodiazepines	0	2	5	1	$^{\S}p = 0.18$
Cannabis use					
none	76	28	17	12	
less than monthly	0	2	5	3	
monthly	0	1	4	4	$^{\S}p = 0.40$
weekly	0	1	0	0	
daily	0	2	1	1	

Groups: HC = healthy control; DC = depressive control; ARMS-NT = At Risk Mental State individuals without later transition to psychosis; ARMS-T = At Risk Mental State individuals with later transition to psychosis

*SD, standard deviation; †Chi-square test; ‡Kruskal-Wallis test; §Monte Carlo test with 2000 replicates

Table 3: Depression in DC and ARMS individuals (ICD-10 code)

Diagnosis ICD-10	ARMS-T	ARMS-NT	DC
Depressive episode (F32) or recurrent depressive episode (F33)			
Mild (F32.0/33.0)	1	1	4
Moderate (F32.1/F33.1)	4	7	17
Severe (F32.2/F 33.2)	-	1	6
Severe with psychotic symptoms (F32.3/F33.3)	2	-	-
Currently in remission (F33.4)	-	-	1
Depressive episode, not further classified	1	1	4
Dysthymia (F34.1)	1	-	-
Adjustment disorder (F43.20, F43.21, F43.22)	-	4	2
Total	9/22	14/25	34/34

Groups: DC = depressive control; ARMS-NT = At Risk Mental State individuals without later transition to psychosis; ARMS-T = At Risk Mental State individuals with later transition to psychosis

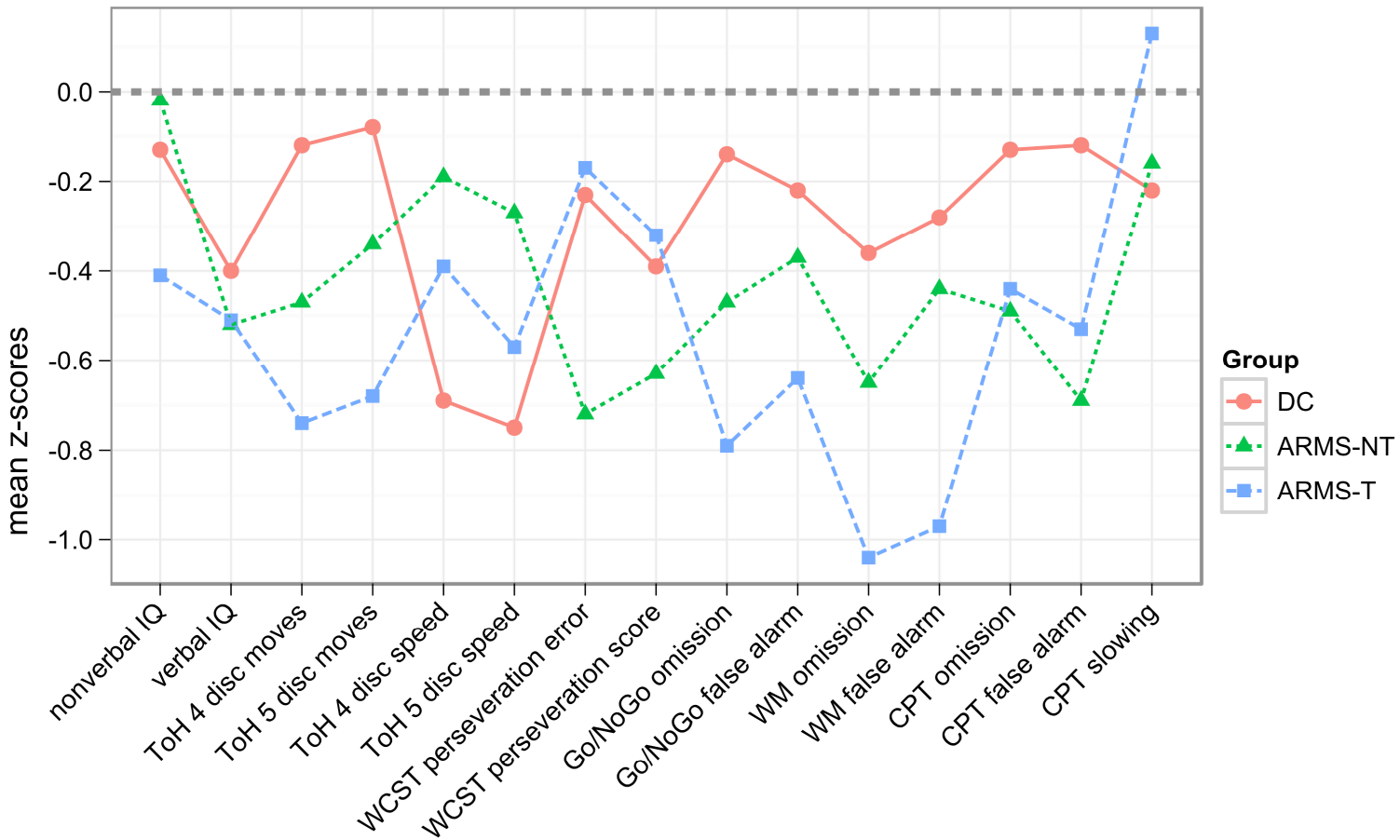
Table 5: Performance of ARMS-T, ARMS-NT, DC versus HC and ARMS-T versus DC

	ARMS-T vs HC				ARMS-NT vs HC				DC vs HC				ARMS-T vs DC			
	Diff in Z-Scores	95% Confidence Interval		p-value	Diff in Z-Scores	95% Confidence Interval		p-value	Diff in Z-Scores	95% Confidence Interval		p-value	Diff in Z-Scores	95% Confidence Interval		p-value
		lwr	upr			lwr	upr			lwr	upr			lwr	upr	
Intelligence																
nonverbal IQ	-0.41	NA[††]	NA[†]	NA[†]	-0.02	NA[†]	NA[†]	NA[†]	-0.13	NA[†]	NA[†]	NA[†]	-0.28	NA[†]	NA[†]	NA[†]
verbal IQ	-0.51	NA[†]	NA[†]	NA[†]	-0.52	NA[†]	NA[†]	NA[†]	-0.4	NA[†]	NA[†]	NA[†]	-0.11	NA[†]	NA[†]	NA[†]
Executive Function																
Tower of Hanoi 4 disc moves	-0.74	-1.28	-0.2	<0.01	-0.47	-0.94	0.01	0.06	-0.12	-0.54	0.3	0.87	-0.62	-1.12	-0.02	0.04
Tower of Hanoi 5 disc moves	-0.68	-1.27	-0.09	0.02	-0.34	-0.85	0.18	0.33	-0.08	-0.52	0.37	0.97	-0.6	-1.25	0.05	0.08
Tower of Hanoi 4 speed	-0.39	-1.05	0.27	0.42	-0.19	-0.77	0.39	0.83	-0.69	-1.2	-1.8	<0.01	0.3	-0.43	1.03	0.71
Tower of Hanoi 5 speed	-0.57	-1.24	0.09	0.12	-0.27	-0.86	0.31	0.62	-0.75	-1.25	-0.24	<0.001	0.17	-0.56	0.91	0.93
WCST perseveration error	-0.17	-0.76	0.42	0.88	-0.72	-1.24	-0.19	<0.01	-0.23	-0.7	0.24	0.59	0.06	-0.6	0.72	1.00
WCST perseveration score	-0.32	-0.96	0.33	0.58	-0.63	-1.18	-0.07	0.02	-0.39	-0.9	0.1	0.17	0.08	-0.64	0.79	0.99
Go/NoGo omission	-0.79	-1.32	-0.25	0.001	-0.47	-0.96	0.02	0.06	-0.14	-0.58	0.3	0.84	-0.65	-1.25	-0.05	0.03
Go/NoGo false alarm	-0.64	-1.14	-0.14	<0.01	-0.37	-0.83	0.1	0.17	-0.22	-0.64	0.2	0.52	-0.42	-0.98	0.15	0.22
Working memory and attention																
TAP Working memory omission	-1.04	-1.63	-0.44	<0.001	-0.65	-1.2	-0.11	0.01	-0.36	-0.84	0.13	0.24	-0.68	-1.35	-0.01	0.04
TAP Working memory false alarm	-0.97	-1.55	-0.4	<0.001	-0.44	-0.97	0.09	0.14	-0.28	-0.75	0.44	0.41	-0.69	-1.33	-0.05	0.03
CPT omission	-0.44	-1	0.13	0.19	-0.49	-1.02	0.04	0.08	-0.13	-0.6	0.34	0.89	-0.31	-0.95	0.33	0.59
CPT false alarm	-0.53	-1.12	0.06	0.10	-0.69	-1.24	-0.14	<0.01	-0.12	-0.61	0.37	0.93	-0.41	-1.08	0.25	0.37
CPT slowing	0.13	NA[‡]	NA[‡]	NA[‡]	-0.16	NA[‡]	NA[‡]	NA[‡]	-0.22	NA[‡]	NA[‡]	NA[‡]	0.35	NA[‡]	NA[‡]	NA[‡]

[†]MANOVA showed no significance
[‡]ANOVA showed no significance
ToH = Tower of Hanoi; WCST = Wisconsin Card Sorting Test; WM = working memory; CPT = Continous performance task

Groups: HC = healthy control; DC = depressive control; ARMS-NT = At Risk Mental State individuals without later transition to psychosis; ARMS-T = At Risk Mental State individuals with later transition to psychosis

Figure1:


mean z-scores
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
nonverbal IQ
verbal IQ
ToH 4 disc moves
ToH 5 disc moves
ToH 4 disc speed
ToH 5 disc speed
WCST perseveration error
WCST perseveration score
Go/NoGo omission
Go/NoGo false alarm
WM omission
WM false alarm
CPT omission
CPT false alarm
CPT slowing
Group
DC
ARMS-NT
ARMS-T