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Study of Neurocognitive correlates of Schizotypy Personality Clusters in healthy individuals

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ABSTRACT – *Background and Objectives*: Inconsistencies in the relationship between schizotypy dimensions and neurocognitive functions found in correlational studies may be clarified with the use of alternative methodological approaches. The aim of this study was to examine the existence of different profiles of schizotypal traits and their neurocognitIve correlates in non-clinical subjects by means of cluster analysis.

Methods: We examined seventy six healthy adults from the general population with a comprehensive neurocognitive battery and a schizotypal personality self-report.

Results: Four neurocognitive factors were extracted: visuospatial, semantic evocation, verbal memory, and set-shifting. A three cluster model yielded the following clusters: "lowschizotypy", "positive schizotypy", and "negative/disorganized schizotypy". The positive and negative/disorganized schizotypy clusters showed poorer performance on semantic evocation compared with the low schizotypy cluster.

Conclusions: We found different patterns of specific schizotypy features in a healthy adult community sample and these clusters presented differential performance in relation with the ability to evoke semantic information.

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Introduction

Schizotypy is a personality dimension that comprises cognitive-perceptual unusual experiences, as well as motivational, affective, social and behavioural oddities[1]. Schizotypy is a phenotype hypothesized to result from the psychobiological organization underlying the risk for schizophrenia[2]. In the last years, the study of schizotypy has become an important tool for the research on the aetiology of schizophrenia spectrum, given that studying schizophrenic patients makes it difficult to disentangle the impact of confounding variables such as the presence of psychotic symptoms and the effects of antipsychotic drugs.

Factor analytic studies of schizotypy traits have shown at least three components: negative, positive and disorganization dimensions[3-8]. Similarly, factor analytic studies in schizophrenia have reliably shown that psychotic symptoms can be grouped into positive, negative and disorganization dimensions[9-15]. Although factor analytic studies have provided information about the dimensional structure of schizophrenia and schizotypy based on the interrelationships between *measures*, they do not give us information about how *subjects* might be grouped according to their responses in the schizophrenia/schizotypy measures[16].

Despite of the value of cluster analysis, there have been few cluster analytic studies in schizotypy (see Table I), with the number of clusters yielded ranging from 3 to 4 clusters[16-20]. The inspection of Table I reveals that the most replicated clusters are “low schizotypy”, “positive schizotypy”, and “negative schizotypy”. A “cognitive disorganization” cluster appears only in some studies or it is found associated with negative or positive features, mostly depending on whether specific measures of this construct were actually included in the studies. Finally, some studies found clusters with mixed features of varying levels of intensity (“high schizotypy” or “average schizotypy” cluster). Similarly, in schizophrenia three consistent clusters emerge based on a specific profile of symptoms: one predominantly positive, a second one predominantly negative, and a third one with high scores on both dimensions (positive and negative)[21-28].

A general pattern of neurocognitive deficits has been found in schizophrenia patients, with attention, memory, and executive functions showing the greatest magnitude of impairment[29-32]. Some studies have tried to understand such heterogeneity by relating cognitive performance to the clinical dimensions of schizophrenia. However, although the negative and disorganized dimensions have been overall more closely associated with poorer performance in memory and executive functions, there is no specific pattern of associations that can be consistently replicated across studies[33].

The same inconsistencies described for schizophrenia have been found in schizotypy[34]. These discrepancies may be due to the fact that correlational analyses do not give us information about how *subjects* might be grouped according to their responses in the schizophrenia/schizotypy measures. Therefore, we hypothesized that natural groupings in schizophrenia/schizotypy, based on cluster analysis, and may be more strongly related with specific neurocognitive profiles than schizophrenia/schizotypy dimensions. However, cluster analytic studies relating cognition and schizophrenia/schizotypy are rare. Suhr and Spitznagel[34] found in a selected sample (only high scorers on schizotypy) that the cluster with predominantly negative schizotypy performed worse than all the remaining clusters on the Wisconsin Card Sorting Test (WCST), a measure of executive functioning. Likewise, Barrantes-Vidal *et al.*[17]

Table I
Summary of studies on schizotypy clusters in non-clinical samples.

Reference	Sample	Measures	Cluster analysis method	Results
Williams, 1994	70 undergraduates gender distribution not provided (mean age 23; range 18-43)	MIS, STA, PhAS, SoAS.	Explorative Agglomerative hierarchical	*4 cluster solution:* 1)“Low Schizotypy”: Low levels of schizotypal traits (n = 22) 2)“Ideational/Perceptual Disturbance”: High scores on magical ideation, low level of both physical and social anhedonia, average STA (n = 14) 3)“Physical Anhedonia”: High level physical anhedonia, average social anhedonia, average on STA and low level of magical ideation (n = 15) 4)“Cognitive Disorganisation/ Social Anhedonia”: Very high scores on STA and social anhedonia, generally high MI Scale scores, average scores on physical anhedonia (n = 18)
Loughland and William, 1997	69 undergraduates 47 female/22 males (mean age 24.7; range 17-53)	O-LIFE	Explorative Agglomerative hierarchical	*4 cluster solution:* 1)“Low Schizotypy”: Low scores on all three subscales (n = 19) 2)“Unusual Experiences”: High scores on the unusual experiences (n = 27) 3)“Cognitive Disorganisation”: High scores on the cognitive disorganisation and also moderately high scores on both the unusual experiences and introvertive anhedonia (n = 18) 4)“Introvertive Anhedonia”: Very high scores on the introvertive anhedonia, moderately high scores on the cognitive disorganisation (n = 5)
Suhr and Spitznagel, 2001a	1366 undergraduates 931female/435 males (mean age not provided; range not provided)	SPQ, PAS, MIS	Explorative Agglomerative hierarchical; K-means iterative	a) Unselected sample: *4 clusters:* 1)“Positive and disorganized”: High on positive and disorganized dimensions (n = 228) 2)“Low Schizotypy”: Low scores on all scales (n = 638) 3)“Average Schizotypy”: Scored average on all scales (n = 415) 4)“High Schizotypy”: High on all scales (n = 39) b) Selected Sample of high scorers: (n = 348; student who scored in the top 10th percentile on any of the three scales) *4 clusters:* 1)“Low Schizotypy”: Low scores on all scales (n = 80) 2)“Positive Schizotypy”: Scored high on ideas of reference, magical thinking, and unusual perceptions (n = 95) 3)“High Schizotypy”: Scored high on all scales (n = 98) 4)“Negative Schizotypy”: Scored high on negative symptoms, including social anxiety, lack of close friends, and restricted affect, and were average on odd behaviour, odd speech, ideas of reference, and suspiciousness (n = 75)

Table I (Cont)

Reference	Sample	Measures	Cluster analysis method	Results
Barrantes-Vidal *et al*. 2003	270 normal adolescents 129 girls/141 boys (mean age 13.4; range not provided)	PAS, PhAS, SAS	K-means iterative	*4 Clusters:* 1) "Negative Schizotypy": High scores on both physical and social anhedonia, low scores on positive schizotypy (n = 36) 2) "High Schizotypy": High scores for both positive and negative schizotypy, with a slight predominance of social anhedonia over physical anhedonia (n = 59) 3) "Positive Schizotypy": High scores on perceptual aberration with average social anhedonia and low physical anhedonia (n = 67) 4) "Normal scorers": Average or low scores on the three scales (n = 108)
Goulding, 2004	88 undergraduates 70 female/16 males (mean age = 25.9; range 18-52)	O-LIFE	Explorative Agglomerative hierarchical	*3 clusters* 1) "Cognitive Disorganization (CG) – Introvertive Anhedonia (IA)": High scorers on CD and IA and average scores on UE (n = 16) 2) "Unusual Experiences (IE)": High scores on UE, average on CD and below average on IA (n = 23) 3) "Low Schizotypy (LS)": Below average scores on all the subscales (n = 49)
Goulding, 2005	129 healthy volunteers 106 female/23 males (mean age = 46.8; range 21-85)	O-LIFE	Explorative Agglomerative hierarchical; K-means iterative	*3 clusters* 1) "Introvertive Anhedonia (IA)": High scores on the IA and moderately high scores on the CD and UE sub-scales (n = 35) 2) "Cognitive Disorganization (CD)": High scores on CD, moderately high scores on UE and very low on the IA (n = 33) 3) "Low Schizotypy (LS)": Below average scores on all three sub-scales (n = 60)

Abbreviations: MIS = Magical Ideation Scale (62); STA = Schizotypal Personality Scale (63); PhAS = Physical Anhedonia Scale (64); SAS = Social Anhedonia Scale (65); O-LIFE = Oxford-Liverpool Inventory of Feelings and Experiences (66) (Impulsive Nonconformity subscale was not included in these studies); SPQ = Schizotypy Personality Questionnaire (67); PAS = Perceptual Aberration Scale (68).

found poorer performance in an attentional task for the “high schizotypy” cluster (i.e, high on *both* positive and negative dimensions), and worst scores on the WCST for the “negative schizotypy” cluster.

The aims of this study were, first, to explore the presence of different schizotypy profiles in a non-clinical adult sample by means of cluster analysis. Secondly, to compare the relationship between schizotypy and neurocognition as examined by correlating the schizotypy *dimensions* with neurocognitive functions, and comparing schizotypy *clusters* on neurocognitive functions. We hypothesized that there would be meaningful variation in schizotypy scores and sound clusters in a general population sample, and that different profiles of schizotypy personality would contribute to explain the heterogeneity of neurocognitive functioning in such non-clinical sample. Specifically, we predicted that a cluster of high scorers (subjects scoring high on several schizotypy dimensions) or with predominant negative features would perform worse on the neurocognitive tests.

Method

Participants

Ninety healthy participants completed a comprehensive neurocognitive battery (44 females; mean age = 32.5, SD = 10.8; range 20-64); mean years of education = 15.4, SD = 3.8). Of these ninety individuals, usable schizotypy questionnaires were available for seventy six (40 females; mean age = 31.9, SD = 10.2; range 20 - 64; mean years of education = 15.7, SD = 3.7).

Participants were recruited from the community through advertisements placed at several university offices and community vocational and technical schools from the metropolitan area of Barcelona. All participants provided written informed consent. Exclusion criteria were: i) presence of Cluster A or Borderline Personality Disorder assessed by Structured Clinical Interview for DSM-IV Personality Disorder (SCID-II[35]) ii) presence of any past or major psychiatric disorder; iii) presence of any diagnosis of psychosis or any severe mental disorder in first degree relatives assessed by means of the “Family Interview for Genetics Studies” (FIGS[36]).

Measures

Estimated general intelligence was assessed by Block Design (BD) and Information (I) subtests of the Wechsler Adult Intelligence Scale-III (WAIS-III[37]). Logical Memory (LM), immediate and delayed, of the Wechsler Memory Scale Revised (WMS-R[38]) was used to assess verbal memory. Visual attentional span and working memory functions were evaluated by the Visual Memory Span (VMS) forward and backward of the WMS-R. D’shapes and d’numbers indices of the Continuous Performance Test-Identical Pairs version (CPT-IP[39]) were used to assess sustained attention. Moreover, phonemic verbal fluency was measured with the Controlled Oral Word Association test (COWA[40] and semantic verbal fluency with the Animal Naming (AN[41]). Finally, executive functions were assessed by the perseverative errors (PE) and total correct (TC) indices of the Wisconsin Card Sorting Test (WCST[42]).

Schizotypy was measured with the Schizotypy Personality Questionnaire-Brief (SPQ-B[43]). This self-report questionnaire assesses negative or interpersonal, positive or cognitive-perceptual and disorganized schizotypy dimensions. Following the authors’ recommendation, we used the complete scale for the disorganization dimension (the abbreviated version of the disorganized dimension obtained unsatisfactory reliability indices) along with the short version of the positive and negative dimensions.

Statistical analysis

A factor analysis with the twelve individual test scores described was performed to reduce the number of neurocognitive variables for subsequent analysis in the sample of 90 participants. The analysis was carried out using a principal components factor analysis with varimax rotation.

An agglomerative hierarchical cluster analysis using Ward's procedure was performed on the three schizotypy scales. Cluster analysis is a multivariate technique which aims at assembling objects (personality profiles in this case) based on the characteristics that they possess, that is, delineating "natural" groups in the data themselves. First, similarity between groups is defined by their proximity (euclidean distance), next step consisted of forming cluster solution by means of hierarchical procedure (it moves in a stepwise fashion to form an entire range of cluster solutions) and using an agglomerative method (clusters are formed by the combination of existing clusters). Finally, visual inspection of the dendrogram plot and the values of the fusion coefficient may support the cluster solution selected. Then, a multivariate analysis of variance (MANOVA) was conducted using the cluster solution assignment as the independent variable and the schizotypy scores as the dependent variables, in order to obtain a discriminative index for the clusters created.

Finally, an univariate analysis of variance (ANOVA) and correlational analysis were carried out to test the specific relationship between schizotypic clusters and neurocognitive domains. The association between schizotypy and neurocognition was conducted with 76 participants. All results are presented with two-tailed levels of significance.

Results

Data Reduction of Neurocognitive Tests

Four factors were extracted with an eigenvalue of 1 or greater, which explained 71.1% of the total variance; the amount of variance accounted for by each factor can be seen in Table II. The first factor was named "visuospatial" because all the measures loading in this factor (Forward and Backwards VMS, BD, CPT-IP D'Shapes and D'Numbers) require visuospatial abilities for their performance. The second factor, which consisted of measures of verbal fluency (semantic and phonemic) and I (WAIS-III), was labeled "semantic evocation". The third one was called "verbal memory", because it was constituted by immediate and delayed VM (WMS-R); and the fourth factor was labeled "set-shifting", as it was formed by the PE (with negative loading) and the TC from the WCST.

Cluster Analysis of Schizotypy Variables

Visual inspection of the dendrogram plot and the values of the fusion coefficient supported a three cluster solution. Wilks' Lambda ($\lambda = 0.14$) was significant ($p < 0.0001$), explaining 86% of the total variability. Therefore, a three-cluster model was retained (see Table III). Cluster 1 consisted of 48 subjects (25 females; mean age = 31.4, SD = 9.5; mean years of education = 16.3, SD = 3.2) and reflected low scores on all schizotypy dimen-

Table II
Factor Analysis of neurocognitive tests in non-clinical individuals (n = 90).

Neurocognitive measures	Factors			
	Visuospatial	Semantic evocation	Verbal memory	Set - shifting
Forward Visual Memory Span WMS-R	0.796	*	0.188	*
Backwards Visual Memory Span WMS-R	0.819	*	0.283	*
Block Design WAIS-III	0.780	0.148	*	
D' Shapes CPT-IP	0.675	0.360	*	0.194
D' Numbers CPT-IP	0.578	0.448	*	0.216
Phonemic fluency	*	0.862	*	*
Information WAIS-III	0.224	0.701	0.181	*
Semantic fluency	0.214	0.651	0.349	0.115
Immediate logical memory WMS-R	0.205	0.189	0.902	0.178
Delayed logical memory WMS-R	0.132	0.223	0.914	*
Perseverative errors WCST	-0.397	-0.190	-0.144	-0.702
Total Correct WCST	*	*	*	0.882
% Explained variability	25.2 %	17.8 %	16.3 %	11.8 %

[a]These are varimax rotated principal components.
*Absolute values below 0.10.
Abbreviations: WAIS: Weshler Adult Intelligence Scale; WMS-R: Weschler Memory Scale-Revised; CPT-IP: Continous Performance Test- Identical Pairs version; WCST: Wisconsin Card Sorting Test.

sions (positive, negative and disorganized). It was named "Low Schizotypy". Cluster 2 was formed by 10 subjects (8 females; mean age = 33.1, SD = 8.5; mean years of education = 14.3, SD = 4.3). This cluster showed low scores on negative and disorganized dimensions, but high scores on the positive dimension. It was labeled "Positive Shizotypy". The third cluster was composed of 18 participants (7 females; mean age = 32.8.7, SD = 12.9; mean years of education = 14.8, SD = 4.4). It showed intermediate scores on the positive dimension and high scores on the negative and disorganized dimensions, and it was called "Negative-Disorganized Schizotypy". No significant differences were found for age (F = 0.18, p = 0.83), years of education (F = 2.09, p = 0.13) or sex (χ^2 = 4.37, p = 0.11) between the three clusters.

Table III
Descriptive data of the schizotypy dimensions (Z scores) for each cluster and MANOVA results with a posteriori contrasts (Least Significant Differences).

Schizotypy factors	Cluster 1 n = 48 Low Schizotypy	Cluster 2 n = 10 Positive Schizotypy	Cluster 3 n = 18 Negative/ disorganized Schizotypy	F	p	LSD
Negative or interpersonal	-0.37(0.69)	-0.28(0.91)	1.17(0.87)	27.5	< 0.0001	3 > 2 = 1[a]
Disorganized	-0.39(0.52)	-0.54(0.33)	1.35(1.03)	50.1	< 0.0001	3 > 2 = 1[b]
Positive or cognitive-perceptual	-0.57(0.29)	1.51(0.75)	0.68(1.05)	61.5	< 0.0001	2 > 3 = 1[c]

[a] Cluster 1 not differ from 2 (p = 0.72), but differ from 3 (p < 0.0001), cluster 2 different from 3 (p < 0.0001).
[b] Cluster 1 not differ from 2 (p = 0.54), but differ from 3 (p < 0.0001), cluster 2 different from 3 (p < 0.0001).
[c] All clusters significantly different at p < 0.0001.
Abbreviation: LSD means Least Significant Differences.

Neurocognitive Performance and Schizotypy

Statistical significance was found only for the semantic evocation factor ($F = 4.7$; $p = 0.012$) (see Figure 1). A posteriori analysis carried with the Least Significant Differences method indicated that the positive and the negative-disorganized clusters performed significantly worse compared with the low schizotypy cluster ($p = 0.032$ and $p = 0.01$ respectively). No statistical differences were found between the negative-disorganized and the positive clusters ($p = 0.97$).

Negative and positive schizotypy dimensions only correlated significantly (inversely) with the "semantic evocation" factor (see Table IV).

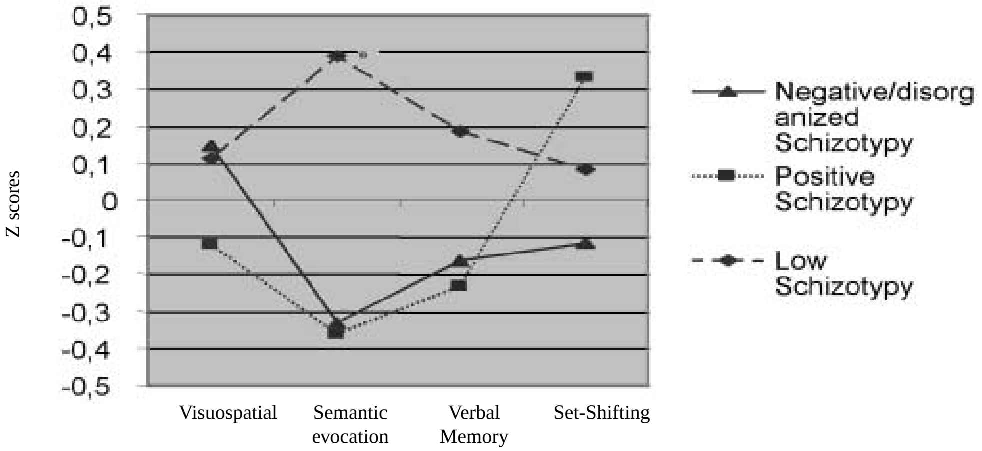

Figure 1. Mean values (Z scores) of each neurocognitive factor for the schizotypy clusters in the non-clinical adult sample. * p < 0.05

Table IV
Zero-order correlations between neurocognitive factors and schizotypy dimensions.

	Negative or interpersonal	Disorganized	Positive or cognitive-perceptual
Visuospatial	0.134	0.165	-0.133
Semantic evocation	-0.355**	-0.203	-0.474**
Verbal memory	-0.105	-0.019	-0.091
Set - shifting	-0.075	-0.134	-0.006

* p < 0.05; ** p < 0.01.

Discussion

Dimensions of schizotypy in the analyzed sample

The cluster analysis carried out in the present study showed three different patterns of specific schizotypy features in a healthy adult community sample. A first cluster was defined by low scores on all schizotypy dimensions. This cluster contained the highest number of subjects from our sample (63.2%), as expected in a non-clinical population. Secondly, a small cluster of predominantly positive features emerged (13.2%), and, finally, we found a third cluster with both negative and disorganized traits (23.7%). Our results with an adult sample (mean age 30) highly resemble previous cluster studies that, almost exclusively (except for[17,19] have been carried out with undergraduate students [16,18,20]). This convergence seems to support the generalizability of the cluster solutions found in previous studies to the general population.

The neurocognitive correlates of schizotypy

This study also explored the neurocognitive correlates associated with schizotypy in non-clinical subjects. The comparison of the schizotypy clusters on neurocognitive performance showed a subtle difference in the “semantic evocation” factor. The positive and negative/disorganized schizotypy clusters showed poorer performance compared to the low schizotypy cluster. Correlational analysis also showed a negative relationship between the positive and negative schizotypal dimensions with the “semantic evocation” factor. Thus, contrary to our expectations, both approaches yielded the same results in this study. Therefore, in this sample of non-clinical young adults, we found support for the hypothesized relationship between individual differences on schizotypy and neurocognition variability but we were not able to show that the cluster of high negative schizotypy scorers has a worse neurocognitive functioning. It must be taken into account that the current sample size yielded schizotypy clusters with a relatively low number of subjects, something that may have reduced our ability to detect stronger differences.

The difference on semantic evocation seems to be consistent with the results of the cluster analysis by Barrantes-Vidal *et al.*[17] with healthy adolescents, where the high schizotypy cluster (high on both positive and negative schizotypy) obtained the worst scores in verbal fluency, a task embedded in our semantic retrieval factor. The results are also consistent with those studies relating schizotypy dimensions with verbal fluency[44-46]. For instance, Krabbendam *et al.*[47] found in non-clinical subjects from the general population that high scores on positive and negative schizotypy had poorer verbal fluency performance. However, other studies failed to find an association [48,49].

These results are also in agreement with the consistent finding of impaired verbal fluency in the studies of cognition in schizophrenia[50,51]. Moreover, studies carried out in non-affected relatives of schizophrenia patients suggest verbal fluency as a vulnerability factor for schizophrenia[52-55], as indeed has been confirmed in recent meta-analyses[56-58].

The association of *both* positive and negative schizotypy with semantic evocation may be related to the fact that verbal fluency performance involves several cognitive functions, such as verbal memory (previously associated with *positive* schizotypy[46,59]); executive functioning (mostly associated with *negative* schizotypy[46,60]; and psychomotor speed[61]. This may explain the lack of a specific association between this cognitive function and a particular schizotypy dimension, and points out the difficulty in linking symptom/trait dimensions with molar cognitive measures or constructs that are actually subserved by a number of components.

In addition, the fact that we only used the SPQ-B for assessing schizotypy traits may have had an impact on our ability to properly capture a group of anhedonic participants in the general population. Although the SPQ rates the nine symptoms of Schizotypal Personality Disorder, it does not adequately tap anhedonia, which is suggested to be the core feature of negative schizotypy. This might have also contributed to explain the lack of specificity found among positive and negative/disorganized clusters and semantic evocation and may explain the differences with other studies using the Chapman scales[17,34], where anhedonia is a key component of negative schizotypy. In this respect, the slight difference in the construct of negative schizotypy may contribute to account for the lack of a differential relationship between neurocognition and positive and negative schizotypy, both when exploring *dimensions* by means of correlational analysis and high scoring *subjects* by means of cluster analysis.

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