

PREDOMINANT NEGATIVE SYMPTOMS IN 22Q11.2 DELETION SYNDROME AND THEIR ASSOCIATIONS WITH COGNITIVE FUNCTIONING AND FUNCTIONAL OUTCOME

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ABSTRACT

22q11.2 deletion syndrome (22q11.2DS) is a neurogenetic condition associated with increased risk for schizophrenia. No study to date has explored how positive and negative symptoms of psychosis are distributed among individual patients with 22q11.2DS and if distinct patterns of symptoms can be identified. Negative symptoms being more frequent than positive symptoms in 22q11.2DS, we expected that a high number of patients would display predominant negative symptoms (PNS), whereas pre-dominant positive symptoms would be less frequently reported. The present study aims at investigating the cognitive deficits and functional outcome associated with distinct patterns of psychotic symptoms in 22q11.2DS. 63 adolescents and young adults with 22q11.2DS participated in this study. Each participant underwent a clinical and a cognitive evaluation. A cluster analysis was used to identify groups of individuals with distinct patterns of symptoms. Individuals from the different clusters were then compared on a series of cognitive measures and on functional outcome. Three clusters of individuals were identified: low levels of symptoms, PNS, and high levels of symptoms. Individuals with PNS had significantly lower visual memory scores and decreased processing speed compared to participants with low levels of symptoms. They were also rated as having lower functional and occupational outcome. The present results indicate that one third of adolescents and young adults with 22q11.2DS display PNS. This pattern of symptoms was associated with specific cognitive deficits and

decreased functional outcome. Future studies are needed to examine the developmental trajectories of these individuals and assess their risk of conversion to full-blown psychosis.

Introduction

22q11.2 deletion syndrome (22q11.2DS) is a neurogenetic condition affecting 1/4300-7000 live births (Oskarsdóttir et al., 2004) and associated with a markedly elevated risk for schizophrenia spectrum disorders (Murphy, 2005). Transient positive psychotic manifestations are experienced by more than 50% of adolescents and 20% of children with this syndrome (Baker and Skuse, 2005; Debbané et al., 2006; Schneider et al., 2013). Attenuated negative symptoms are also an integral part of the 22q11.2DS profile, as they are present in up to 80% of adolescents (Schneider et al., 2012; Stoddard et al., 2010). A previous study by our group established that negative symptoms in 22q11.2DS are divided in two main dimensions relating to decreased emotional expressiveness (expressive symptoms) and social withdrawal/amotivation (amotivation symptoms) (Schneider et al., 2012). While single dimensions of early psychotic manifestations have been well described in this syndrome, the actual relationship between positive (hallucination and delusion-like symptoms) and negative symptoms (expressive and amotivation symptoms) has yet to be explored. The use of cluster analysis is a well-suited way to examine if distinct patterns of positive and negative symptoms are identifiable among 22q11.2DS individuals. Cluster analyses on psychotic-like symptoms in individuals without 22q11.2DS usually delineate four patterns of symptoms: low levels of symptoms, predominant positive symptoms (PPS), predominant negative symptoms (PNS), and high levels of symptoms (e.g. Barrantes-Vidal et al., 2010). These results indicate that positive and negative symptoms are not always concurrent, which argues in favour of distinct etiological factors leading to the expression of these two symptomatic dimensions.

The identification of a group of 22q11.2DS individuals scoring high on a single dimension of psychotic symptoms (i.e. individuals with PPS or PNS) would help disentangle the specific contribution of several factors in the pathogenesis of positive and negative symptoms. In particular, we seek to identify if specific cognitive deficits are associated to the presence of predominant positive and negative symptoms in 22q11.2DS. Research in the field of schizophrenia indicates that negative symptoms are strongly associated to cognitive impairments, even if precise nature of their relationship is still not fully established (Harvey et al., 2006). More specifically, negative symptoms have been associated with various cognitive domains, such as processing speed (Lipkovich et al., 2009; McDowd et al., 2011), working memory (Kebir and Tabbane, 2008; O'Gráda et al., 2009; Szendi et al., 2006), long-term memory (McDowd et al., 2011), executive functioning (Clark et al., 2010; Lewandowski et al., 2011), and attention (Sanz

et al., 2012; Tsai et al., 2010). On the opposite, positive symptoms are thought to be largely independent of cognitive deficits (e.g. Green and Nuechterlein, 1999).

In a second part of the study, we also aimed at investigating the impact of predominant positive and negative symptoms on educational and professional outcome. Indeed, previous studies have suggested that some individuals with 22q11.2DS have a poorer outcome than what would have been expected based on their cognitive level (Butcher et al., 2012). In our opinion, the presence of negative symptoms may be a contributing factor for poor vocational outcome in 22q11.2DS, as it has been observed in patients with schizophrenia (for a review, see Mäkinen et al., 2008). On the opposite, positive symptoms have been related to outcome to a much lesser extent (e.g. Rabinowitz et al., 2012).

The present study examines the cognitive and functional characteristics associated with individual dimensions of psychotic symptoms in adolescents and young adults with 22q11.2DS. Specifically, we formulated three main hypotheses. First, we expected that individuals would cluster in four groups according to their pattern of positive and negative symptoms: low levels of symptoms, PPS, PNS, and high levels of symptoms. Given the high prevalence of negative symptoms in 22q11.2DS (Schneider et al., 2012; Stoddard et al., 2010), we expected that a substantial proportion of individuals would be characterized by PNS, whereas only a small group would display PPS. Secondly, we examined which cognitive dimensions were associated with the presence of pre-dominant positive and negative symptoms and expected to observe strong associations between PNS and cognitive deficits. Finally, we explored if participants with PPS or PNS were characterized by decreased functional and vocational outcome. Again individuals with PNS were expected to have particularly low outcome. Finally, due to the strong associations between anxiety and outcome in individuals with 22q11.2DS (Angkustsiri et al., 2012), we examined the contribution of internalizing symptoms (anxiety/depression) to the observed findings.

MATERIAL AND METHODS

PARTICIPANTS

63 participants with 22q11.2DS aged between 10 and 28 years were included in the study (m 16.96, sd = 4.17, 33 (52.4%) females). The presence of a 22q11.2 microdeletion was confirmed using quantitative fluorescent polymerase chain reaction (QF-PCR).

21 (33.3%) participants were receiving psychotropic medication at the time of testing: 10 (15.9%) were on methylphenidate, 6 (9.5%) on antidepressants, 6 (9.5%) on antipsychotics, and 3 (4.8%) on anticonvulsants.

22q11.2DS participants were recruited through advertisements in patient association newsletters and through word of mouth. Written informed consent was obtained from participants and their parents under protocols approved by the Institutional Review Board of the Department of Psychiatry at the University of Geneva Medical School.

MATERIALS

CLINICAL ASSESSMENT

The presence of psychiatric disorders was evaluated in adolescents below 18 years using the Diagnostic Interview for Children and Adolescent e Revised (DICA-R; Reich, 2000) and the psychosis supplement from the Kiddie-Schedule for Affective Disorders and Schizophrenia Present and Lifetime version (K-SADS-PL; Kaufman et al., 1997). Adult participants were screened using the Structured Clinical Interview for DSM-IV axis I disorders (SCID-I; First et al., 1996).

The presence of attenuated positive and negative symptoms of schizophrenia was assessed using two evaluation scales. The Structured Interview for Prodromal Syndromes (SIPS; Miller et al., 2003) evaluates positive, negative, disorganization and general prodromal symptoms. Symptoms are assessed on a 7-point severity scale (ranging from 0 to 6). For more direct comparison with the results obtained with the PANSS, we rescored the SIPS items on a scale ranging from 1 to 7. The Positive And Negative Symptom Scale (PANSS; Kay et al., 1967) is composed of a positive, negative and general psychopathology subscale. All symptoms are rated on a 7-point severity scale (ranging from 1 to 7).

In a previous study published by our group (Schneider et al., 2012), a factor analysis using the PANSS and the SIPS items enabled to identify one positive and two negative dimensions (i.e. expressive and amotivation dimensions). In the present study, we used the same dimensions and computed three symptom scores as followed: positive score (mean of SIPS P1, P2, P3, P4, D2 and PANSS P1, P2, P3, P4, P5, P6, P7), expressive score (mean of SIPS N3, N4 and PANSS N1, N2, N6, N7, G7), and amotivation score (mean of SIPS N1, N2, D4 and PANSS N4, G16). In the original factor analysis, PANSS item N5 (difficulty in abstract thinking) loaded on the expressive dimension of negative symptoms. However in the present paper, we decided to remove this item in order to avoid redundancy with the cognitive scores, which could inflate correlations.

Finally, the parents of all participants completed the Child Behaviour Checklist (CBCL; Achenbach and Rescorla, 2001) or the Adult Behaviour Checklist (ABCL; Achenbach and Rescorla, 2003) to obtain a global parental report of behavioural difficulties. Specifically, we used the anxious-depressed *t*-score as a measure of anxiety/depression.

COGNITIVE ASSESSMENT

Each participant underwent a general cognitive evaluation using the Wechsler Intelligence Scale for Children (WISC-III; Wechsler, 1991) or the Wechsler Adult Intelligence Scale (WAIS-III; Wechsler, 1997) in the context of the clinical assessment. Using additional evaluation tools, six neurocognitive skills were also examined: processing speed, verbal memory, visual memory, working memory, attention, and executive functioning.

Processing speed was assessed using the Processing Speed Index from the WISC-III or WAIS-III.

The three memory domains were assessed using subtests from the Children Memory Scale (CMS; Cohen, 1997) or the Wechsler Memory Scale (WMS-III; Wechsler, 1987).

Verbal memory was assessed using the Verbal Paired Associates Immediate standard score, visual memory was assessed using the Face Memory Immediate standard score, and working memory was assessed using the Digit Span Backward standard score.

Attention was assessed using the Conners' Continuous Performance Test e II (CPT-II; Conners, 2000). Specifically, we used the attentiveness score (d') t -score provided by the computer program. We were not able to obtain the CPT scores for two participants because of a technical problem so we replaced their attentiveness score by the sample mean score (53.96).

Finally, executive functioning was assessed using the number of total correct answers during the Semantic Verbal Fluency Test (animal naming).

FUNCTIONAL OUTCOME

During the clinical evaluation, the Global Assessment of Functioning (GAF) was completed to assess the overall level of functioning on a scale ranging from 0 to 100.

The participants' level of education or professional status was systematically recorded and used to determine educational/professional outcome. Based on this information, the participants' educational or professional outcome was classified into 8 categories (ordinary school, vocational training, gainful employment, special school, specialized vocational training, sheltered employment, no activity, and other). These categories were then merged into two main domains: ordinary (ordinary school, vocational training, and gainful employment) and special needs (special school, specialized vocational training, sheltered employment, no activity and other).

Finally, parents of 51 individuals (70% of the entire sample) were interviewed using the Vineland Adaptive Behaviour Scales (VABS; Sparrow et al., 1984) to obtain information about adaptive functioning in various domains: communication, daily-life functioning, and socialization. At the time of data collection, VABS interview were not systematically conducted for individuals older

than 18 years. This is the reason why 12 individuals aged 19 years or higher have no VABS interview.

STATISTICAL ANALYSES

We first used a cluster analysis approach to test our first hypothesis regarding the presence of four clusters of individuals with different symptom profiles. Specifically, we used the positive, expressive and amotivation scores as classification variables and followed the procedure suggested by Clatworthy et al. (2005). We first performed a hierarchical cluster analysis to determine the appropriate number of clusters. Then, we performed a K-means cluster analysis to optimize the results. Finally, the mean severity of symptoms was compared across the different clusters using multiple ANOVAs with post-hoc Tukey HSD comparisons.

Cognitive functioning and functional outcome (GAF score) were compared across the different clusters using ANOVAs. In order to characterize the associations between cognitive functioning, functional outcome, and individual symptomatic dimensions (positive, expressive, and amotivation symptoms), Pearson correlations were performed.

The participants' educational or professional status was also compared between the groups using Chi-Square tests.

All the analyses were performed using SPSS version 19.

Results

CLUSTER ANALYSIS

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In the total sample, positive, amotivation and expressive symptom dimensions were correlated with one another ($r_{\text{positive-amotivation}} = 0.619, p < 0.001$; $r_{\text{positive-expressive}} = 0.694, p < 0.001$; $r_{\text{amotivation-expressive}} = 0.804, p < 0.001$). This indicates that, on average, these symptoms tend to occur together. Nevertheless, some degree of variability in the participants' symptom profile can be observed on the scatter plots (see Fig. 1), which may be suggestive of distinct clusters of individuals.

The hierarchical cluster analysis using the positive, amotivation and expressive symptom scores as classification variables and the dendrogram indicated a three-cluster solution. We then performed a k-means cluster analysis and forced a three-cluster solution. The selection of the three-cluster solution was supported by the high agreement between the two classification methods ($\text{kappa} = 0.745, p < 0.001$). In addition, when the three symptom scores were entered into a discriminant function analysis, the three clusters were largely

distinct in discriminant function space (see *Fig. 2*).

The 63 participants were divided into the three clusters as followed: 35 participants were included in cluster 1, 21 participants in cluster 2, and 7 participants in cluster 3. The mean severity of the positive, amotivation, and expressive symptoms significantly differed between the three groups (see *Fig. 3*): individuals from clusters 1 and 2 differed regarding the severity of amotivation and expressive symptoms ($p < 0.001$) but not positive symptoms ($p = 0.176$). Individuals from cluster 3 differed from the other groups on all symptomatic dimensions (all $p < 0.001$). Clusters were labelled based on the patterns of positive and negative symptoms: low levels of symptoms (cluster 1); predominant negative symptoms (PNS) (cluster 2); high levels of symptoms (cluster 3). The clinical characteristics of participants in the three groups are provided in *Table 1*.

In accordance with our first hypothesis, a substantial group of participants was characterized by PNS. Comparing individuals included in cluster 2 (PNS) from individuals included in cluster 1 (low levels of symptoms) enables to examine the relationship between negative symptoms, cognitive functioning and functional outcome, by excluding the influence of positive symptoms. However and contrary to our hypothesis, no cluster brought together individuals with predominant positive symptoms (PPS). This prevented from examining the relationship between positive symptoms, cognitive functioning, and outcome, by excluding the influence of negative symptoms. Individuals included in cluster 3 (high levels of symptoms) were not compared with other participants' groups, as they displayed comorbid positive and negative symptoms.

CHARACTERIZATION OF INDIVIDUALS WITH PNS

COGNITIVE FUNCTIONING

One participant from cluster 2 was diagnosed with a psychotic disorder. All the analyses were performed with and without inclusion of this participant to examine his influence on the results.

Participants with low levels of symptoms and individuals with PNS did not significantly differ regarding age ($t = -1.308, p = 0.197$), gender distribution ($\chi^2 = 0.172, p = 0.678$), or full-scale IQ ($t = 0.643, p = 0.523$) (see *Table 2*).

We performed a multiple ANOVA with the six cognitive scores as independent variables (see *Table 2*). Participants with PNS had significantly lower scores than individuals with low levels of symptoms on the Face Memory Immediate subtest ($F(1,54) = 5.412, p = 0.024$). The group difference for the Processing Speed Index approached significance ($F(1,54) = 3.954, p =$

0.052). When the participant diagnosed with a psychotic disorder was excluded from the analyses, participants with PNS had significantly lower scores on the Face Memory Immediate subtest ($F(1,53) = 5.138, p = 0.028$) and the Processing Speed Index ($F(1,53) = 4.782, p = 0.033$).

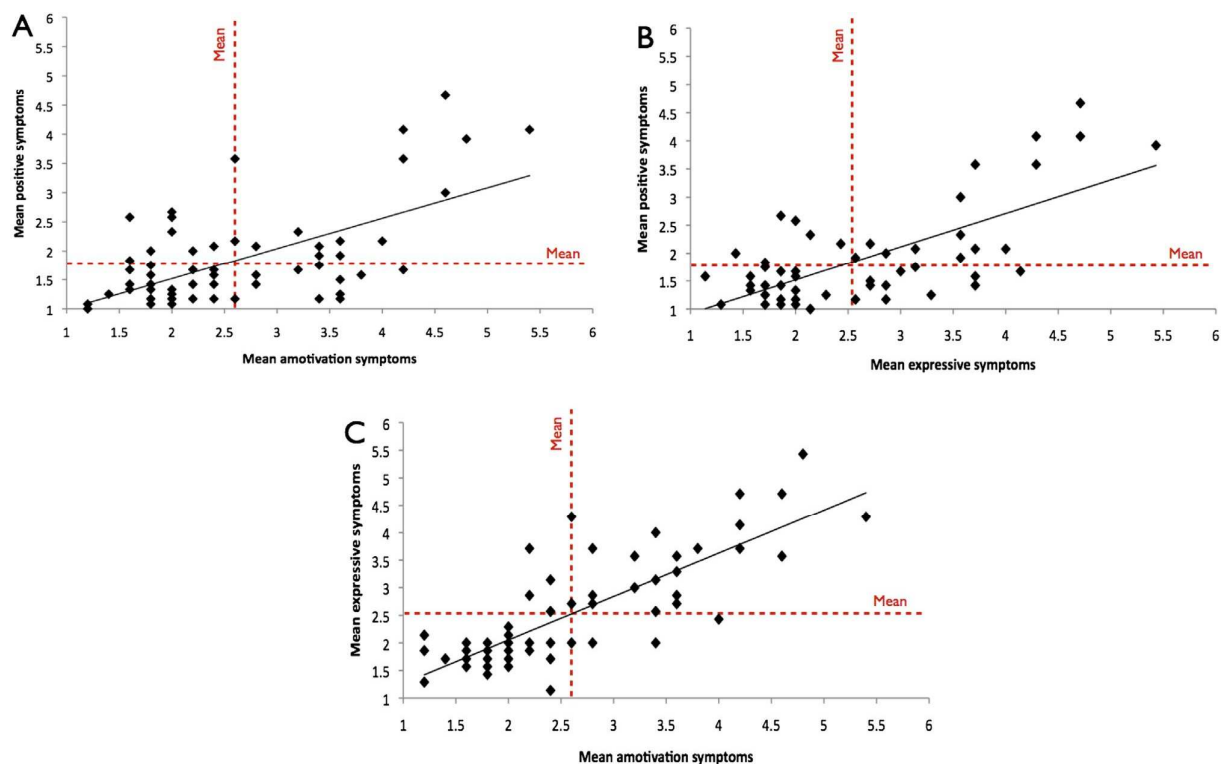


Fig. 1. Scatter plots representing the associations between positive, amotivation and expressive symptoms. For visualization's purpose, the mean of the dimensions is represented on the graphs. The positive correlations indicate that these symptoms tend to occur together. Nevertheless, some individuals display above average negative symptoms and below average positive symptoms (i.e. individuals located in the lower right quadrant of Fig. 1A and B). A minority of individuals also seems to display above average positive symptoms and below average negative symptoms (i.e. individuals located in the upper left quadrant of Fig. 1A and B). This suggests that different clusters of individuals can be identified.

In individuals with PNS, the Processing Speed Index was significantly correlated with the severity of expressive symptoms ($r = -0.496, p = 0.022$), but not amotivation symptoms ($r = -0.271, p = 0.235$). Correlations with individual SIPS or PANSS items revealed that the Processing Speed Index was significantly correlated with PANSS items N1 (blunted affect; $r = -0.464, p = 0.034$), N6 (lack of spontaneity; $r = -0.459, p = 0.036$), and N7 (stereotyped thinking; $r = -0.646, p = 0.002$). The Face Memory Immediate subtest was not significantly associated with the two dimensions of negative symptoms (both $p > 0.05$). Of note, full-scale IQ was not significantly associated with expressive or amotivation symptoms in individuals with PNS (both $p > 0.05$).

OUTCOME

There was a highly significant difference in the mean GAF score between the two groups ($t = 4.258, p < 0.001$), individuals with PNS having significantly lower GAF scores (see *Table 2*).

The participants' educational or professional outcome is displayed in *Table 3*. The comparison between the ordinary and the special needs categories revealed a significant difference between the two groups ($\chi^2 = 5.531, p = 0.019$). Specifically, a greater proportion of participants with PNS had special needs regarding education or employment compared to participants with low levels of symptoms.

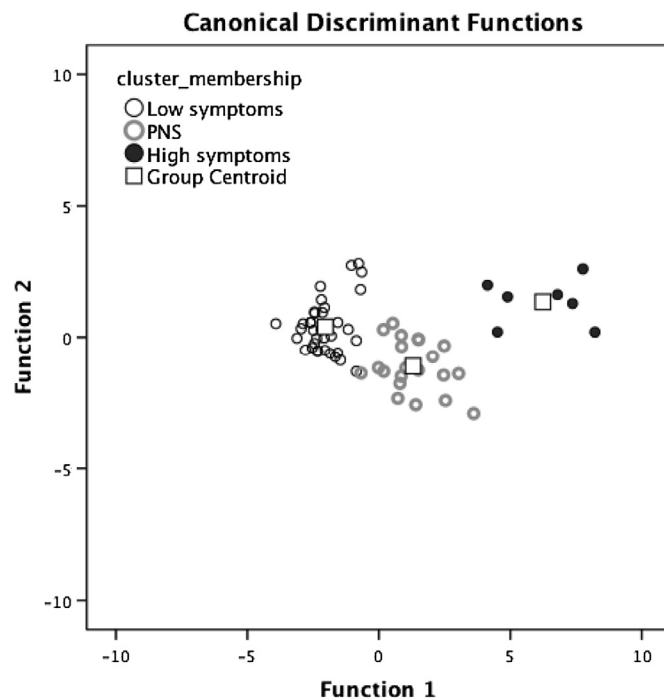


Fig. 2. Participants plotted in discriminant function space.

Finally, we compared the two groups regarding their level of adaptive functioning in various domains. VABS interviews were available for 30 individuals with low levels of symptoms (86%) and 16 individuals with PNS (76%). A multiple ANOVA revealed a significant group difference for the socialization domain ($F(1,44) = 5.112, p = 0.029$). The communication and daily-life functioning domains were not significantly different between the two groups (both $p > 0.05$).

The group comparisons remained unchanged when the participant diagnosed with a psychotic disorder was excluded from the analyses.

In individuals with PNS, the GAF score was significantly correlated with the severity of amotivation symptoms ($r = -0.562, p = 0.008$) but not expressive symptoms ($r = 0.296, p = 0.193$). Correlations with individual SIPS or PANSS items revealed that the GAF score was significantly correlated with SIPS item D4 (decreased personal hygiene; $r = -0.503, p = 0.020$), and PANSS item N7 (stereotyped thinking; $r = -0.487, p = 0.025$). The VABS domains were not significantly correlated with the severity of amotivation or expressive symptoms (all $p > 0.05$).

The results remained unchanged when the level of anxiety/depression (CBCL anxious-depressed t-score) was taken into account.

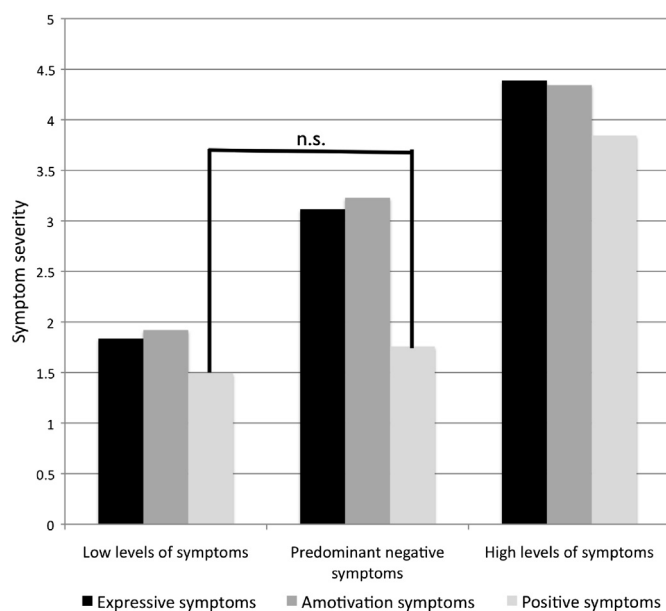


Fig. 3. Mean positive, amotivation and expressive scores in each cluster.

DISCUSSION

A large body of research has contributed to the understanding of attenuated psychotic symptoms in 22q11.2DS (e.g. Armando et al., 2012; Debbané et al., 2006; Gothelf et al., 2007). However, no study to date has investigated how attenuated positive and negative symptoms are distributed among adolescents and young adults with 22q11.2DS. The present study is a first attempt to identify homogeneous subgroups of patients based on their symptomatology. Contrary to our hypothesis, the cluster analysis established the presence of only three clusters: low levels of symptoms, high levels of symptoms, and predominant negative symptoms (PNS).

Cluster analyses in participants without 22q11.2DS usually delineate a fourth cluster, which includes individuals with predominant positive symptoms (Barrantes-Vidal et al., 2010). This difference suggests that the severity of negative symptoms represent the predominant clinical characteristic of psychotic expression in 22q11.2DS. Indeed, negative symptoms seem to be present in the majority of adolescents and young adults and to appear either alone or together with positive symptoms. Furthermore, our results indicate that PNS are frequent, as approximately one third of the participants were included in this subgroup. This is consistent with previous studies showing that negative symptoms are more frequent and severe than positive symptoms in this population (Schneider et al, 2012; Stoddard et al., 2010). Furthermore, Armando et al. (2012) observed that individuals at ultra-high risk for schizophrenia with and without 22q11.2DS differed regarding the severity of negative symptoms but not positive or disorganization symptoms

Table 1

Clinical characteristics of individuals in the three clusters.

	Cluster 1 Low levels of symptoms (N = 35)	Cluster 2 Predominant negative symptoms (N = 21)	Cluster 3 High levels of symptoms (N = 7)
Anxiety disorder ^a	12 (34%)	10 (48%)	3 (43%)
Mood disorder ^b	(17%)	2 (10%)	1 (14%)
Disruptive disorder ^c	11 (31%)	4 (19%)	1 (14%)
Psychotic disorder ^d	0 (0%)	1 (5%)	5 (71%)
Prodromal Syndrome (SIPS)	4 (11%)	5 (24%)	4 (57%)

^a Includes: simple phobia, social phobia, generalized anxiety disorder, separation anxiety disorder (only in adolescents < 18 years), obsessive-compulsive disorder, panic disorder (only in adults ≥ 18 years), and post-traumatic stress disorder.

^b Includes: major depressive disorder and dysthymia.

^c Includes: ADHD (only in adolescents < 18 years), oppositional defiant disorder, and conduct disorder.

^d Includes: schizophrenia, schizoaffective disorder, schizophreniform disorder, brief psychotic disorder, and psychotic disorder NOS.

The frequency of negative symptoms in 22q11.2DS raises the important issue of the differential diagnosis of negative symptoms in this population, and more broadly in individuals with developmental disabilities. First, differential diagnosis between negative symptoms and autistic traits should be considered, as both are characterized by marked impairments in the

social area. Nevertheless, the developmental trajectory of social impairments in the context of negative symptoms/increased risk for schizophrenia or autism spectrum disorder (ASD) is different: whereas individuals with ASD experience early impairments in the social area, those who develop schizophrenia typically experience a decrease in social competences and functioning from the beginning of adolescence (see Salokangas and McGlashan, 2008). To our knowledge, no study to date has investigated the developmental trajectory of social impairments from early childhood until adolescence in 22q11.2DS. This should be performed in future studies in order to better delineate the social phenotype in 22q11.2DS. Secondly, negative symptoms in 22q11.2DS are often viewed as a direct consequence of lower intellectual functioning and therefore as being unrelated to schizophrenia. However, we observed that individuals with PNS did not differ from individuals with low levels of symptoms regarding general intellectual functioning. This argues against the causal role of intellectual disability in the presence of negative symptoms. Finally, negative symptoms can appear as a side effect of psychotropic medication. Again, this doesn't seem to be the case in the present sample, as only 19% of individuals with PNS were receiving psychotropic medication at the time of testing. In comparison, this percentage was higher (37%) in the group of patients with low levels of symptoms.

Despite the clinical significance of negative symptoms in 22q11.2DS, very few studies have focused on these manifestations and no study to date explored the cognitive factors that may contribute to their emergence. The present study suggests that individuals with PNS have specific cognitive impairments compared to individuals with low levels of symptoms. Specifically, this subgroup of patients had a significant decrease in visual memory, whereas verbal memory was not impaired. An important difference between the tasks assessing visual and verbal memory is the use of social vs. non-social material. Visual memory was assessed using a face memory task, and verbal memory using a paired associates task. It may be the case that a deficit in memory of social information contributes to the presence of negative symptoms in 22q11.2DS. Indeed, it has been shown that abnormal visual exploration strategies contribute to face processing difficulties in 22q11.2DS (Campbell et al., 2010; Glaser et al., 2010). It is possible that abnormal visual exploration during social interactions contributes to memory deficits for social information and to disturbed relationships to the environment, which manifest themselves by an increase in negative symptoms. Further studies investigating several aspects of social cognition in 22q11.2DS are needed to confirm and extend this hypothesis. If future work supports the role of social cognitive deficits in the pathogenesis of negative symptoms, children and adolescents with 22q11.2DS should benefit from socio-cognitive remediation programs (see Glaser et al., 2012).

Table 2

Mean (sd) for the demographics, neurocognitive and social cognitive variables in participants with low levels of symptoms (cluster 1) and predominant negative symptoms (cluster 2).

	Cluster 1 Low levels of symptoms	Cluster 2 Predominant negative symptoms	P
Age	16.24 (4.26).	17.77 (4.20)	n.s.
Gender (Females/Males - %females)	18/17 (51.4%)	12/9 (57.1%)	n.s.
Full-scale IQ	71.77 (10.53)	69.90 (10.52)	n.s.
GAF	69.40 (8.51)	58.76 (9.90)	p < 0.001
VABS communication	72.23 (14.67)	67.81 (16.67)	n.s.
VABS daily-life functioning	73.70 (13.56)	70.06 (14.60)	n.s.
VABS socialization	79.37 (17.64)	68.31 (11.41)	p = 0.029
Processing Speed Index (z-score))	0.20 (0.99)	_-0.33 (0.95)	p = 0.052
Verbal Paired Associates Immediate SS (z-score)	_-0.11 (1.01)	0.19 (0.97)	n.s.
Face Memory Immediate SS (z-score)	0.23 (1.01)	_-0.39 (0.87)	p = 0.024
Digit Span Backward SS (z-score)	_-0.05 (0.99)	0.09 (1.04)	n.s.
CPT attentiveness (d') TS (z-score)	0.06 (1.12)	_-0.09 (0.77)	n.s.
Verbal Fluency total score (z-score)	0.16 (1.03)	_-0.26 (0.92)	n.s.

SS = *standard score*.

TS = *t-score*.

Processing speed was also decreased in participants with PNS and was mainly associated with the expressive dimension of negative symptoms. These results suggest that processing speed contributes to the clinical expression of negative symptoms and may act as a non-specific factor of resource limitation (see Rector, 2005). Indeed, decreased processing speed may alter the ability to process ongoing information (e.g. during social interactions), which leads to a sense of failure, decreases the motivation to initiate social contacts and contributes to the development of negative symptoms.

The second aim of this study was to investigate the impact of PNS on outcome. In accordance with a previous research by our group (Schneider et al., 2012), our results indicate that individuals with PNS have significantly decreased functional and occupational outcome compared to individuals with low levels of symptoms. Specifically, our data point towards particular impairments in the area of socialization, whereas other domains were unimpaired. The difference in occupational outcome was also striking between the two groups: whereas

special needs regarding education or work were required by approximately one third of participants with low particular, levels of symptoms, this percentage rose to almost 60% in individuals with PNS. One could argue that the observed associations between PNS and outcome were driven by other confounding factors, and especially by a difference in cognitive efficiency or internalizing symptoms (anxiety/depression) level between the two groups. However, they did not significantly differ in several potentially confounding factors such as age, gender, and full-scale IQ. Furthermore, when the analyses were controlled for the level of anxiety/depression, results remained identical. Therefore, we have good evidence to state that the presence of negative symptoms is a key contributor to this difference.

The relationship between negative symptoms and outcome stresses the importance of promoting intervention strategies in 22q11.2DS that target negative symptoms. This may improve outcome and reduce the direct and indirect costs generated by negative symptoms (e.g. loss of autonomy, employment). In particular, psychotherapeutic interventions should focus on amotivation symptoms, as they appeared to be the best predictor of outcome in the present study. There is some evidence suggesting that cognitive behavioural therapy focused on negative symptoms is effective in schizophrenic patients without 22q11.2DS (Klingberg et al., 2011; Perivoliotis and Cather, 2009). Interestingly, a recently published article showed that this type of intervention improved motivation in low-functioning patients with schizophrenia (Grant et al., 2012). This may indicate that similar strategies could be implemented in patients with 22q11.2DS to improve negative symptoms.

The results of this study should be interpreted in the light of the following limitations. First, the use of a cross-sectional design did not allow investigating the causal relationships between the studied variables. Specifically, it is still to be determined whether cognitive deficits play a causal role in the development of negative symptoms or if they appear as a consequence of them. We are currently performing longitudinal evaluations of this cohort in order to overcome this issue. In addition, longitudinal follow-up will help to understand the developmental trajectories of individuals with PNS. In particular, the risk for the development of full-blown psychosis in this subgroup of individuals is still unknown. Longitudinal research in high-risk samples without 22q11.2DS suggests that the severity of negative symptoms has a predictive value for the development of psychosis later in life (Demjaha et al., 2012; Johnstone et al., 2005; Velthorst et al., 2009). Therefore, it is important to identify if 22q11.2DS patients with PNS are at increased risk for schizophrenia spectrum disorders and warrant a heightened monitoring of their psychotic symptoms. Finally, a major limitation relates to the use of a cognitive battery performed in the context of a clinical evaluation. This may partly explain why several cognitive domains were not specifically altered in patients with PNS. Indeed, recent conceptualizations of specific negative symptoms have supported the role of precise cognitive mechanisms that were not assessed with the present evaluation battery. For example, research has highlighted

that deficits in situations involving multitasking is a key component of apathy and is strongly related to daily-life functioning (e.g. Esposito et al., 2010). The use of more theoretically oriented assessment tools should be implemented in future studies in order to better understand the role of specific cognitive deficits.

Table 3

Description of the educational or professional outcome in participants with low levels of symptoms (cluster 1) and participants with predominant negative symptoms (cluster 2).

	Ordinary school	Special school	Vocational training	Specialized vocational training	Gainful Employment	Sheltered employment	No activity	Other ^a	Ordinary ^b	Special needs ^c
Cluster 1: low levels of symptoms	23 (66%)	3 (9%)	2 (6%)	3 (9%)	1 (3%)	2 (6%)	1 (3%)	0 (0%)	26 (74%)	9 (26%)
Cluster 2: predominant negative symptoms	6 (29%)	5 (24%)	3 (14%)	2 (10%)	0 (0%)	3 (14%)	0 (0%)	2 (10%)	9 (43%)	12 (57%)

^aIncludes homeschooling ($n = 1$) and voluntary work within the family enterprise ($n = 1$).

^bSum of the following categories: ordinary school, vocational training, and gainful employment.

^cSum of the following categories: special school, specialized vocational training, sheltered employment, no activity, and other.

Despite these limitations, we believe that the present study contributes to the characterization of negative symptoms in 22q11.2DS, which are an important target in psychological interventions for this population. A better understanding of the cognitive difficulties contributing to their emergence will enable the development of specific neuropsychological rehabilitation strategies for 22q11.2DS patients with severe negative symptoms.

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Contributors

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Schneider, S. Menghetti, B. Glaser, M. Debbané and S. Eliez acquired the data; M. Schneider and M. Van der Linden analyzed the data and undertook the statistical analyses; M. Schneider wrote the first draft of the manuscript; all authors contributed to the interpretation of the results and the writing of the manuscript. All authors have approved the final manuscript.

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