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Shall we use non-verbal fluency in schizophrenia? – A pilot study

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ABSTRACT

Over the last few years, numerous studies have attempted to explain fluency impairments in people with schizophrenia, leading to heterogeneous results. This could notably be due to the fact that fluency is often used in its verbal form where semantic dimensions are implied. In order to gain an in-depth understanding of fluency deficits, a non-verbal fluency task – the Five-Point Test (5PT) – was proposed to 24 patients with schizophrenia and to 24 healthy subjects categorized in terms of age, gender and schooling. The 5PT involves producing as many abstract figures as possible within 1 min by connecting points with straight lines. All subjects also completed the Frontal Assessment Battery (FAB) while those with schizophrenia were further assessed using the Positive and Negative Syndrome Scale (PANSS). Results show that the 5PT evaluation differentiates patients from healthy subjects with regard to the number of figures produced. Patients' results also suggest that the number of figures produced is linked to the "overall executive functioning" and to some inhibition components. Although this study is a first step in the non-verbal efficiency research field, we believe that experimental psychopathology could benefit from the investigations on non-verbal fluency.

1. Introduction

In the field of neuropsychology, *fluency* generally refers to two distinct forms of verbal ability. The first concerns linguistic aptitude and implies speaking in a given rhythm while respecting coherence and conjunctions, and refers both to the content and to the form of speech. Good *fluency* skills thus ensure a fluent, fluid, meaningful and structured discourse (Rondal and Seron, 2003; De Perrot and Weyeneth, 2004). In schizophrenia, *fluency* problems mainly consist of the unusual usage of words, neologisms, stereotypes or perseverations, and could be due to both thought and cognitive disorders (Frith, 1992; Kuperberg and Caplan, 2003). The second form concerns *fluency* in terms of a neuropsychological task in which the experimenter focuses on how to mobilize both semantic and cognitive skills (Troyer et al., 1998, 2002; Sauzéon et al., 2004; Meulemans and Seron, 2004) by asking the subject to produce as many words as he can with regard to a certain semantic category, a letter (Cardebat et al., 1990; Pradat-Dhiel, 2006) or a word class such as verbs (Piatt et al., 1999; Woods et al., 2005). Many studies exploring verbal fluency tasks in schizophrenia have shown different, and sometimes inconsistent types of impairments (for a review, see Bokat and Goldberg, 2003; Van Beilen et al., 2004; Ojeda et al., 2010). Globally, these two meanings (linguistic ability or neuropsychological task) rely on the same concept of *efficiency* because they both imply that subjects use strategies to maximize their production while respecting a set of rules and environmental constraints.

In this paper, we will consider *efficiency* as the ability of a subject to integrate instructions and contextual/environmental constraints in order to accomplish a specific activity that results in something directly quantifiable where the higher the magnitude, the more efficient the subject's processing. This definition suggests that *efficiency* is a key concept to investigate in neuropsychological assessment not only because of its close links with daily life issues (Rempfer et al., 2003; Kurtz, 2011), but also because it could enable a more global view of executive functioning (and in particular, how executive functions are associated, enabling the subject to increase his performance).

However, considering what we have mentioned above with regard to verbal language impairments in schizophrenia, verbally evaluating a subject with schizophrenia can potentially lead to misinterpretations. This could be due to the fact that in the tasks specified, executive functions and semantic/linguistic abilities and their impairments are confounded. Non-verbal fluency makes it possible to override these issues because it does not refer to any semantic representations.

Indeed, we can still focus on efficiency in a non-verbal way without narrowing down to a simple motor task and propose a task that constantly involves high cognitive functioning. Non-verbal fluency has been mentioned in the literature since 1977 when Jones-Gotman and Milner focused on the impairments of brain-injured patients with fronto-central lesions during a task in which subjects had to create drawings on a sheet of paper. In this

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task, subjects had to draw something they had never seen before (even regular geometric forms were excluded). There were two conditions: one in which they could draw freely and another in which they had to draw using four lines; both conditions lasted 5 min and examples were given along with the instructions. The researchers also found that patients with left and right temporal lesions had more moderate impairments (Jones-Gotman and Milner, 1977). Today, there are two designed tasks that are mainly used as non-verbal fluency tests: the Ruff Figural Fluency Test (RFFT) and the Five-Point Test (5PT), the RFFT being primarily a modified version of the 5PT (Regard et al., 1982). These two tests involve creating as many *abstract figures* as possible within one minute by connecting points in different patterns using straight lines. The RFFT (see Fig. 1) consists of five parts; each part is composed of a specific point arrangement and lasts one minute. Scores are computed from the number of figures produced and the perseverations, but other scores such as the number of rotations and enumerations can also be computed and used qualitatively. This task was recently tested in a cohort of 1651 adults aged between 35 and 82 years old and the results indicated a correlation between RFFT, age and the education level (Ruff et al., 1987; Izaks et al., 2011). The 5PT (see Fig. 2) is also a structured figural fluency test that involves drawing different figures but only in one given configuration of symmetrically and identically arranged dots (identical to the arrangement on a dice). Several studies have collected normative data for this test using different size samples (Goebel et al., 2009; Cattelani et al.,2011; Khalil, 2010; Tucha et al., 2012). They have demonstrated the test's construct validity, as well as good correlations with verbal fluency, processing speed and mental flexibility (Tucha et al., 2012); its sensitivity to large and significant differences between the performance of healthy subjects and patients with Parkinson's disease (Goebel et al., 2012; Tucha et al., 2012) and its inter-rater (Tucha et al., 2012) and test–retest reliability (Fernandez et al., 2009; Goebel et al., 2009; Tucha et al., 2012).

To a larger extent, non-verbal fluency impairments, as tested with the RFFT, have been found in populations with several neurological or psychiatric conditions including people with borderline personality disorders (Beblo et al., 2006), obsessive-compulsive disorders (Fenger et al., 2005), major depression (Mondal et al., 2007) or head injuries (Ruff et al., 1987) and those with right anterior lesions in particular (Ruff et al., 1994). Deficits have also been found in adolescents with generalized epilepsy (Gelziniene et al., 2011) and in patients with ADHD (Tucha et al., 2005). Moreover, it is worth mentioning that, in some cases, non-verbal fluency can be impaired despite preserved performances with regard to other executive measures (Hanks et al., 1996), and, in particular, verbal fluency (Fenger et al., 2005).

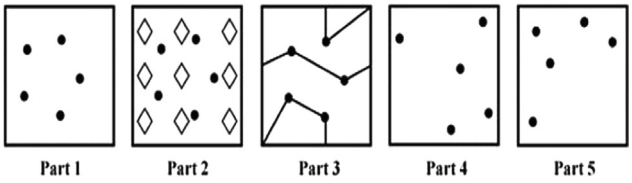

Fig. 1. Five dots patterns of the RFFT (Izaks et al., 2011).

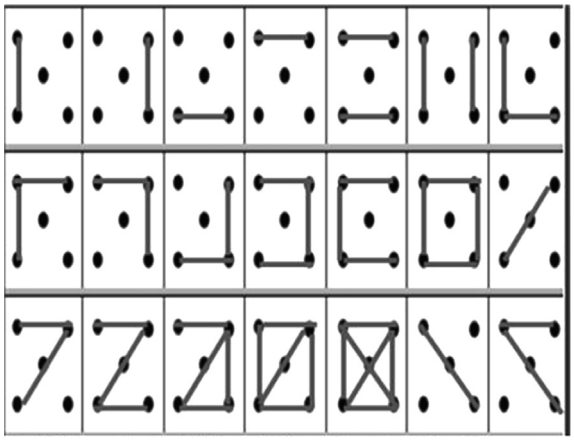

Fig. 2. Example of a 5PT resolution. The original grid is composed of five lines of seven boxes.

Impairments in non-verbal fluency tasks have therefore been found in several psychopathological populations using the RFFT. Nevertheless, this has not led to a more systematic use of the tool, neither in experimental psychopathology nor in the clinical neuropsychology field. To date, we have found only one study using the RFFT in schizophrenia, and only as a secondary measure (Brown et al., 2009).

The aim of this study is therefore to assess how the 5PT differentiates healthy subjects from patients with schizophrenia, and to analyze its potential links with the overall executive functioning and specific components of schizophrenia as symptoms and groups of symptoms. We assume that, as an *efficiency* measure, non-verbal fluency can be linked to the general executive functioning and that symptomatology can specifically influence the results with lesser unique designs in patients with a negative syndrome and more perseverations in patients with a positive or disorganization syndrome. Indeed, whereas negative symptoms might more significantly influence the skills related to *efficiency*, and especially expression and initiation (Frith, 1992; Torres et al., 2004; Langdon et al., 2007), positive and disorganization symptoms could possibly be linked to errors (Woodward et al., 2003).

2. Methods

2.1. Participants

We recruited 24 inpatients from three public mental health institutions from Belgium hosting closed hospitalization services for psychosis. All the individuals met the DSM-IV-TR (American Psychiatric Association, 2004) criteria for schizophrenia, which was determined through consensus between their psychiatrist and a psychiatrist with specific expertise in neuropsychiatric research. Subjects were aged between 20 and 62 years, and included 16 men and eight women. Diagnosed comorbidity with other mental disorders and neurological or vascular past histories were excluded. The age limit was fixed at 65 to avoid an aging effect or any pre-demential/demential state and none of the subjects had mental retardation (IQ < 85, IQ was established from prior evaluation). The socio-cultural level was estimated based on the number of school years accomplished since the first grade. This ranged from 6 to 17 years (see the demographic descriptive data in Table 1). The patients could be described as "stable" (in terms of medication and behavior within an assessment context). Twenty-four control subjects were compared to each experimental subject based on age, sex and schooling (number of school years and type of schooling). Control subjects were recruited on the basis of free participation and were selected depending on their potential similarity to one or several patients. None of them had a psychological, psychopathological, neurological or vascular history, nor were they substance abusers nor on medication.

The study was approved by the ethics committee of each institution, and all participants gave their informed written consent once procedures had been fully explained.

2.2. Procedure

Subjects first completed the Positive and Negative Syndrome Scale (PANSS) (Kay et al., 1987) (see table 2) and the Frontal Assessment Battery (FAB) (Dubois et al., 2000) in order to control the influence of symptomatology and global executive functioning. The PANSS was filled using the subjects' responses to a semi-structured interview (SCI-PANSS) (Lepine and Perreti, 2008) and further information was obtained from the caregivers when necessary. We computed three scale scores (positive, negative and general psychopathology scales), three factor scores (positive, negative and disorganization factors) (Bell et al., 1994; Clark et al., 2010) and two negative subfactor scores (*core negative symptoms* and *social amotivation* symptoms). The two negative subfactors were used to reinforce the potential symptomatology analysis implications of the negative symptoms by differentiating

Table 1
Demographic data.

	Patients ($n=24$)	Controls ($n=24$)
Age	38.95 ± 11.87	38.79 ± 11.54
Schooling	11.37 ± 2.12	11.25 ± 1.98

	Patients ($n=24$)		Controls ($n=24$)	
	n		*n*	
	Male	Female	Male	Female
Sex	16	8	16	8
Elementary school (accomplished)	1		1	
General middle school (accomplished)	4		4	
General high school (unaccomplished)	2		2	
General high school (accomplished)	6		6	
Technical high school (accomplished)	9		9	
College (bachelor) (accomplished)	1		1	
College (master) (accomplished)	1		1	

The table shows the characteristics of participants in terms of age, gender and schooling.

Table 2
Descriptive statistics for the PANSS in the experimental group.

	N	Mean
General psychopathology	24	50.25 ± 10.92
Duration of illness	24	11.25 ± 9.89
Positive scale	24	26.58 ± 6.86
Negative scale	24	24.83 ± 5.58
Positive factor	24	24.04 ± 6.51
Negative factor	24	26.00 ± 7.56
Disorganization factor	24	24.08 ± 6.56
Core negative symptoms	24	19.33 ± 5.24
Social amotivation	24	10.83 ± 3.67

The table shows the parameters of PANSS scores in the patients group.

expressive symptoms that are the core of negative psychopathology (computed by summing the items: *avolition, mannerisms and posturing, motor retardation, flat affect, poor rapport* and *lack of spontaneity*), from those related to community issues (computed by summing the items: *passive withdrawal, emotional withdrawal* and *active social avoidance*) (Liemburg et al., 2013).

The FAB is a neuropsychological test used to assess frontal and executive functioning in healthy and pathological populations. It is composed of six subtests that briefly evaluate six executive components (namely *inhibition, mental flexibility, environmental autonomy/ prehension behavior, interference management, motor programming* and *reasoning*). This test enables a rapid screening of the executive functioning, is significantly correlated with classical neuropsychological tests (such as Winsconsin Card Sorting Test, Stroop test or Mattis Scale) (Spyridi et al., 2007; Cunha et al., 2010) and is likely to differentiate clinical populations including subjects with schizophrenia (Nimatoudis et al., 2007). Its rapid execution makes it possible for the experimenter to avoid changes in performance which could be associated with fluctuating motivation or mental and mood fluctuations in patients.

Subjects were then asked to complete the 5PT. A short trial (five squares) was presented before completing the form. The numbers of Unique Designs (UD) and perseverations were computed.

2.3. Statistical analysis

All statistical analyses were performed using the software SPSS 17 for Windows with a statistical threshold fixed at $p<0.05$. Normal distribution of data was verified using the Kolmogorov–Smirnov test for one sample. In order to identify significant differences between groups, we used a *t*-test for independent samples. Group differences on non-normally distributed data were analyzed using the non-parametric Mann–Whitney *U* test. Intergroup differences were analyzed with Bonferroni correction ($p<0.005$). Effect sizes were calculated with Cohen's *d* parameter and correlations were tested using the *r* of Bravais–Pearson.

3. Results

3.1. Intergroup differences

With regard to the FAB, patients performed significantly lower for all subtests but, as shown in Table 3, one of the subtests reached a ceiling effect in controls (*environmental autonomy*) and therefore needs to be carefully analyzed.

Concerning non-verbal fluency, patients made significantly less UDs ($t=-6{,}789$, $p<0.001$, $d=-1.96$) but not more perseverations than healthy subjects ($z=-2.833$, $p=0.045$; $d=-0.891$) (see Table 4).

Both the FAB and the Five Point Test are thus likely to differentiate patients from controls.

3.2. Correlation analyses

In the patient group, correlations showed no significant relationship between age and UDs ($r=-0.073$, $p=0.733$), age and perseverations ($r=-0.274$, $p=0.195$), schooling and UDs ($r=0.056$, $p=0.794$) or schooling and perseverations ($r=0.105$, $p=0.626$). Consequently, the 5PT could represent an age- or schooling-dependent tool in people with schizophrenia. As controls had a mean of perseverations close to zero, no correlation was computed. However, scores in the control group did not show a relationship between UDs and age ($r=0.012$, $p=0.956$), nor between UDs and schooling ($r=-0.350$, $p=0.093$). Nevertheless, it is worth noting that this last correlation, although not significant, is greater among healthy subjects than among patients.

Among patients, the total FAB (global executive functioning) was significantly correlated with UDs ($r=0.539$, $p=0.007$) but not with perseverations ($r=0.216$, $p=0.310$) (see Fig. 2) and the numbers of UDs and perseverations were also significantly correlated ($r=0.418$, $p=0.042$). Indeed, the 5PT could enable a good approximation of the overall executive functioning. Nevertheless, an analysis of the subtests reveals that two subtests of the FAB mainly correlated with the number of UDs, which are the inhibition subtest ($r=0.576$, $p=0.003$) and the interference subtest ($r=0.504$, $p=0.012$); this refers to an inhibition component.

None of the psychopathological scores were significantly correlated with the number of UDs and the item *psychomotor slowing* of the PANSS (used here as a control measure for the motor component) is negatively but not significantly correlated with UDs ($r=-0.085$, $p=0.692$). Only one significant correlation was found between the 5PT and the symptomatology scores, namely, a positive correlation between perseverations and the negative factor ($r=0.421$, $p=0.040$). These results invalidate our hypothesis on the relationship between the number of perseverations and the positive or disorganization syndrome.

Finally, concerning the relationship between FAB scores and PANSS dimensions, results show significant correlations between *mental flexibility* and the positive factor score ($r=-0.427$, $p=0.037$); *motor programming* and the negative scale ($r=-0.413$, $p=0.045$) and negative factor score ($r=-0.422$, $p=0.040$); *environmental autonomy* and general psychopathology ($r=$-0.444, $p=0.030$), positive scale ($r=-0.447$, $p=0.028$), positive factor ($r=-0.522$, $p=0.009$) and disorganization factor score ($r=-0.517$, $p=0.010$).

4. Discussion

Our study seeks to question the relevance of a shortened version of the RFFT – the Five Point Test (5PT) – in the cognitive and neuropsychological assessment of people with schizophrenia. Results show that the 5PT can highlight neuropsychological differences between patients with schizophrenia and healthy

Table 3
Descriptive statistics and intergroup differences for the FAB.

	Patients ($n=24$) Mean	*Controls* ($n=24$) Mean	t/z	sig	Cohen's d
Total FAB	11.96 ± 2.73	17.62 ± 0.57	-9.963^{**}	0.001	−2.876
Reasoning*	1.92 ± 1.02	3.00 ± 0.00	-4.976^{**}	0.001	−1.497
Mental flexibility	1.46 ± 0.88	2.71 ± 0.46	-6.135^{**}	0.001	−1.771
Motor programming (*)	2.08 ± 0.65	3.00 ± 0.00	-5.210^{**}	0.001	−2.001
Inhibition	1.58 ± 1.10	2.87 ± 0.34	-5.499^{**}	0.001	−1.587
Environmental autonomy (*)	2.96 ± 0.20	3.00 ± 0.00	-1.000^{**}	0.001	0.289
Interference (*)	2.12 ± 1.03	0.00 ± 0.00	-3.912^{**}	0.001	−1.208

The table shows parameters in patients and controls, intergroup comparisons value (t or z score) and effect sizes for the Frontal Assessment Battery. The asterisk (*) refers to non-normal distribution and the use of a Mann–Whitney U test.
$^{**}p < 0.005$.

Table 4
Descriptive statistics and intergroup differences for non-verbal fluency.

	Patients ($n=24$) Mean	Controls ($n=24$) Mean	t/z	sig	Cohen's d
Unique designs	11.00 ± 5.83	22.17 ± 5.56	-6.789^{**}	0.001	−1.960
Perseverations (*)	0.29 ± 0.46	0.00 ± 0.00	−0.2883	0.045	−0.891

The table shows parameters in patients and controls, intergroup comparisons value (t or z score) and effect sizes for the Five Point Task. The asterisk (*) refers to non-normal distribution and the use of a Mann–Whitney U test.
$^{**}p < 0.005$.

subjects, regardless of their age, schooling level and symptoms, and this could represent an advantage of the 5PT compared to the RFFT. The lack of influence of age and schooling on the 5PT healthy subjects' performances remains a point of debate in studies proposing standards; whereas some find correlations with age (Goebel et al., 2009; Cattelani et al., 2011; Tucha et al., 2012), others do not (Khalil, 2010). However, we can assume that these influences or lack thereof are related to the specific nature of the population assessed. We must also keep in mind that in our study, the level of education is simply an IQ equivalent and the lack of correlation must therefore be interpreted with caution.

Considering the exploratory nature of this study, our hypotheses on the relationships between the 5PT and PANSS dimensions were based in particular on what we know about verbal fluency in schizophrenia, that is, that positive symptoms are related to idiosyncratic responses (Rossell et al., 1999) and switching impairments (Woodward et al., 2003) that could correspond to perseverations in the 5PT, whereas negative symptoms are related to less produced words (Robert et al., 1996; Faerden et al., 2009) and greater latencies (Docherty et al., 2011) that may correspond to less unique designs in the 5PT. Results show that only one correlation was found, against all odds, between the negative factor and the number of perseverations. One possible interpretation is that in the 5PT, perseverations may not potentially reflect an inhibition deficit as is commonly considered, but may be related to a more global difficulty relative to updating. However, in a study carried out in 2005, Brazo and colleagues found some differences between primary and secondary negative symptoms with regard to cognitive tasks. While subjects with primary symptoms showed greater impairments with the Modified Card Sorting Test and Verbal Fluency, no differences were found between subjects with primary or secondary symptoms with the TMT and Stroop tests (Brazo et al., 2005). Moreover, as we found a significant correlation between FAB subtests and PANSS dimensions, the limited nature of the sample cannot fully account for the lack of correlations between the 5PT and the symptoms.

Considering the cognitive nature of the 5PT, our results suggest that in patients, the number of unique designs is related to the "overall executive functioning" (FAB total score) and inhibition components (*inhibition* and *interference* subtests scores). The number of perseverations does not provide additional information. This is consistent with analyses that highlight the relationship between the 5PT and other cognitive measures in healthy subjects (Stroop Color and Word Test, Verbal Fluency, Trail Making Test A and B and Visual Memory Span Task) (Tucha et al., 2012). Nevertheless, compared to the study carried out by Tucha et al. (2012) where the indices that were the most highly correlated with the number of UDs were processing speed (reading of color words and TMT-A) and mental flexibility, our results suggest that in patients with schizophrenia, *efficiency* can be related in particular to inhibition components. However, these results must be interpreted with caution as several scores are global and thus reveal trends rather than static knowledge concerning the interrelations between abilities. The FAB is therefore useful in recording a synthetic and global view of executive efficiency and is clearly a new field of analysis, but it does not enable more nuanced analyses. Its limited variation on control subjects may also be problematic for a more in-depth interpretation. In addition to a clinical/behavioral study (*psychomotor poverty* item of the PANSS), this study could also benefit from a neuropsychological measure of psychomotor slowing (e.g. TMT-A), especially as results on the influence of motor components remain heterogeneous. A study comprising healthy subjects has found non-visual motor programming to be part of the predictor of RFFT performance (Kraybill and Suchy, 2008) while motor components have been found to be unrelated to non-verbal fluency performances in subjects with Parkinson's disease (Goebel et al., 2009). Finally, in our study, none of the "motor components" (PANSS psychomotor poverty and *motor programming* subtest) were significantly correlated with the number of produced figures.

We can conclude that generally speaking, the 5PT is a short, well-structured and powerful test with regard to its robust psychometric properties (Fernandez et al., 2009; Goebel et al., 2009, 2012; Tucha et al., 2012), the clarity of its instruction and the ease with which its correction systems enable good standardization. Besides, as we have already mentioned, with the exception of fluency tasks, very few neuropsychological tasks evaluate *efficiency* because most of them do not enable the subject to find his own strategies in order to maximize his performance. This is one of the reasons why non-verbal fluency is sometimes considered as divergent thinking or a creativity test (Hart and Wade, 2006).

More importantly, in the field of schizophrenia, assessing efficiency/fluency in a non-verbal way is crucial as experimenters can then avert most of the difficulties of interpretation that are associated with verbal fluency in people with schizophrenia. Indeed, many variables could interfere with the assessment of efficiency in relation

to verbal fluency tasks such as the quality and organization of lexical information, the ability to retrieve semantic representation, etc. Moreover, many questions on the potential causes of verbal fluency disorders in schizophrenia remain unresolved. While some authors identify qualitative and quantitative deficits of the semantic store (Rossell et al., 1999; Chen et al., 2000; Bokat and Goldberg, 2003), others defend a global intellectual or cognitive deficit (O'Leary et al., 2000; Ojeda et al., 2008) linked with retrieval impairments. Non-verbal fluency makes it possible to override these issues because it does not refer to any semantic representations. If our results were to be replicated, it would mean that within a relatively short period, an experimenter could identify some form of meta-executive ability that we have called *efficiency* as we are currently unable to determine its exact nature.

Despite the moderate to large effect sizes' values we found with a small sample, we think that further studies would need to replicate these results with larger samples, especially in order to focus on the specific abilities involved in non-verbal fluency tasks. In particular, as this study has highlighted the potential relationships between the 5PT and the inhibition component, experimenters should concentrate on these components, but also integrate updating and mental flexibility evaluation (Miyake et al., 2000). Future investigations could also compare the relative costs and benefits of the 5PT to the RFFT and should control specific variables such as visuomotor skills and IQ. Finally, it could be interesting to look for additional indices such as strategies (e.g. rotations operated by the subject to improve performance) and latencies (e.g. time before the first design, breaks between designs, etc.) to better understand the subject's functioning on a given task.

Although this study represents a first step in the non-verbal efficiency research field in schizophrenia, we strongly believe that experimental psychopathology could benefit from investigations on non-verbal fluency.

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