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Research Paper

The Category Fluency Test components and their association with cognition and symptoms in adolescents with schizophrenia

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ABSTRACT

Background: The category Fluency Test (CFT) is included in the MATRICS consensus cognitive battery for schizophrenia (MCCB). This test has several components that allow the exploration of other cognitive functions and could be related to different symptom profiles.
Methods: a sample of 98 Mexican adolescents was evaluated with the CFT and the following components were analyzed: total words, errors, clusters, switching, related words, and categories. Demographic and clinical differences among them and correlations with other MCCB tests and with Positive and Negative Syndrome Scale (PANSS) factors were explored.
Results: The CFT components showed significant correlations with each other and with other MCCB tests, particularly with those related to verbal learning, working memory, and speed of processing. In addition, they showed moderate correlations with the total PANSS score and with the negative, positive, and cognitive PANSS factors.
Conclusions: The analysis of CFT components allows clinicians and investigators to obtain information regarding other cognitive functions and symptom profiles in adolescents with schizophrenia.

1. Introduction

The Category Fluency Test (CFT) was created to assess semantic fluency. It consists of asking the individual to name as many animals as possible in 60 s. Performance on CFT can be evaluated through several components, such as the number of correct words, clusters, switching, related words, and intrusion and perseveration errors (Robert et al., 1998; Troyer et al., 1997).

Studies in English-speaking subjects described various cognitive functions involved in the execution of the task. For example, perseveration errors could be associated with deficits in semantic search and response monitoring (Giovannetti et al., 2003); and increased switching could be associated with poor working memory (Hills et al., 2013; Unsworth et al., 2011).

The studies aimed to obtain normative data of fluency tests in languages such as Chinese, Hebrew, and Dutch in children, adolescents, and adults (Chan and Poon, 1999; Kavé et al., 2008; Lee et al., 2002; Van der Elst et al., 2011) reported a significant correlation between age and outcome measures. In addition, education (Lee et al., 2002) and parents' education (Van der Elst et al., 2011) showed an effect on the test scores.

Regarding the Spanish language, a recent study examined normative data, reliability, and validity of the test in a sample of Colombian children and adolescents obtained intraclass correlation coefficients $\geq$0.90, and showed that clustering and switching predicted the number of total words in a multiple regression analysis (Álvarez et al., 2023). Such correlation with switching was also found in an adult sample (Velázquez et al., 2014). In addition, the number of total words was found to be similar between adolescents and adults (Olabarrieta-Landa et al., 2017).

The Measurement and Treatment Research to Improve Cognition in Schizophrenia group decided to include the CFT in the Matrics, Consensus Cognitive Battery (MCCB), based on properties such as test-retest reliability, relationship to functional status, potential changeability in response to pharmacological agents, and tolerability for patients (Nuechterlein et al., 2008). In addition, its brevity and associations with other cognitive domains make it particularly useful. Previous studies on CFT in patients with schizophrenia showed

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important differences when compared with healthy subjects: Portuguese-speaking adolescents and adults with schizophrenia showed lower scores in the number of correct words, and cluster-related words (Berberian et al., 2016); English-speaking adults with schizophrenia showed a lower number of clusters (Giovannetti et al., 2003), another study in English-speaking adolescents and adults with schizophrenia showed that they had a higher number of perseveration errors (Phillips et al., 2004) than controls.

Studies in adult patients in Greece (Bozikas et al., 2005) and Norway (Egeland et al., 2018) showed that the performance of CFT varies according to the severity of some symptoms such as disorganization.

However, the studies examining CFT in adolescents with schizophrenia have not examined Spanish-speaking samples, included small samples, and did not evaluate the correlation with other cognitive tests or the symptoms. So, the present work aimed to explore some aspects of the validity of CFT in adolescents with schizophrenia and to determine if CFT components are correlated with other cognitive processes and with the severity of symptoms.

2. Method

The study was approved by the Institutional Ethics Committee and followed the guidelines of the Declaration of Helsinki, patients gave informed consent, and their anonymity was preserved. A total of 98 participants were recruited at the inpatient and outpatient services of the Child Psychiatric Hospital in Mexico City. Inclusion criteria were male and female adolescents between 12 and 17 years, diagnosed with schizophrenia or schizophreniform disorder according to the Diagnostic and Statistical Manual of Mental Disorders, fifth edition (DSM-5) (American Psychiatric Association, 2013), and had not received drug treatment in the previous four weeks. Their demographic and clinical characteristics are depicted in Table 1.

2.1. Instruments

The Mini-International Neuropsychiatric Interview: Child and Adolescent Version (MINI KID) (Sheehan et al., 1998) was used to confirm the patient's diagnosis.

The MATRICS Consensus Cognitive Battery (MCCB) was used to assess the cognitive functioning domains as follows: Speed of processing by the Trail Making Test A (TMT-A), Symbol Coding (BACS SC), and CFT; attention/vigilance by Continuous Performance Test-Identical Pairs (CPT-IP); working memory by Spatial Span (WMS-III SS) and Letter-Number Span (LNS); verbal learning by Hopkins Verbal Learning Test-Revised (HVLT-R); visual learning by Brief Visuospatial Memory Test-Revised (BVMT-R), and reasoning and problem-solving by Mazes test (NAB) (Nuechterlein et al., 2008).

The Positive and Negative Syndrome Scale (PANSS) (Kay et al., 1987) was used to evaluate the severity of symptoms. The scores were analyzed following the five-factor structure obtained by Fresán et al. (2005) in a sample of Mexican adult patients: positive, negative, cognitive, depression/anxiety, and aggression.

The MINI and the PANSS were completed during an interview by trained psychiatrists or child psychiatrists; the MCCB was administered by trained clinical psychologists during a 60 to 90-minute session.

Table 1
Demographic and clinical characteristics of the sample.

Mean age (SD)	14.94 (1.57) y.o.
Males	70.7 %
Attending school	41.5 %
Mean years of school (SD)	8.16 (1.57)
Diagnoses	Schizophrenia 56.1 %
	Schizophreniform disorder 43.9 %
Mean age of onset (SD)	13.92 (1.86) y.o.
Total PANSS	98.92 (23.15)

2.2. Statistical analysis

The evaluation of CFT included:

a) Number of correct words: Number of animals emitted per minute, The participant received one point either for animals from main (e.g. dog) or secondary categories (e.g. cocker, labrador,) as well as for extinct animals (e.g. dinosaurs, mammoth). Imaginary animals were not rated (Nuechterlein et al., 2008).

b) Errors: Included intrusion errors (words that do not belong to the semantic field), and perseveration errors (repeated words) (Landrø and Ueland, 2008).

c) Clusters: Number of groups of at least 2 successively generated words belonging to the same semantic subcategory (e.g. gorilla-hippopotamus-leopard, in the African subcategory) (Troyer et al., 1997).

d) Related words: number of cluster-related words (Berberian et al., 2016).

e) Switching: Calculated according to the formula: Word Production - Related Words + Number of clusters (Robert et al., 1998).

f) Categories: Number of subcategories mentioned according to Troyer et al. (1997).

g) The Impulsivity Control Index (ICI) was included as a measure of sustained attention and obtained by the formula: Total words - Errors / Total words (Crespo-Eguílaz et al., 2006).

The analysis included descriptive statistics for demographic, clinical variables, and the CFT components. Reliability was explored by calculating Cronbach's alpha.

The Spearman test was used to evaluate the correlations among the CFT components, PANSS scores, and MCCB scores, which included a composite score minus category fluency calculated using the mean of the eight non-demographically corrected t-scores following Burton's method (Burton et al., 2013). Statistical analyses were performed using IBM SPSS Statistics (version 21) software.

3. Results

3.1. Performance on the CFT

Table 2 shows the sample's performance on the test. The CFT components showed significant correlations with each other, total words correlated with almost all components, while the ICI was only negatively correlated with the number of errors. The reliability analysis of the CFT showed a Cronbach's alpha of 0.81.

3.2. CFT correlations with cognition and symptoms

Total words, related words, and categories showed significant, although modest, correlations with MCCB tests; the ICI showed correlations with tasks related to working memory and attention. Regarding the correlations with the symptoms, the components of CFT showed negative correlations with total PANSS and with the negative, positive, and cognitive factors (Table 3).

4. Discussion

The present work aimed to explore some aspects of the validity of the Category Fluency Test in adolescents with a diagnosis of schizophrenia and to determine their relationship with other cognitive tests included in the MCCB and with the severity of symptoms. The CFT showed internal consistency, and its components showed significant correlations with those MCCB tests related to speed of processing and the cognitive PANSS factor, which accounts for its validity.

The mean scores of total words, clusters, related words, and errors were similar to those reported in previous studies with adolescents (Juuhl-Langseth et al., 2014; Landrø and Ueland, 2008; Phillips et al., 2004) or adults (Berberian et al., 2016). The mean ICI was close to 1, meaning few errors. This index has been used in studies evaluating

Table 2
Description of the CFT in a sample of adolescents with schizophrenia.

Variable	Mean
Total words	16.85 ± 6.30
Errors	0.82 ± 1.01
Clusters	2.98 ± 1.78
Switching	11.69 ± 3.88
Related words	8.13 ± 5.24
Categories	8.27 ± 2.26
ICI	0.90 ± 0.12

Subcategory	Frequency	Most frequently mentioned animal
Africa	90 (91.8 %)	Tiger
Canine	83 (84.7 %)	Dog
Farm	76 (77.6 %)	Cow
Pet	74 (75.5 %)	Cat
Reptile/ Amphibian	72 (73.5 %)	Snake
Water	70 (71.4 %)	Fish
Birds	61 (62.2 %)	Bird
Carrying load animals	59 (60.2 %)	Horse
Insects	53 (54.1 %)	Butterfly

attention and deficits in inhibitory control (Apiquian et al., 2020; Crespo-Eguílaz et al., 2006). By combining total words and errors, the ICI would give more information on the cognitive process of the patient when solving the CFT.

The most commonly mentioned subcategories (Africa and canine) differed from those reported by a Norwegian sample of adults (fish and birds) (Egeland et al., 2018), which could reflect language or cultural differences.

4.1. Correlation with MCCB

All the CFT components showed significant correlations with MCCB tests. Total words showed correlations with TMT-A and BACS, the latter showed correlations with all the CFT components, supporting the inclusion in the speed of processing domain (Fong et al., 2020; Nuechterlein et al., 2008), which has been proposed to mediate the relationship between verbal fluency and functional impairment in adults with schizophrenia (Ojeda et al., 2008). In addition, total words, clusters, related words, and categories showed correlations with HVLT-R. This test evaluates learning and verbal memory (Brandt, 1991), which are important to keep in mind the semantic fields to which the words belong to achieve a good performance.

Although all the CFT components showed significant correlations with the MCCB tests, switching deserves special attention. This score provides information about the ability of the patients to alternate between categories, allowing them to continue retrieving information in an organized and efficient way (Hurks, 2012; Robert et al., 1998). Frequent switching could be the result of a deficit in the organization and evocation, as the negative correlation with the PANSS cognitive factor suggests. So, the inclusion of switching in the MCCB scoring of the CFT could give additional information on the patient's cognitive flexibility.

4.2. Correlation with symptoms

As previously reported, poor performance in the CFT was associated with positive, negative, and cognitive symptoms. In contrast with a study performed on adults with chronic schizophrenia (Galaverna et al., 2014), the present study did not show correlations between errors and the PANSS scores.

The correlation between CFT and positive symptoms was previously described (De Freitas et al., 2009), in particular, speech hallucinations have been related to alterations in the cortical regions responsible for speech processing (Hoffman et al., 1999). More recently, the role of set-shifting as a moderator for the performance in fluency tests in patients

Table 3
Significant correlations between CFT with the MCCB tests and the PANSS factors.

		CFT Components						
		Total words	Errors	Clusters	Switching	Related words	Categories	ICI
MCCB	TMT-A	r = −0.475	r = 0.142	r = −0.336	r = −0.381	r = −0.394	r = −0.347	r = −0.191
		p = 0.000	p = 0.163	p = 0.001	p = 0.000	p = 0.000	p = 0.000	p = 0.059
	BACS SC	r = 0.493	r = −0.217	r = 0.298	r = 0.425	r = 0.358	r = 0.374	r = 0.284
		p = 0.000	p = 0.032	p = 0.003	p = 0.000	p = 0.000	p = 0.000	p = 0.005
	HVLT-R	r = 0.625	r = −0.045	r = 0.428	r = 0.580	r = 0.443	r = 0.435	r = 0.110
		p = 0.000	p = 0.663	p = 0.000	p = 0.000	p = 0.000	p = 0.000	p = 0.282
	WMS-IIISS	r = 0.474	r = −0.157	r = 0.330	r = 0.379	r = 0.347	r = 0.271	r = 0.204
		p = 0.000	p = 0.124	p = 0.001	p = 0.000	p = 0.000	p = 0.007	p = 0.044
	LNS	r = 0.531	r = −0.075	r = 0.341	r = 0.447	r = 0.377	r = 0.358	r = 0.124
		p = 0.000	p = 0.468	p = 0.001	p = 0.000	p = 0.000	p = 0.000	p = 0.233
	NAB	r = 0.375	r = −0.055	r = 0.238	r = 0.413	r = 0.225	r = 0.314	r = 0.125
		p = 0.000	p = 0.588	p = 0.018	p = 0.000	p = 0.026	p = 0.002	p = 0.219
	BVMT-R	r = 0.377	r = −0.121	r = 0.199	r = 0.342	r = 0.231	r = 0.297	r = 0.139
		p = 0.000	p = 0.236	p = 0.049	p = 0.001	p = 0.022	p = 0.003	p = 0.171
	CPT-IP	r = 0.386	r = −0.154	r = 0.200	r = 0.366	r = 0.258	r = 0.364	r = 0.207
		p = 0.000	p = 0.140	p = 0.054	p = 0.000	p = 0.012	p = 0.000	p = 0.047
	Composite	r = 0.547	r = −0.155	r = 0.376	r = 0.510	r = 0.428	r = 0.417	r = 0.214
		p = 0.000	p = 0.127	p = 0.000	p = 0.000	p = 0.000	p = 0.000	p = 0.034
PANSS	Negative	r = −0.311	r = −0.081	r = −0.236	r = −0.264	r = −0.262	r = −0.193	r = 0.036
		p = 0.002	p = 0.428	p = 0.020	p = 0.009	p = 0.010	p = 0.058	p = 0.726
	Positive	r = −0.214	r = −0.164	r = −0.236	r = −0.194	r = −0.202	r = −0.219	r = 0.129
		p = 0.038	p = 0.112	p = 0.021	p = 0.059	p = 0.050	p = 0.033	p = 0.214
	Cognitive	r = −0.344	r = −0.025	r = −0.279	r = −0.319	r = −0.287	r = −0.277	r = −0.21
		p = 0.001	p = 0.811	p = 0.007	p = 0.002	p = 0.005	p = 0.007	p = 0.844
	Total	r = −0.306	r = −0.125	r = −0.276	r = −0.280	r = −0.271	r = −0.257	r = 0.068
		p = 0.002	p = 0.203	p = 0.006	p = 0.006	p = 0.007	p = 0.011	p = 0.510

with hallucinations was also reported (Siddi et al., 2017).

Negative symptoms were related to fewer switches, fewer repetitions, and fewer single animal intrusions, while positive symptoms were associated with a good performance on the test when controlling for disorganization (Egeland et al., 2018).

The observed correlation between switching and the negative and cognitive PANSS factors supports the usefulness of this component in the identification of patients within the pathway of psychosis associated with cognitive impairment and the negative-disorganized symptom dimension (De Gracia et al., 2009).

To the best of our knowledge, this is the first study describing the qualitative and quantitative components of CFT in a sample of adolescents with schizophrenia. This age group is important because a number of patients have an illness onset before the age of 18 and research indicated that early age of onset is related to a poorer prognosis and cognitive functioning (Immonen et al., 2017); in line with this, a recent study on Chinese adolescents with schizophrenia in which the concentration of oxygenated hemoglobin in the frontotemporal area during a verbal fluency task was analyzed and reported a decrease in cortical activity, in contrast with the pattern reported in adults, which could reflect neurodevelopmental abnormalities in this age group (Zhang et al., 2023).

4.3. Limitations

Present results should be examined taking into account limitations such as the lack of a control group and the fact that the patients mentioned local animals which could not be accurately classified. In this line, future studies should consider the geographical differences while examining the semantic categories proposed by Troyer et al. (1997).

5. Conclusions

The examined components of the CFT showed correlations with the MCCB tests and with the PANSS factors. The analysis of this test beyond the number of words emitted per minute allows the integration of other cognitive functions. The CFT is a brief and easy-to-complete task that constitutes a practical tool for the assessment of adolescents with schizophrenia.

CRediT authorship contribution statement

REU, RA, and GV designed the study; REU, RD, and GV collected and analyzed data. REU, RD, and GV wrote the first draft, and all authors reviewed and accepted the final draft.

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Ethical standards

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

Declaration of competing interest

The authors declare that there is no conflict of interest.

Data availability

The data that support the findings of this study are available from the corresponding author, [REU], upon reasonable request.

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