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Research Paper

Fluency Impairment in Chronic Schizophrenia

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ABSTRACT

Fluency impairment is a core feature of chronic schizophrenia (CSZ). The present study focused on the investigation of fluency impairment among Nigerian patients diagnosed with chronic schizophrenia. The assessment tools utilized were fluency tasks, mini-mental status examination (MMSE), trail making test (TMT) parts A and B. The executive function domain of fluency expressed in three categories as semantic verbal fluency, phonemic verbal fluency and design fluency were examined. A total of ninety-seven participants consisting of patients diagnosed with schizophrenia (n=53, 29 females and 24 males); and a control group of 44 persons (21 females and 23 males) took part in the study. There were significant mean differences between schizophrenics and controls on all the parameters employed. Utilizing regression analysis, the most significant predictors of fluency parameters (semantic fluency, phonemic fluency and design fluency) among CSZ cases were with general cognitive functioning (t= 5.45, P< 0.001), (t= 4.71, P<0.001), (t=3.36, P=0.001) and TMT B, design fluency: (t=2.30, P=0.025), semantic fluency: (t=2.79, P=.007), phonemic fluency: (t=6.54, P<0.001). The findings show that chronic schizophrenics are at higher risk of developing fluency dysfunction than the general population.

Keywords: *fluency, chronic, schizophrenia, impairment, rehabilitation*

Fluency impairment in Chronic schizophrenia (CSZ) is associated with executive dysfunction involving abnormalities in the structural and functional levels in the brain with regards to the structure of language and creativity, among others (Chrobak, Turek, Machalska, Arciszewska, Starowicz-Filip, Krupa, Dudek & Siwek 2022; Tyburski, Mak, Sokołowski, Starkowska, Karabanowicz, Kerestey, Lebiecka, Pres, Sagan, Samochowiec & Jansari 2021; Dickinson & Ramsey 2007; Fioravanti, Bianchi & Cinti 2012) According to the current edition (as of date) of World Health Organization (WHO schizophrenia report Feb 2022), schizophrenia is a disabling mental disorder which affects approximately 24 million people or 1 in 300 persons (0.32%) worldwide- this ratio is 1 in 222 people (0.45%) among adults (GHDx 2019). The disorder is comparatively less common than other mental illnesses. Onset of schizophrenia is most often during late adolescence and the twenties; onset happens earlier among men than among women[5]. And the probability of persons with schizophrenia experiencing complete remission of symptoms

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is 0.33 or one out of three patients (WHO schizophrenia report Feb 2022; Harrison Hopper Craig Siegel & Wanderling 2001).

Schizophrenia is characterized by significant impairments in the way reality is perceived with associated changes in behaviour (WHO schizophrenia report Feb 2022). In general, these are: 'positive symptoms' including persistent delusions- the person has fixed beliefs that something is true, despite evidence to the contrary (Harrison Hopper Craig Siegel & Wanderling 2001; Rosen, Mohs, Johns, Small, Kendler, Horvath & Davis 1984) persistent hallucinations- the person may hear, smell, see, touch, or feel things that are not there (Patel 2014); experiences of influence, control or passivity- the experience that one's feelings, impulses, actions, or thoughts are not generated by oneself, are being placed in one's mind or withdrawn from one's mind by others, or that one's thoughts are being broadcast to others; disorganized thinking, which is often observed as jumbled or irrelevant speech (WHO schizophrenia report Feb 2022); highly disorganized behaviour such that the person does things that appear bizarre or purposeless, or the person has unpredictable or inappropriate emotional responses that interfere with their ability to organize their behavior (Rabinovici, M.L. Stephens and K. L. Possin 2015); "negative symptoms" such as very limited speech, restricted experience and expression of emotions, inability to experience interest or pleasure (ahedonia), and social withdrawal; and/or extreme agitation or slowing of movements, maintenance of unusual postures and apathy (WHO schizophrenia report Feb 2022; Chrobak, et al 2022). Hence, the functional-behavioral consequence is that individuals diagnosed with chronic schizophrenia often experience executive dysfunction marked by persistent difficulties with their adaptive skills, such as fluency, working memory, inhibitory control, and set-shifting (Lawani & Tomar 2022). The brain structure of language and creativity identified as dysfunctional in schizophrenia relates to the fluency component of executive function (Chrobak etal 2022).

Fluency involves mental mechanisms which enable individuals to initiate adaptive behavior, be creative thus making possible higher order planning and organization. Therefore, in my conceptualization of the four-factor model of executive function, fluency takes precedence over inhibitory control and set-shifting components in the operational processes of executive function- working memory being central to these processes. Fluency occupies the initiation stage, while inhibitory control occupies the perpetuation stage and set-shifting, the completion stage; working memory being central and constantly activated through the initiation to completion of goal-motivated behavior. This explanation is in sync with my definition of executive function as an individual's ability to initiate, perpetuate and complete series of goal-motivated behavior required for adaptive living. Contrary to the suggestions by researchers, fluency and not inhibitory control kick-starts the executive control process (Diamond 2012). For example, an architect (who is an ardent football fan) accepted a building plan drawing contract to be completed and delivered on December 20th, 2022. He must first hold a picture of the shape of the building whether square, rhombus, rectangle or spherical foundation to the building and the different vertical and horizontal dimensions associated with the latter, etc, in his/her working memory in order to generate the building plan; and having begun the drawing, he must inhibit the thought of abandoning the job to watch the FIFA football competitions so as to beat the contract delivery deadline. Significantly, impaired design fluency performance cannot be explained by language or memory, or motor deficits (Ruff, Evans & Marshall; Delis, Kaplan & Kramer 1986). Fluency is an important component of executive function (Rabinovici et al 2015; Lawani et al 2022) and represents the ability to maximize the deliberate generation of novel and appropriate responses in accordance with stipulated criteria (Rabinovici et al 2015).

Therefore, fluency impairment renders individuals incapable of initiating goal motivated behavior, planning and organization (Suchy 2010; Rabinovici et al 2015). Three categories of fluency are frequently described in the literature. They are verbal fluency (semantic/categorical fluency and phonemic/letter fluency); and design fluency. Verbal fluency tests and design fluency tasks are most commonly used neuropsychological tasks in schizophrenia research studies (Possin, Chester, Laluz, Bostrom, Rosen, Miller, & Kramer 2012; Ruff et al 1986; Suchy et al 2010).

In order to improve the diagnosis and treatment of dysfunction of executive components in schizophrenia, it is necessary to improve our understanding of the complex relationship between executive function and the brain's structure and activation (Tyburski et al 2021; Millan, Agid, Brüne, Bullmore, Carter, Clayton, Connor, Davis, Deakin, DeRubeis et al 2012). Executive dysfunction due to abnormalities in the structure and activity of the prefrontal and thalamic networks are seen as the most characteristic neuropsychological symptoms of schizophrenia (Tyburski et al 2021; Orellana & Slachevsky 2013; Giraldo-Chica, Rogers, Damon, Landman & Woodward et al 2018; Bressler & Menon 2010; Uddin, Yeo & Spreng 2019). Generally, the main cause of executive dysfunction is believed to be abnormalities in different regions of the prefrontal cortex; these include dorsolateral, ventrolateral, and anterior cingulate cortices and their connections with other brain regions, which are part of complex neural circuits (Eisenberg & Berman 2010). Executive dysfunctions, including verbal fluency, are often present in subjects with schizophrenia (Volz, Gaser. Häger, et al 1997). As well, verbal fluency has a significant effect on the efficacy of other cognitive and executive function components and determines individual adaptability (Tyburski et al 2019).

The efficacy of the design fluency test and verbal fluency test as good diagnostic indicator of frontal lobe dysfunction has been established (Possin et al 2012; Baldo, Schwartz, Wilkins, &Dronkers 2006). The Verbal Fluency Test, similarly to other tests that assess executive function enables one to detect dysfunctions of the frontal lobes, particularly of the left frontal cortex. (Gouveia Brucki, Malheiros, & Bueno 2007). Area 44 and 45 situated within the inferior frontal gyrus (Broca's region) and dorsolateral prefrontal cortex of the left hemisphere are activated while performing this test (Oades, Bender. Müller, & Sartory 2001). The inferior part of the left prefrontal cortex is activated while executing the letter test, while the anterior inferior part of the prefrontal cortex is activated while executing the category test (Gaillard, Hertz-Pennier, Mott, Barnett, LeBi han &Theodore 2000). Hence, the consensus is that the anatomical site of the control mechanism of fluency component of executive function is the frontal lobe.

In a study involving 280 psychiatric patients and 317 healthy controls demonstrated the presence of cognitive and fluency dysfunction among the schizophrenia patients, bipolar disorder patients and other medical conditions (Vannorsdall, Tracy, David. Barry Gordon & Schretlen 2012). However, the distribution of each psychiatric disorder wasn't specified. Similarly, in a study of forty-four patients with schizophrenia and 40 healthy controls found that in comparison to healthy controls, individuals with schizophrenia obtained significantly lower total scores for both verbal (phonological, semantic) and design fluency measures (Krukow, Harciarek, Morylowska-TopolskaKarakuła-Juchnowicz&Jonak 2017).

In general, very little research has been carried out on fluency as a component of executive function and its dysfunction in chronic schizophrenia; and perhaps none yet from Nigeria. In the present study, the following measures were employed: semantic fluency test, phonemic

fluency and design fluency test, trail making test parts A and B; and mini-mental state examination, to test for the presence of fluency and general cognitive functioning impairments in patients diagnosed with chronic schizophrenia.

The hypotheses are:

1. Patients diagnosed with CSZ would significantly differ from CG on tasks assessing semantic fluency, phonemic fluency and design fluency, such that CSZ patients reflect fluency dysfunction;
2. CSZ patients would perform significantly poorer than CG on MMSE test;
3. There would be significant differences between the test scores of CSZ and CG reflecting fluency dysfunction on TMT parts A and B.

MATERIALS AND METHOD

Sample

A total of 97 participants (n=47 females and n=50 males were included in the study. Among them we have a sample consisting of fifty-three chronic schizophrenia patients (n= 29 females and n=24 males) aged between 18 and 68 years selected after consent was obtained at the In-Patient and Out-Patient departments of Federal Neuropsychiatric Hospital, Benin City, Nigeria There was a control group of forty-four volunteers (n=21females and n=23 males) aged between 18 and 68 years. Subjects in both cases and control groups had the mini mental status examination (MMSE), the Trail Making Test (TMT) from the D-KEPS, and Fluency tasks, individually administered to them.

Instruments

The following measures were used in this study:

Fluency: The three most common types of fluency tasks are category, letter, and design. Verbal fluency tasks are often included in neuropsychological assessment, in clinical practice, and in research (Rabinovici et al 2015)] The Verbal Fluency Test is a commonly accepted and widely applied test, used for assessing verbal fluency. Verbal fluency is of two categories: (1) semantic fluency and (2) phonemic fluency (Rabinovici et al 2015; Lezak 1995; Fisk &Sharp 2004). In semantic fluency tests, participants are required to generate as many items belonging to a certain category (for example, items in a grocery store, or animals in a zoo) as possible within a certain time window. In phonemic fluency tests, the subject is asked to generate as many words starting with a given letter as possible. Category/semantic fluency and letter/phonemic fluency tests require different strategies for the creation and selection of appropriate novel responses, and depend on distinct memory processes (Baldo etal 2006). Semantic fluency depends on semantic memory to retrieve previously obtained semantic knowledge on items belonging to a certain category, whereas in phonemic fluency appropriate items are selected based on phonological word knowledge (Baldo et al 2006). The popular use of the verbal fluency tasks stems from their face validity as tests of both verbal ability and executive control (Shao, Janse, Visser & Meyer 2014).

The validity of the fluency tasks as a measure to assess verbal ability, specifically lexical access ability, has been confirmed in numerous studies comparing groups of participants that would be expected to differ in this ability. The reliability of this test has been demonstrated by other authors and a high level of internal coherence was found (Salthouse 1996; Wysokiński, Zboralski, Orzechowska, Gałecki, Florkowski, Talarowska 2010; Vlaar & Wade 2003). Disorders of verbal functions in subjects with schizophrenia are strictly associated with disorders of information processing processes, executive functions and memory processes. They are present in subjects with schizophrenia in the prodromal period,

as well as in their first-degree relatives (Lipska, D.R. Weinberger 2002; Meilijson & Elizur 2004).

In design fluency test (DFT), also known as "figural" or "nonverbal" fluency test represents a method of assessment of executive functioning, commonly used in research and clinical practice (Suchy et al 2010). Participants are instructed to draw as many unique designs as possible in a specific time frame, while avoiding repeating previous designs (Suchy et al 2010). We now have several versions of DF tests, most of which require that designs be drawn by connecting dots in a series of five-dot matrices, using four lines (Rabinovici et al 2015). Design fluency is a measure of (a) planning/initiation, (b) cognitive flexibility/divergent thinking, and (c) fluency in generating visual patterns (Suchy et al 2010), Please see Lawani & Tomar 2022 for detailed discussion of mini mental state examination (MMSE) and trail making test Parts A and B.

Procedure

Each participant completed tests of letter- and category-cued word fluency and design fluency. To assess letter fluency, subjects were asked to generate as many words as possible that start with G excluding names of people and places or grammatical variants of previous responses, in 60 seconds, while measures of semantic fluency were obtained by asking patients to name as many animals as possible in 60 seconds. For design fluency, subjects were asked to generate as many unique designs as possible within sixty seconds while using only four lines to connect the dots. The number of acceptable words reported by each participant was summed separately for letter- and category-cued verbal fluency tasks. The total number of acceptable, unique designs drawn in 60 seconds was recorded to assess design fluency. All participants also completed the five subtests of the mini mental state examination and TMT Parts A and B.

Statistical analysis

The t-test at 95 percent confidence interval was used to assess the mean differences between CSZ and CG to estimate the effect sizes for the continuous and outcome variables. Regression analyses were performed to test for effects of different clinical and demographic variables on semantic fluency, phonemic fluency and design fluency among cases. Variables included were age, school years, age, duration of illness TMT and MMSE. Furthermore, each fluency category was regressed on the others. Data was analyzed using IBM SPSS Statistics version 20.0.

RESULTS AND ANALYSIS

Table 1 Group Comparisons

	Chronic schizophrenia (clinical group)		**Control Group**			
Variables	***M***	***SD***	***M***	***SD***	***t***	***P-value***
Age	39.41	11.12	31.90	14.46	4.917	.000
School years	13.61	2.03	13.43	1.96	.655	.516
Orientation	6.77	3.14	9.70	1.06	6.78	.000
Memory	1.58	.84	2.45	.97	7.48	.000
Attention	3.11	1.90	4.40	1.26	4.72	.000
Recall	2.35	.98	2.72	.69	2.67	.010
Language	6.50	2.34	6.43	2.60	0.24	.806
Total MMSE	20.03	6.79	25.11	4.45	5.32	.000

Semantic fluency	8.90	5.43	17.90	3.98	12.05	.000
Phonemic fluency	4.15	3.05	10.68	3.50	15.53	.000
Design fluency	2.83	2.88	6.18	2.18	8.44	.000
Total fluency	15.73	9.22	30.38	10.94	11.56	.000
Duration of illness	3.91	7.46	NA	NA	NA	NA
TMT A	132.52	85.32	54.59	18.82	6.65	.000
TMT B	243.77	111.76	98.95	40.45	9.43	.000

Note: NA= Not applicable

Demographic characteristics:

The mean ages (standard deviations, *SD*) of the cases and controls were 39.41 (*SD*=11.2) and 31.90 (*SD*=14.40) years respectively. There were significant differences between mean ages of cases and controls (t=4.91, *p*<.001). Gender-wise distribution of the sample was 54.8% females, 45.2% males among cases and 47.7% females, 52.3% males among controls. The mean years of education were comparable: for cases 13.13 (*SD*=2.30) and controls 13.43 (*SD*=1.96). There were no significant differences between cases and controls on schooling years.

CSZ versus CG:

CSZ cases and controls were compared on fluency tasks, MMSE and Parts A and B of the TMT.[Table 1]. There were significant differences, reflecting CSZ impairments, between these groups on semantic fluency (t= 12.05, *p<.001*), phonemic fluency (t= 15.53, *p<.001*) and design fluency t= 8.44, *p<.001*(); various subtests of MMSE- orientation (t=6.78, *p<.001*), memory (t=7.48, *p<.001*), attention (t= 4.72, *p<.001*) and recall (t=2.47, *p=.010*). Also, CSZ group had significantly poorer performance than the control group on Part A of the TMT (t=6.65, *P*<0.001) On Part B of the TMT, schizophrenics 243.77 (*SD*=111.76) seconds, took significantly more time than controls 98.95 (*SD*=40.45) seconds, (t=9.43, *P*<0.001)

Table 2: Regression analyses with TMT A and B as dependent variable and fluency categories as independent variables

Predictors (Independent variable)	**Standardized Coefficients**	**t**	**Sig**	**95.0% Confidence Interval for B**	
	Beta			**Lower Bound**	**Upper Bound**
a. TMT A	.280	-2.167	.035	.036	.001
b. TMT B	.307	2.304	.025	.015	.001
c. TMT B	.365	2.797	.007	.030	.005
d. TMT B	.325	2.450	.018	.010	.002

a. Dependent Variable: Semantic fluency score of CSZparticipants
b. Dependent Variable: Design fluency score of CSZparticipants
c. Dependent Variable: Semantic fluency score of CSZ participants
d. Dependent Variable: Phonemic fluency score of CSZparticipants

Table 3: Regression analyses with MMSE as dependent variableand fluencycategories as independent variables

Predictors (Constant)	Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
	Beta			Lower Bound	Upper Bound
a. TOTAL MMSE SCORE	.607	5.459	.000	.308	.665
b. TOTAL MMSE SCORE	.551	4.717	.000	.143	.354
c. TOTAL MMSE SCORE	.426	3.367	.001	.073	.290
d. DESIGN FLUENCY SCORE OF CSZ PAARTICIPANTS	.412	3.23	.002	.294	1.257
e. POLEMIC FLUENCY SCORE OF PARTICIPANTS	.674	6.520	.000	.829	1.566
a.Dependent Variable: Semantic fluency score of CSZ participants b.Dependent Variable: Phonemic fluency score of CSZ participants c.Dependent Variable: Design fluency score of CSZ participants d.Dependent Variable: Semantic fluency score ofcsz participants e. Dependent Variable: Semantic fluency score of csz participants					

Regression analyses were performed to test for effects of different clinical and demographic variables on semantic fluency, phonemic fluency and design fluency tasks among the CSZ group [Table 2]. Variables selected for analysis included age, school years, duration of illness, MMSE, TMT Parts A and B. MMSE, a measure of general cognitive functioning significantly predicted the three categories of fluency: semantic fluency, phonemic fluency and design fluency respectively (t=5.45, *p<.001),* (t=4.71, *p<.001*), (t=3.36, *p=.001*). TMT A and B significantly predicted semantic fluency t=2.16, (*p=.035*), (t=2.79, *p=.007*), while only TMT B proved to be significant predictor of phonemic and design fluency (t=2.30, *p=.025*), (t=2.45, *p=.018*).

Regression analyses in which each fluency measure was regressed on the other two fluency measures were conducted [Table 3]. All three analyses yielded highly significant models. Each of the other fluency measures proved to be significant predictors of the fluency measure that served as the dependent variable in each analysis. Phonemic fluency proved to be the most significant predictor of the other two (t=6.52, *p<.001)*

DISCUSSION

The results show that Nigerian subjects diagnosed with chronic schizophrenia performed worse than controls on Parts A and B of the TMT, semantic fluency, phonemic fluency and design fluency tasks assessing fluency component of executive function and; MMSE assessing general cognitive functioning. To my knowledge, this is one of the first reports involving fluency component of executive function, and its dysfunction among chronic schizophrenia patients in Nigeria. My findings are consistent with those of earlier reports (Krukow et al 1995; Rabanea-Souza et al 2016). Contrary to previous findings (Bhatia et al 2009), age (lowest age for this sample was 25 years) had no significant effect on fluency component of executive function among chronic schizophrenia patients. This seems to support the suggestion that early and accurate diagnosis of the disorder improves prospects of recovery (Marshal et al 2011;Soares-Weiser 2015). In previous studies investigating predictors of verbal and design fluency in patients with schizophrenia, authors demonstrated that poor results in both types of fluency tasks resulted from a deficient initiation process,

indicated by the number of correct words and designs produced by the examinees (Krukow et al 1995). This may suggest that psycho pharmaceutical treatment should target the mental mechanisms responsible for initiation and creativity. While psychotherapy/rehabilitation paradigms are tailored towards restoration of these skills and subjective experience variables.

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Conflict of Interest

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