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CLUSTERING AND SWITCHING STRATEGIES DURING THE SEMANTIC FLUENCY TASK IN MEN WITH FRONTAL LOBE LESIONS AND IN MEN WITH SCHIZOPHRENIA

Differences in semantic clustering and switching were examined in men with frontal lobe lesions, men with schizophrenia and healthy men. Men with frontal lobe lesions and men with schizophrenia generated fewer words than healthy men and presented intact clustering, but decreased switching during the semantic fluency task. However, after controlling for the number of words produced, between-group differences in switching disappeared. These findings suggest that all three groups used similar strategies of clustering and switching during the semantic fluency task, although men with frontal lobe lesions and men with schizophrenia did it less efficiently than healthy men.

Key words: clustering, switching, verbal fluency, schizophrenia, frontal lobes

Introduction

Verbal fluency tasks are among the most frequently used tasks for assessing executive functioning (Alvarez & Emory, 2006). Since examination of verbal fluency is one of the least time-consuming and easiest to perform neuropsychological procedures, it has been successfully applied in studies on various neuropsychiatric disorders (Strauss et al., 2006). A typical procedure of verbal fluency assessment consists of two tasks in which phonetic and semantic fluency levels are consequently examined. On the phonetic fluency task, the participant is asked to generate as many words beginning with a given letter as possible during a 60-second period. The letters are chosen according to the frequency of words beginning with a given letter. In Polish, the letter

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"K" is considered an "easy" letter while "F" is often used as a "difficult" one (Jodzio, 2008). On the semantic (category) fluency task, the participant is required to name as many objects which belong to a specified category (animals, fruits, sharp objects, etc.) as possible. The verbal fluency task has been shown to be a sensitive indicator of brain dysfunction and is included in most of the neuropsychological assessment batteries (Strauss et al., 2006). It has also been shown that decreased phonetic fluency is associated mainly with frontal lobe impairment, while semantic fluency deficits are associated rather with temporal lobe dysfunction (Henry & Crawford, 2004).

The quantitative approach to verbal fluency, in which only the number of words produced during both fluency tasks is measured, has been criticized (Troyer et al., 1997). Single indexes of the total number of words produced during the phonemic and semantic task are alleged to have little informative value and not to elucidate the cognitive processes which underlie verbal fluency. Troyer et al. (1997) suggested that fluency is a multifactorial task and two different components of verbal fluency can be described: (a) clustering which allows to produce multiple words within a given semantic or phonetic category and (b) switching, i.e. the ability to shift efficiently to the next category after the exhaustion of the previous one. Troyer et al. (1998) theorized that the two components of fluency could be associated with different brain structures, as clustering relies heavily on semantic store/memory/knowledge and switching depends on mental flexibility and set-shifting ability. Therefore, clustering should be deficient in patients with temporal lobe lesions, while less switching should be found in patients with frontal lobe impairment. These assumptions have been partially confirmed (Troyer et al., 1998).

Structural and functional abnormalities of the frontal lobes are brain abnormalities that are commonly found in patients with schizophrenia (Keshavan et al., 2008). "Hypofrontality" has been frequently observed in patients with schizophrenia who performed various tasks which are known to be associated with the activity of the frontal lobes (Hill et al., 2004). With respect to these facts, it can be hypothesized that similar mechanisms could underlie the executive deficits observed in patients with schizophrenia and in patients with frontal lesions of various etiology. Thus, when it comes to the fluency task, one can suspect that according to the previous studies, in both groups of patients, deficient switching and proper clustering would be found. The aim of this study was to verify this hypothesis by comparing clustering and switching scores in the semantic fluency task in men with schizophrenia, men with frontal lobe lesions and healthy men.

Material

In total 89 men participated in the study. Only male patients were recruited for the study, since it has been reported that sex differences in clustering and switching strategies can be observed (Weiss et al., 2006). Three groups of participants were recruited for the study.

The first group consisted of men with frontal lobe lesions ("F" group; n = 30), who were recruited from patients of the Department of Neurosurgery and Oncology of the Central Nervous System, Medical University of Łódź (n = 14), the Neurosurgical Ward, Wyszyński Hospital in Sieradz (n = 11) and the Neurosurgical Ward, Skłodowska-Curie Provincial Hospital in Zgierz (n = 5). Male patients (28 to 58 years old) diagnosed with frontal lobe lesions in a CT/MRI examination were included in the study. Patients who were diagnosed with lesions which were not restricted to the frontal lobes or with any comorbid psychiatric disorders were excluded from the study. If any signs of speech disorders or wakefulness/consciousness disturbances were observed during the examination, the patients' results were not included in further analyses. The majority (28) of patients were examined between the second and fourteenth day after being admitted to hospital. In the case of two patients this period was longer and lasted respectively one and three months. The lesions of 21 patients were caused by traumatic brain injury, eight patients suffered from tumors and one from vascular disease. Sixteen patients had unilateral lesions (eight right and eight left) and 14patients had bilateral lesions.

Thirty patients with schizophrenia (group "S") were recruited from Units VIIIb (n = 5) and IXb (n = 11) of Babiński Hospital in Łódź and from the Male Psychiatric Ward, Skłodowska-Curie Provincial Hospital in Zgierz (n = 14). Male patients (28 to 58 years old) diagnosed with schizophrenia due to the ICD-10 criteria were recruited for this study. Psychiatric history records were available to the authors, patients with any information on psychoactive substance dependence or other comorbid psychiatric or neurological disorders were excluded from the study.

The control group (group "C"; n = 29) consisted of healthy volunteers who were matched to the patients on the basis of socio-demographic characteristics. No significant differences in the age (mean age: F: 43.3 ± 10.0 y.o.; S: 45.7 ± 7.5 y.o.; C: 43.0 ± 9.3 y.o.; $F(2, 87) = 0.794$, n.s.) or education level of the participants (elementary and vocational/ secondary/ tertiary: F: 22/6/2; S: 18/10/2; C: 15/12/3; $\chi^2 = 8{,}68$, n.s.) were found between the groups.

Method

The verbal fluency task was performed as part of a neuropsychological battery used in a wider study whose procedure was accepted by Bioethical Committee of the Medical University of Łódź (No. RNN/192/12/KE). During the semantic fluency task, patients were asked to list as many names of animals as they could during the 60-second period. Data collected from participants were transcribed into one worksheet and anonymized.

Two independent raters, blind to the participants' group affiliation, performed the procedure of clustering the words. The detailed procedures of computing the mean cluster size and number of switches score are given elsewhere (Troyer et al., 1997). Shortly, at least two successively produced words belonging to the same

Table 1. Basic descriptive statistics of the total number of words and qualitative scores in the semantic fluency task

Semantic fluency task	Frontal lesions		Schizophrenia		Control		ANOVA		Patients vs. controls (*p*)	Schizophrenia vs. frontal lesions (*p*)
	M	SD	M	SD	M	SD	F	*p*		
No. of words	11.5	5.8	13.1	6.0	19.8	7.7	13.35	< 0.001	< 0.001	0.34
Mean cluster size	1.67	1.26	1.65	1.85	1.62	0.81	0.01	0.99	–	–
No. of switches	4.2	2.9	5.5	2.9	7.6	4.1	7.64	< 0.01	< 0.01	0.14

semantic category (e.g. farm animals) were considered to be a cluster. Cluster size was counted from the second word belonging to the cluster, thus any single word had a cluster size of zero. The categories proposed by Troyer et al. (1997) were adjusted to the regional specificity, thus if a patient listed "bison, boar, wolf, deer," all of the words were scored as forest animals instead of scoring only the last two words as animals from North America. Since many participants (especially living in the countryside) listed dog and cat among farm animals, in those cases these animals were considered to be "livestock" rather than "pets" and the clusters which included them were not split. Each transition between two clusters, a cluster and a single word, or two single words was counted as a switch. The total number of produced words, mean cluster size and number of switches was calculated for each participant. Inter-rater reliability was excellent for number of switches (r = 0.98) and satisfying for mean cluster size (r = 0.81). If any discrepancies between the two raters' scores were found, raw data was reviewed until agreement on scoring was reached. After that, the results were subjected to statistical analysis using the IBM SPSS Statistics 21 package.

Results

To verify the hypotheses of the study, one-way ANOVA of the total number of generated words, number of switches and mean cluster size in the semantic fluency task was performed. The basic descriptive statistics of these measures are shown in Table 1. Levene's test revealed that the variances of all of the variables analyzed in this study are homogenous. The results of one-way ANOVA revealed significant differences between the groups in the number of words generated ($F(2, 87) = 13.35$; $p < 0.001$) and the number of switches ($F(2, 87) = 7.64$; $p < 0.01$), but not in the mean cluster size ($F(2, 87) = 0.01$; $p = 0.99$).

In the second step of the analysis, the following planned contrasts (noted as (F, S, C), where F is the contrast coefficient for patients from the frontal lobe lesions

group, S is the contrast coefficient for patients from the schizophrenia group, and C is the contrast coefficient for the control group) were analyzed:

1) (-1, -1, 2) – to verify the hypothesis that men with frontal lobe lesions and men with schizophrenia switched between the clusters less frequently than the healthy controls;
2) (-1, 1, 0) – to verify the hypothesis that men with frontal lobe lesions and men with schizophrenia do not differ in the number of switches during the task.

The first contrast was revealed to be statistically significant ($t(86) = 3.6$; $p < 0.01$), while the second was revealed to be non-significant ($t(86) = -1.5$; $p = 0.14$), thus both of the study hypotheses were verified positively.

Finally, the total number of words produced in the semantic fluency task was entered as a covariate in the analysis and as a result between-group differences in the number of switches disappeared ($F(2, 85) = 0.79$; $p = 0.46$).

Discussion

This study has confirmed that patients with schizophrenia and patients with frontal lobe lesions employ similar strategies of switching and clustering during the semantic fluency task. Deficient switching and intact clustering was observed in both of these groups during the semantic fluency task.

The pattern of dissociation between semantic switching and clustering has also been observed in other schizophrenia studies. Moore et al. (2006) reported that decreased semantic switching, but not clustering, was found in a large group (n = 163) of middle-aged and older outpatients with schizophrenia. Bozikas et al. (2005) reported less semantic switching, but also a lower number of cluster-related words in schizophrenia patients (n = 119). However, mean cluster sizes were not reported in that study.

The results of this study are also consistent with earlier studies on qualitative fluency scores in patients with focal brain lesions. Troyer et al. (1998) have shown that patients with left dorsolateral or superior medial frontal lesions switch less frequently but produce normal mean cluster size in the semantic fluency task. A differential deficit in switching, but not in clustering, was also found in 20 patients with right frontal lobe tumor resection (Davidson et al., 2008).

This study is, to the author's best knowledge, the first one which shows that semantic switching is comparably decreased in patients with schizophrenia and in patients with frontal lobe lesions of various etiology. The clinical utility of this finding is limited for now by the fact that a similar dissociation pattern in the semantic fluency task was also observed in patients with multiple sclerosis (Troster et al., 1997), patients with HIV-associated dementia (Woods et al., 2004) and in depressed patients (Fossati et al., 2003).

Between-group differences in the number of switches disappeared when the results were adjusted for the total number of words produced in the semantic fluency task by each group in this study. A similar effect was observed in studies on

clustering and switching in schizophrenia patients (Bozikas et al., 2005; Elvevag et al., 2002). Although it has been shown in neuroimaging studies that semantic switching mechanisms can be subserved by the frontal lobes (especially by the left inferior frontal gyrus; Hirshorn & Thompson-Schill, 2006), the results of the present study suggest that patients with frontal lobe impairment of various etiology could use the same strategies as healthy persons when performing the semantic fluency task. However, they do it less efficiently. It can be hypothesized that a general slowing of processing due to brain impairment could be a factor moderating patients' performance on the verbal fluency task. This hypothesis is consistent with a recent study which has shown that processing speed is the best single predictor of cognitive performance in schizophrenia (Burton et al., 2013). It has been also observed that processing speed is the main predictor of verbal fluency in healthy adults, and that while working memory is a predictor of verbal fluency level in cognitively impaired patients with schizophrenia, processing speed predicts the level of verbal fluency in patients with superior cognitive performance (Ojeda et al., 2010).

On the other hand, methodological concerns have been raised over Troyer et al.'s (1997) method of qualitative assessment of the verbal fluency task. Mayr (2002) has alleged that with this method, general reduction in processing speed can easily be confused with selective switching deficit. More sophisticated scoring systems which expand Troyer et al.'s method have also been proposed, e.g. Abwender's system in which cluster switches (transition between two meaningful clusters) and hard switches (transition between a cluster and a single word or between two single words) are counted separately to dissociate purposeful strategic actions from the effects of random mental processing (Ross et al., 2007).

Despite the methodological limitations, the present paper might shed some light on common factors which could moderate the verbal fluency level in various clinical populations. To verify the hypothesis that decreased semantic fluency in frontally impaired patients is associated with general slowing of processing rather than selective switching deficit, further studies should use a more sophisticated scoring system as well as control for processing speed in patients (e.g. by including symbol coding task results as a covariate in the analyses).

References

Alvarez, J.A. & Emory, E. (2006). Executive function and the frontal lobes: A meta-analytic review. *Neuropsychology Review*, 16, 17-42.

Bozikas, V.P., Kosmidis, M.H., & Karavatos, A. (2005). Disproportionate impairment in semantic verbal fluency in schizophrenia: differential deficit in clustering. *Schizophrenia Research*, 74, 51-59.

Burton, C.Z., Vella, L., Harvey, P.D., Patterson, T.L., Heaton, R.K., & Twamley, E.W. (2013). Factor structure of the MATRICS Consensus Cognitive Battery (MCCB) in schizophrenia. *Schizophrenia Research*, 146, 244-248.

Davidson, P.S., Gao, F.Q., Mason, W.P., Winocur, G., & Anderson, N.D. (2008). Verbal fluency, trail making, and Wisconsin Card Sorting Test performance following right frontal lobe tumor resection. *Journal of Clinical and Experimental Neuropsychology*, 30, 18-32.

Elvevag, B., Fisher, J.E., Gurd, J.M., & Goldberg, T.E. (2002). Semantic clustering in verbal fluency: Schizophrenic patients versus control participants. *Psychological Medicine*, 32, 909-917.

Fossati, P., Guillaume, B., Ergis, A.M., & Allilaire, J.F. (2003). Qualitative analysis of verbal fluency in depression. *Psychiatry Research*, 117, 17-24.

Henry, J.D. & Crawford, J.R. (2004). A meta-analytic review of verbal fluency performance following focal cortical lesions. *Neuropsychology*, 18, 2, 284-295.

Hill, K., Mann, L., Laws, K.R., Stephenson, C.M., Nimmo-Smith, I., & McKenna, P.J. (2004). Hypofrontality in schizophrenia: A meta-analysis of functional imaging studies. *Acta Psychiatrica Scandinavica*, 110, 243-256.

Hirshorn, E.A. & Thompson-Schill, S.L. (2006). Role of the left inferior frontal gyrus in covert word retrieval: Neural correlates of switching during verbal fluency. *Neuropsychologia*, 44, 2547-2557.

Jodzio, K. (2008). *Neuropsychologia intencjonalnego działania. Koncepcje funkcji wykonawczych* [*Neuropsychology of Intentional Action. Concepts of Performing Functions*]. Warszawa: Scholar.

Keshavan, M.S., Tandon, R., Boutros, N.N., & Nasrallah, H.A. (2008). Schizophrenia, "just the facts": What we know in 2008. Part 3: Neurobiology. *Schizophrenia Research*, 106, 89-107.

Mayr, U. (2002). On the dissociation between clustering and switching in verbal fluency: Comment on Troyer, Moscovitch, Winocur, Alexander and Stuss. *Neuropsychologia*, 40, 562-566.

Moore, D.J., Savla, G.N., Woods, S.P., Jeste, D.V., & Palmer, B.W. (2006). Verbal fluency impairments among middle-aged and older outpatients with schizophrenia are characterized by deficient switching. *Schizophrenia Research*, 87, 254-260.

Ojeda, N., Sánchez, P., Peña, J., Elizagárate, E., Yoller, A.B., Larumbe, J., Gutiérrez, M., Casais, L., & Ezcurra, J. (2010). Verbal fluency in schizophrenia: Does cognitive performance reflect the same underlying mechanisms in patients and healthy controls? *Journal of Nervous and Mental Disease*, 198, 286-291.

Ross, T.P., Calhoun, E., Cox, T., Wenner, C., Kono, W., & Pleasant, M. (2007). The reliability and validity of qualitative scores for the Controlled Oral Word Association Test. *Archives of Clinical Neuropsychology*, 22, 475-488.

Strauss, E., Sherman, E.M., & Spreen, O. (2006). *A Compendium of Neuropsychological Tests: Administration, Norms, and Commentary*. New York: Oxford University Press.

Troster, A.I., Fields, J.A., Testa, J.A., Paul, R.H., Blanco, C.R., Hames, K.A., Salmon, D.P., & Beatty, W.W. (1998). Cortical and subcortical influences on clustering and switching in the performance of verbal fluency tasks. *Neuropsychologia*, 36, 295-304.

Troyer, A.K., Moscovitch, M., & Winocur, G. (1997). Clustering and switching as two components of verbal fluency: Evidence from younger and older healthy adults. *Neuropsychology*, 11, 138-146.

Troyer, A.K., Moscovitch, M., Winocur, G., Alexander, M.P., & Stuss, D. (1998). Clustering and switching on verbal fluency: The effects of focal frontal- and temporal-lobe lesions. *Neuropsychologia*, 36, 499-504.

Weiss, E.M., Ragland, J.D., Brensinger, C.M., Bilker, W.B., Deisenhammer, E.A., Delazer, M. (2006). Sex differences in clustering and switching in verbal fluency tasks. *Journal of International Neuropsychological Society*, 12, 502-509.

Woods, S.P., Conover, E., Rippeth, J.D., Carey, C.L., Gonzalez, R., Marcotte, T.D., & Heaton, R.K. (2004). Qualitative aspects of verbal fluency in HIV-associated dementia: A deficit in rule-guided lexical-semantic search processes? *Neuropsychologia*, 42, 801-809.