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Clustering and switching strategies in verbal fluency tasks: Comparison between schizophrenics and healthy adults

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Abstract

Verbal fluency tasks are frequently used in clinical neuropsychology. Clustering (the production of words within semantic subcategories) and switching (the ability to shift between clusters) have been described as 2 components underlying fluency performance. We compared the use of clustering and switching in schizophrenic patients and healthy subjects. Seventy-eight schizophrenic subjects (DSM–IV criteria) and 64 control participants matched for age and educational level were recruited. Negative, disorganized, and productive clinical dimensions were evaluated using the SANS and SAPS scales. The number of words generated per semantic–phonemic cluster and the number of switches were evaluated during 2 verbal fluency tasks (phonemic and semantic). In the healthy controls switching and clustering were closely related to the total number of words generated in the verbal fluency tests. The role of the 2 components was partly dependent on the specific task. Switching was prevalent in formal fluency, while both switching and clustering contributed to semantic fluency. In comparison to the healthy controls, the overall group of schizophrenic patients showed a significant impairment of switching in the formal fluency task and of both switching and clustering in the semantic fluency task, and both the negative and disorganized dimensions correlated with verbal fluency performance, the number of switches during the phonemic fluency task, and the clustering during semantic fluency task. (*JINS*, 1998, *4*, 539–546.)

Keywords: Schizophrenia, Neuropsychology, Verbal fluency, Clustering, Switching

INTRODUCTION

Verbal fluency tasks require persons to generate as many words as possible beginning with a defined letter (formal or phonemic fluency), or instances of a category (semantic fluency), in the order the instances occur to them in a limited amount of time (Spreen & Strauss, 1991). Several studies of verbal fluency have indicated that schizophrenic patients produce fewer words than healthy individuals (Allen & Frith, 1983; Crawford et al., 1993; Gruzelier et al., 1988; Kolb & Whishaw, 1983). According to the schizophrenic subtype, poor performance has been linked to poverty and disorganization, but not to hallucinations or delusion (Johnstone & Frith, 1996). These impairments were explained in terms of subnormal capacity to initiate willed action (Frith, 1992), impaired semantic memory (McKay et al., 1996), and reduced access to semantic memory because of difficulties in organizing the search; that is, in generating semantic dimensions (Allen et al., 1993). From a cognitive point of view, verbal fluency is considered a multifactorial task; the number of correct words generated does not fully capture the different aspects of the underlying processes. The first component thought to be involved is called clustering. Semantic fluency provides a good approach to this mechanism. In semantic fluency tasks, people first search for meaningful semantic fields or subcategories which, when encountered, cause clusters of related words to be made available for recall (Gruenewald & Lockhead, 1980). Laine (1988) defined semantic conceptual clusters as two or more consecutive words, the meaning of which is either associated or shared.

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In a previous study (Robert et al., 1997), we observed a correlation between the number of semantic clusters and word production in 100 healthy participants, indicating that the better the individual organizes his search through the use of semantic clusters, the more words he is able to produce. In the same study, schizophrenic patients showed impaired verbal fluency and generated a smaller number of semantic clusters than the healthy controls. The generation of words using phonemic clusters has also been studied in Parkinson's disease (Auriacombe et al., 1993; Bayles et al., 1993).

Another component called *switching*, defined as the ability to shift effectively from one subcategory to another, was recently proposed by Troyer et al. (1997). Studying 54 older and 41 younger healthy participants, these authors demonstrated that clustering and switching correlated equally with the number of words generated, whereas switching correlated more strongly than clustering with the number of words generated in phonemic fluency tests. This suggested that the mechanisms involved in formal and semantic fluency do not have the same relative importance, and is consistent with studies indicating that multiple brain regions are involved in this task. Formal fluency would be more sensitive to frontal lesions (Coslett et al., 1991; Milner, 1964; Perret, 1974), while semantic fluency would be more sensitive to temporal lesions (Corcoran & Upton, 1993) although this pattern is not always obtained (Joanette & Goulet, 1986).

This study was designed to compare the use of clustering and switching by schizophrenic patients and healthy controls.

METHODS

Research Participants

Seventy-eight native-French-speaking psychiatric patients who met DSM–IV criteria (American Psychiatric Association, 1994) for chronic schizophrenia were evaluated in the memory center of the Nice University psychiatric department with their informed consent. Patients with an organic brain disorder, mental retardation, a history of severe head trauma, or a history of alcohol or drug abuse–dependence were excluded from the study. None of the patients had had acute exacerbations during the previous month. Twelve patients were drug-free, 47 were on neuroleptics and 19 were receiving a neuroleptic plus an anticholinergic agent.

Sixty-two native-French-speaking healthy volunteers matched with the schizophrenic population in terms of sex, age, and educational level formed the control group. Major social-class-of-origin mismatches were excluded on the basis of an interview. All the participants were screened with a medical questionnaire and physical examination to rule out previous neurological or psychiatric disease, significant head injury, and alcohol or drug abuse. All the patients on treatment had been on stable doses for at least 1 month.

Clinical Evaluation

The Scale for the Assessment of Negative Symptoms (SANS) and the Scale for the Assessment of Positive Symptoms (SAPS) were developed to explore the clinical and neural correlates of these symptoms in schizophrenia (Andreasen, 1983, 1984). These scales are widely used throughout the world in research and clinical practice. Since these publications, the authors have completed five studies using correlational and factorial analyses to examine the interrelationships between positive and negative symptoms (Andreasen et al., 1995; Andreasen & Grove, 1986; Andreasen & Olsen, 1982; Arndt et al.,1991; Miller et al., 1993). A review of these studies suggests a convergence of the results and indicates that, at a descriptive level, three dimensions rather than two are required to account for the relations among the symptoms of schizophrenia. The negative symptoms remain robust but the positive symptoms subdivide into two dimensions. Our current evaluation of clinical symptoms follows the most recent analysis done in 1995. The first factor reflecting the negative symptom dimension is composed of avolition, anhedonia, and affective flattening. The second factor reflecting the disorganization dimension is composed of inappropriate affect, thought disorder, and bizarre behavior. The third factor reflecting the psychotic or productive dimension is composed of delusions and hallucinations.

Neuropsychological Assessment

The verbal fluency test measures spontaneous oral production of words. Both semantic and phonemic fluency tasks were administered. In the semantic fluency test, participants were instructed to generate words belonging to animal and fruit classes. In the phonemic fluency test, subjects were instructed to generate words beginning with *p* and *r*, with the exception of proper nouns and variants of the same word (e.g., the same word with different suffixes). In the French version (Cardebat et al., 1990), 2 min is allotted for each of the four trials (two semantic and two phonemic). The participants were recorded in order of utterance. The participants were not instructed on how to perform the search; in other words they were free to develop semantic or formal subcategories to organize their thinking and to shift from one subcategory to another. As described above, a consideration of optimal fluency performance might suggest the production of subcategories of semantically or phonemically related words (semantic or phonemic clusters) and, once a subcategory is exhausted, switching to another.

The following scores were obtained in the phonemic and semantic fluency tests: (1) number of words produced, excluding errors and repetitions (WP), (2) number of words related by cluster (RW), and (3) number of switches (WP − RW + number of clusters).

Detailed scoring rules for switching and clustering are provided in the Appendix.

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Semantic clustering score

In the semantic fluency task, clusters were defined as groups of contiguous words belonging to the same semantic subcategory, such as *farm animals*, *birds*, *fish* and *sea mammals* (semantic clusters). This is not required by instructions but provides an excellent means of finding out whether and how well participants organize their thinking. In an animal–name verbal fluency test, the participant might say "hen, dog, fly, whale, nightingale, snake, monkey," all of which are semantically linked to the required animal category. Alternatively, "hen, rooster, goose, fly, cockroach, black beetle, pigeon, gull, nightingale, canary" are all semantically related, but fall into three different subcategories; farm animals, insects, and birds. It is often possible to find a link between two consecutive words, but it is difficult to know whether or not the associations are generated through semantic clustering. To overcome this problem, associations were considered as semantic clusters only when at least three consecutive words were semantically related. The only exception to this rule was when two consecutive words were known to be associated in proverbs or the titles of well-known fables (e.g. *dog–cat* as in "raining cats and dogs," or *crow–fox* and *wolf–lamb*, which are pairs of words occurring in fables by Jean de Lafontaine).

Phonemic clustering score

In the phonemic fluency task, clusters were defined as groups of contiguous words that began with at least the same first two letters (e.g., *pri*ck, *pri*sm, *pri*son), and that differed only by a vowel sound (e.g. r*i*se, r*o*se, r*ou*se), or were homophones (e.g., some, sum). In the case of contiguous homophonic words, two words or more were sufficient to score a formal cluster. All the words belonging to a semantic or phonemic cluster are called related words (RW). Clusters were only scored if they were identified independently by two speech therapists trained in the analysis procedure. Neither assessor was involved in the neuropsychological evaluation.

Switching score

Switches were calculated as the number of transitions between clusters, including single words, in the phonemic and semantic tests. Errors and repetitions were excluded in cluster and switch scoring.

RESULTS

In each group the mean and standard deviation were calculated for each continuous demographic, clinical, and neuropsychological variable. The assumption of normality or homogeneity of variance was confirmed for each variable.

In each group and each fluency task (Table 1), the total number of words generated correlated both with the number of switches and with number of words related by clusters (RW). In the control group the total number of words generated in the phonemic fluency task correlated more strongly with the number of switches, whereas in the semantic fluency task the correlation with RW was stronger. In contrast, in the schizophrenic group, switching correlated more strongly than clustering with word production in both the phonemic and semantic fluency tasks.

Word production (WP), the number of words related by clusters (RW) and the number of switches were analyzed with two-way analysis of variance (ANOVA), with a between-participants factor (group: schizophrenics and controls) and a within-participants factor (condition: phonemic fluency and semantic fluency). The interactions (Group × Condition) were significant for WP [$F(1.138) = 6.61$, $p = .011$] and RW [$F(1.138) = 20.15$, $p < .001$] but not for the number of switches [$F(1.138) = 0.79$, $p = .374$]. The individual comparisons that were significant in the *post hoc* test with the Bonferroni correction are shown in Table 2. In comparison with the control group, the schizophrenics made a significant smaller number of switches in phonemic [$F(1.137) = 31.6$, $p < .001$] and semantic [$F(1.137) = 46.29$, $p < .001$] fluency tasks. RW was only significantly impaired in the semantic fluency task [$F(1.138) = 37.56$, $p < .001$].

Table 3 shows the score difference according to verbal fluency condition (semantic − phonemic) for WP, RW, and switches. Clustering (RW) was more important in the semantic task than in the phonemic task, both in the control group (paired *t* test; $t = 9.49$; $df = 59$; $p < .001$) and in the schizophrenic group ($t = 4.62$; $df = 77$; $p < .001$). In contrast, there was no significant difference in switching (number of switches).

Interrelationships between clinical dimensions and verbal fluency parameters in the overall schizophrenic population are shown in Table 4. Correlations were found between both negative and disorganized dimension on one hand and verbal fluency performance (WP and the number of switches

Table 1. Pearson correlation coefficients (r) between switches and words related by cluster (RW) in controls and in schizophrenics for phonemic and semantic fluency

	Phonemic fluency		Semantic fluency	
Group	Switches	RW	Switches	RW
Controls (word production)	.9***	.32**	.53***	.61***
Schizophrenics (word production)	.86***	.37**	.88***	.77***

$^{**}p < .01$. $^{***}p < .001$.

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Table 2. Demographic characteristics and fluency performances (*M* and *SD*) for control and schizophrenic groups

Variable	Controls ($N = 62$)	Schizophrenics ($N = 78$)	*p*
Age	31.9 (7.6)	31.8 (8.1)	
Sex	17F/45M	20F/58M	
Education level (years)	10.8 (3.1)	10.6 (3.1)	
Phonemic fluency			
Word production (WP)	40 (11.2)	29.1 (10.1)	***
Related words (RW)	7.1 (6.5)	5.6 (6.5)	
Switches	34.7 (10.6)	25 (9.6)	***
Semantic fluency			
Word production (WP)	47.4 (7.8)	32.7 (10)	***
Related words (RW)	18.9 (9.3)	10.3 (7.1)	***
Switches	34.1 (7.3)	25.8 (6.8)	***

***$p < .001$ (Bonferroni corrected significance level).

in phonemic fluency; WP and the number of RW in semantic fluency) on the other hand.

DISCUSSION

The aim of this study was to investigate the involvement of clustering and switching in a verbal fluency task.

In the healthy participants, both clustering and switching correlated strongly with the total number of words generated, implying that optimal fluency requires a balance between these two variables. During the semantic fluency task, as in a previous study (Robert et al., 1997), there was a strong positive correlation between clustering and the number of words produced. In the current study, switching also correlated strongly with the production of words. In the phonemic fluency task, switching was more important than clustering for optimal performance. These results are in agreement with the conclusions of Troyer et al. (1997), that switching and clustering can be considered as dissociable components of fluency performance.

The schizophrenic group differed from the healthy controls in several respects. First, the schizophrenic patients produced a smaller number of switches than the controls. Frith (1987, 1992) proposed that the central impairment in schizophrenia involves the initiation of actions. According to this theory there are two routes to action, one dependent on external factors, and one driven by internal goals and willed intentions (Elliot & Sahakian, 1995). Schizophrenic patients with negative symptoms should fail tests that require them to generate actions based on an internal goal; this is the case in the verbal fluency test, in which participants have to initiate a search through items in long-term memory. Switching is related to the ability to disengage from a previous word and to shift to a new word or a new subcategory. In this way switching could be considered as an initiation process which, when impaired, leads directly to a significant decrease in word production. The results in the healthy control group indicated that switching can be considered related to the frontal lobes. Firstly, switching correlated more strongly than clustering with word production in the phonemic fluency task, which is described to be specifically related to frontal functions (Crowe, 1992; Miceli et al., 1981). Secondly, switching, but not clustering, is impaired in conditions of divided attention, in which the secondary task (sequential finger tapping) is considered to interfere with frontal-lobe functions (Moscovitch, 1992, 1994). According to this hypothesis, the impairment of switching in the schizophrenic patients studied here is in keeping with the “frontal” impairments of schizophrenia (Shallice & Burgess, 1991a, 1991b).

The second difference between the schizophrenic and control participants involved the clustering component, as performance in fluency tasks (especially semantic fluency) is enhanced when clusters of meaningfully related words are produced (Estes, 1974). Clustering is a strategy of organization situated in the areas of executive functions but which also has privileged links with the lexical stock and semantic memory. The results of this study indicate that schizophrenics generate fewer related words (reflecting the clustering process) than healthy controls. This difficulty in using clustering has also been observed in Parkinson’s disease (Raskin et al., 1992) and has been revealed by using the cueing technique, which consists of comparing word production during a classical verbal fluency task and in a directed task. During this last version, the participants had to generate as many words as possible belonging to a specific category,

Table 3. Word production (WP), related words (RW) and switches: Score differences between the semantic and the phonemic fluency task

Score differences	Controls ($N = 62$)	Schizophrenics ($N = 78$)
Word production (WP)	7.4	3.6
Related words (RW)	11.8	4.7
Switches	−0.6	0.8

Table 4. Pearson correlation coefficients between SANS/SAPS three clinical dimensions and verbal fluency performances in the overall schizophrenic population

Clinical dimensions	Negative	Productive	Disorganized
Phonemic fluency			
Word production	−.321**	.238	−.288*
Related words	−.156	.191	−.017
Switches	−.244*	.149	−.280*
Semantic fluency			
Word production	−.291*	.198	−.275*
Related words	−.286*	.113	−.362**
Switches	−.203	.196	−.129

*$p < .05$. **$p < .01$.

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and every 20 s the investigator provided a more specific type of item within that category.

Joyce et al. (1996) found that this procedure, external aid with clustering, improved semantic fluency in 80% of schizophrenic patients. In addition to the clustering mechanism, it is necessary to assess the functioning of semantic memory, which refers to stored, impersonal information that includes, in particular, knowledge of words and their meanings (Tulving, 1983). Several studies have shown that semantic memory is affected in schizophrenia (Chen et al., 1994; Cutting & Murphy, 1988; McKay et al., 1996). We did not assess this component here, as it has been shown that semantic fluency performance is unrelated to performance in the Boston Naming Test, suggesting that impaired verbal fluency in schizophrenia is not due to an impoverished store of words but rather to a failure to access the semantic store efficiently.

Table 3 indicates that clustering was significantly more important during the semantic tasks than during the phonemic tasks, in both the schizophrenic and control groups. This could be due to a methodological problem corresponding to the difficulty of identifying phonemic strategies but also to a structural aspect of the phonemic fluency task, which uses the clustering strategy less but requires direct synergy between switching and the lexical stock. One could compare this to searching differently for information in a dictionary and a catalogue of products classified by the type of article. The fact that switching is the most clearly identifiable mechanism in the formal fluency task does not necessarily mean that it is less important in the semantic fluency task, which requires the use of the two mechanisms, both separately and together. Indeed, closely alternating use of the two mechanisms implies more complex regulation than that resulting from automatic functioning of a single mechanism. It is thus conceivable that the external initiation process is a more mentally demanding task during the semantic fluency test. It is also important to underline that the differences in clustering between semantic and phonemic fluency conditions were far larger in the controls than in the schizophrenics, as the schizophrenics were particularly impaired in clustering.

A correlation was found between the deficient negative dimension and word production in verbal fluency tests. Furthermore, the greater the severity of negative symptoms, the smaller the number of switches in phonemic fluency and the smaller the number of related words in semantic fluency. The same interrelations are found with the disorganization dimension. In contrast, there was no correlation with productive symptoms. These results agree with studies of deficient and disorganized schizophrenic patients suggesting a frontal dysfunction (Johnstone & Frith, 1996; Liddle, 1987a; 1987b) associated with a dysfunction of subcortical frontotemporal connections (Andreasen et al., 1996; Andreasen, 1997; Dolan et al., 1995; Fletcher et al., 1996; Frith et al., 1995).

From the neuropsychologic viewpoint, the results of this study confirm that schizophrenics have globally deficient performance in verbal fluency tasks. The observation of two underlying cognitive mechanisms, however, calls for comment. First, the schizophrenic patient's qualitative use of switching and clustering was the same as the healthy control's, but the quantitative performance was altered in the schizophrenic patients. It is important to identify the nature of the failure, as the verbal fluency test is nonspecific, and a quantitative deficiency in this test is found in other conditions (Caine et al., 1984; Cassens et al., 1990; Franke et al., 1993; Hart et al., 1987; Speedie et al., 1990; Trichard, 1995). Results of another study using the same methodology (Lafont et al., in press) in 16 depressive patients and 11 controls indicates that, in a semantic fluency test, depressed individuals are deficient in switching but not in clustering. This suggests that deficient performance in a verbal fluency test is not always due to concomitant involvement of initiation and organization processes as in schizophrenia. Second, a knowledge of the use of these mechanisms is valuable for individual patient management. Indeed, it is useful to evaluate, in a given patient, the respective importance of the deficiencies in the initiation and organization processes so as to adapt rehabilitation by focusing on the least altered function.

In summary, this study confirms that switching and clustering in normal individuals are strongly related to the total number of words generated during verbal fluency tasks, indicating that they reflect important underlying cognitive processes. The role of the two components is partly dependent on the specific fluency task. Switching is prevalent in phonemic fluency, while both switching and clustering participate in semantic fluency. Close examination of clustering and switching scores provides information on mental initiation and organization. In comparison to healthy controls, schizophrenic patients show an impairment of switching in formal fluency and of both switching and clustering in semantic fluency.

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Appendix

SCORING RULES FOR CLUSTERING AND SWITCHING

Clustering in Phonemic Fluency

Clusters in phonemic fluency trials consisted of successively produced words that shared any of the following phonemic characteristics:

1. *First letters:* at least three successive words beginning with the same two letters such as "*pr*ick, *pr*ism, *pr*ison."
2. *Vowel sound:* at least two successive words that differed only by a vowel sound, such as "r*i*se, r*o*se, r*ou*se."
3. Homophones: at least two successive words with the same oral shape but with different spellings, such as "some, sum."

Example of Phonemic Instance Generation and Scoring

"Paper, power, *product*, *profanation*, *profession*, *progress*, pig, pillow, poison."

- Word production (WP) = 9
- Semantic clusters = 0
- Phonemic clusters = 1
- Related words (RW) = 4
- Switches (WP − RW) + number of clusters = (9 − 4) + 1 = 6.

Clustering in Semantic Fluency

Clusters in semantic fluency trials consisted of the following:

1. At least three successively produced words belonging to the same semantic subcategory, such as listed below.
2. At least two successive words commonly used in proverbs or in titles of well-known fables (e.g., *dog–cat*, as in "raining cats and dogs," or *crow–fox* and *wolf–lamb*, which are pairs of words occurring in fables by Jean de Lafontaine).

Semantic Subcategories in the Animal Word Trial

- Farm animals:
  - Farmyard animals
  - Quadrupedes
  - Gallinaceae
  - Herd animals
- Aquatic animals:
  - Fish:
    - Sea fish
    - Coarse fish
  - Sea mammals
  - Shellfish
- Birds:
  - Birds of prey
  - Pet birds
  - Sea birds
  - Migrating birds

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- Deer family:
  - Deer family animals of the forest
  - Deer family animals of the frozen north
- Insects:
  - Stinging insects
  - Skin parasites
- Reptiles:
  - Crocodiles
- Big game:
  - Monkeys
  - Mountain mammals
  - Gnawing animals
  - Ice floe animals
  - Equidae
  - Bovidae
  - Pets
  - Bears
  - Predators and prey
  - Game animals
  - Creeping animals
  - Pig family

Example of Animal Name Category Instance Generation and Scoring

"*Dog*, *cat*, monkey, *hen*, *rooster*, *goose*, whale, *fly*, *cockroach*, *black beetle*, snake, *pigeon*, *gull*, *nightingale*, *canary*."

- Word production (WP) = 15
- Semantic clusters = 4
- Phonemic clusters = 0
- Related words (RW) = 12
- Switches (WP − RW) + number of clusters = (15 − 12) + 4 = 7

Semantic Subcategories for the Fruit Category, Commonly Generated Subcategories

- Dried fruit
- Red fruit
- Exotic fruit
- Citrus fruit

Example of Fruit Name Category Instance Generation and Scoring

"*Orange*, *lemon*, *grapefruit*, banana, plum, grape, *date*, *fig*, *almond*, peach, apricot, pineapple, avocado, *blackberry*, *cherry*, *strawberry*."

- Word production (WP) = 16
- Semantic clusters = 3
- Phonemic clusters = 0
- Related words (RW) = 9
- Switches (WP − RW) + number of clusters = (16 − 9) + 3 = 10

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