Journal of the International Neuropsychological Society (1998), **4**, 137–143.

Clustering and switching on verbal fluency tests in Alzheimer's and Parkinson's disease

ANGELA K. TROYER,[1] MORRIS MOSCOVITCH,[1,2,3] GORDON WINOCUR,[1,4] LARRY LEACH,[2] AND MORRIS FREEDMAN[1,5]

[1]Rotman Research Institute of Baycrest Geriatric Centre; University of Toronto, Toronto, ON, Canada
[2]Department of Psychology, Baycrest Geriatric Centre, Toronto, ON, Canada
[3]Erindale College, Mississauga, ON, Canada
[4]Trent University, Peterborough, ON, Canada
[5]Behavioral Neurology Program, Baycrest Geriatric Centre; Department of Medicine (Division of Neurology), Mount Sinai Hospital and University of Toronto, Toronto, ON, Canada

(RECEIVED July 15, 1996; REVISED June 2, 1997; ACCEPTED June 27, 1997)

Abstract

Two components of verbal fluency performance—clustering (i.e., generating words within subcategories) and switching (i.e., shifting between subcategories)—were examined in patients with dementia of the Alzheimer type (DAT), patients with dementia with Parkinson's disease (DPD), nondemented patients with Parkinson's disease (NPD), and demographically matched controls. The DAT and DPD groups were impaired in the number of words generated on both phonemic and semantic fluency. The DAT group produced smaller clusters on both tasks and switched less often on semantic fluency than controls. The DPD group switched less often on both tasks and produced smaller clusters on phonemic fluency than controls. The NPD group was not impaired on any fluency variable. Thus, the total number of words generated on phonemic and semantic fluency did not discriminate the dementia groups from their respective control groups, but measures of clustering and switching did. This differential pattern of performance provides evidence for the potential usefulness of measures of switching and clustering in the assessment of dementia. (*JINS*, 1998, *4*, 137–143.)

Keywords: Verbal fluency, Dementia of the Alzheimer type, Parkinson's disease

INTRODUCTION

Tests of verbal fluency are commonly used in clinical and experimental settings with patients with dementia and are sensitive to both the presence and severity of dementia (Hodges & Patterson, 1995; Jacobs et al., 1995; Monsch et al., 1992; Nebes, 1989). The procedure for fluency tests allows the participant 60 s to generate as many words as possible. On tests of phonemic fluency, words must begin with a specified letter such as "s," and on semantic fluency, words must belong to a specified category such as *animals*. The present study was conducted to determine whether two components of verbal fluency, clustering and switching, can differentiate dementia groups with equivalent overall performance on tests of semantic and phonemic fluency.

Reprint requests to: A. Troyer, Rotman Research Institute, Baycrest Centre for Geriatric Care, 3560 Bathurst Street, Toronto, ON M6A 2E1, Canada. E-mail: a.troyer@utoronto.ca.

Fluency in Alzheimer's Disease

An impairment in the number of words generated on verbal fluency tasks has been well documented in dementia of the Alzheimer type (DAT; Chertkow & Bub, 1990; El-Awar et al., 1987; Martin & Fedio, 1983; Mickanin et al., 1994; Monsch et al., 1992, 1994; Ober et al., 1986; Randolph et al., 1993; Shuttleworth & Huber, 1988; Tröster et al., 1989). This impairment in DAT appears to be related to semantic-memory deficits, which are an early feature of DAT (e.g., Hodges & Patterson, 1995). There is evidence, for example, that DAT patients are more impaired on semantic fluency than on phonemic fluency (Butters et al., 1987; Mickanin et al., 1994; Monsch et al., 1994; Pasquier et al., 1995; Rosser & Hodges, 1994), although this pattern is not always obtained (Bayles et al., 1989, 1993; Hart et al., 1988; Ober et al., 1986; Rosen, 1980). Compatible with a semantic-memory-deficit hypothesis, DAT patients rarely generated items on semantic fluency tests for which they were unable

to answer semantic-probe questions (Chertkow & Bub, 1990). Furthermore, DAT patients did not improve on animal fluency when provided with subcategory prompts, such as *pets* and *jungle animals*, at 15-s intervals, suggesting that degradation of semantic stores, rather than a retrieval deficit, was the source of the impairment (Randolph et al., 1993). Additionally, on supermarket fluency, DAT patients generated fewer items per subcategory sampled and also produced a greater proportion of general subcategory labels (as opposed to specific exemplars), suggesting that the specific defining features of the subcategories were lost or inaccessible (Martin & Fedio, 1983; Ober et al., 1986; Tröster et al., 1989).

It is apparent, however, that impaired semantic memory does not fully account for the fluency deficit in DAT. Chertkow and Bub (1990) found no direct correspondence between the specific semantic categories on which DAT patients were relatively impaired at answering semantic-probe questions and the categories on which the same patients showed decreased verbal fluency. Furthermore, the ability to name an object is associated with intact semantic knowledge of that object (Chertkow & Bub, 1990; Flicker et al., 1987; Huff et al., 1986), and DAT patients generated only half the items that they had earlier been able to name (Chertkow & Bub, 1990).

Impairments in lexical processes and cognitive shifting have also been implicated in the fluency deficit in DAT. Bayles et al. (1989) found that better performance on phonemic fluency, relative to semantic fluency, was associated with good performance on a test of writing to dictation. Both tests require consideration of the characteristics of words *per se*, and the correlation between these tests was interpreted as reflecting the importance of lexical processes for phonemic fluency. Better performance on semantic fluency, on the other hand, was associated with good performance on Trail Making Test Part B, possibly reflecting the importance of executive processes such as shifting from one subcategory to another on semantic fluency.

In summary, DAT is consistently associated with a verbal fluency deficit. Impairments in a number of areas of cognitive functioning appear to contribute to this deficit, including impaired semantic memory, lexical processes, and cognitive shifting.

Fluency in Parkinson's Disease

Impaired fluency performance has also been noted among patients with Parkinson's disease (PD; Auriacombe et al., 1993; Dubois et al., 1988; El-Awar et al., 1987; Gurd & Ward, 1989; Jacobs et al., 1995; Randolph et al., 1993). Patients with dementia with PD (DPD) perform more poorly than nondemented patients with PD (NPD) on fluency tasks (Beatty et al., 1989; Cummings et al., 1988). Whereas impaired fluency among NPD patients in comparison to controls has been found in some studies (Bayles et al., 1993; Cummings et al., 1988; Hanley et al., 1990), normal levels of performance have been reported in others (Beatty et al., 1989; Caltagirone et al., 1989; Taylor et al., 1986).

A specific difficulty with search and retrieval processes has been documented among patients with PD (e.g., Auriacombe et al., 1993; Beatty et al., 1989; Taylor et al., 1986), and there is evidence that the fluency impairment in PD is related to this difficulty. For example, semantic fluency among PD patients was impaired relative to controls under normal, uncued procedures, but was unimpaired when subcategory prompts were provided (Randolph et al., 1993). Furthermore, semantic fluency in PD was significantly correlated with free recall of a word list—a memory task with heavy demands on retrieval processes, but not with recognition of the word list—a task in which retrieval processes are less involved (Auriacombe et al., 1993).

Fluency deficits in PD may also be related to a difficulty in shifting attention. PD patients were more impaired on fluency tasks requiring alternation between a phonemic and a semantic category than on tasks not requiring such alternation (Downes et al., 1993), although this pattern is not always obtained (Cooper et al., 1991; Gurd & Ward, 1989).

In summary, there is evidence of a fluency deficit associated with PD, at least among PD patients with dementia. This deficit appears to be related to impairments in search and retrieval processes and attention shifting.

Components of Performance on Fluency Tasks

The total number of correct words generated is the index most commonly used to examine performance on fluency tasks. This index, however, does not necessarily discriminate between different dementia populations. DAT patients, for example, have been found to be more impaired (e.g., Cummings et al., 1988), equally impaired (e.g., Bayles et al., 1993), and less impaired (e.g., Stern et al., 1993) than DPD patients in the number of words generated on fluency tasks.

Furthermore, the total number of words does not provide information about the underlying cognitive components involved in fluency performance. There is evidence that healthy subjects tend to produce words within clusters on fluency tests (e.g., Gruenewald & Lockhead, 1980; Troyer et al., 1997a; Wixted & Rohrer, 1994). Clustering has been examined to a limited extent in patient populations. For example, among patients with DAT, on a phonemic fluency test, 16% of responses were phonetically related and 3% of responses were semantically related to adjacent responses (Bayles et al., 1989). Raskin et al. (1992) demonstrated that NPD patients produced a smaller proportion of semantic clusters than did controls on a semantic fluency task, whereas there were no group differences in phonemic clusters on that task, nor in phonemic or semantic clusters on a phonemic fluency task. In contrast, Auriacombe et al. (1993) found no differences between NPD patients and controls in the proportion of words produced within semantic or phonemic clusters on semantic and phonemic fluency tests.

https://doi.org/10.1017/S1355617798001374 Published online by Cambridge University Press

We have proposed that two important aspects of fluency performance include (1) clustering, the production of words within clusters or subcategories; and (2) switching, the ability to shift efficiently between clusters (Troyer et al., 1997a). We conceptualize these as two components that are necessary for optimal fluency performance and that, together, determine the number of words generated. When applied to normal populations, clustering and switching indices were dissociable, predictive of the total number of words generated, and sensitive to age differences (Troyer et al., 1997a). Related research has implicated the role of the temporal lobes in semantic memory (e.g., Hodges et al., 1992; Pietrini et al., 1988; Warrington & Shallice, 1984) and the frontal lobes in set shifting (e.g., Owen et al., 1991; Vilkki & Holst, 1994). Similarly, we have suggested that, on tests of verbal fluency, clustering relies on temporal-lobe functioning whereas switching relies on frontal-lobe functioning. We have provided evidence for the latter in studies indicating that switching is sensitive to manipulations of attention (Troyer et al., 1997a) and to focal frontal-lobe lesions (Troyer et al., 1997b).

Among patients with dementia, clustering has been examined to some extent, whereas switching has not. The purpose of the present study was to examine clustering and switching on verbal fluency tasks in patients with DAT and PD. We hypothesized that DAT patients would be impaired on clustering on both fluency tasks because clustering involves temporal-lobe abilities such as word storage and semantic memory and because DAT involves predominant neuropathological changes in the temporal lobes, among other brain regions (e.g., Braak & Braak, 1991; Hyman et al., 1984; McKee et al., 1991). Additionally, we hypothesized that PD patients would be impaired on switching on both fluency tasks because switching involves frontal-lobe abilities such as cognitive flexibility and shifting and because PD involves brain changes that predominate in frontal–subcortical structures (e.g., Freedman, 1990; Taylor et al., 1986).

METHODS

Research Participants

Four groups participated in the study (Table 1). All participants, including patients and controls, were screened for neurologic and psychiatric disorders other than their primary diagnoses.

Twenty-three patients were diagnosed with DAT according to NINCDS–ADRDA criteria (McKhann et al., 1984). In the DAT group, the mean Dementia Rating Scale (DRS; Mattis, 1988) score was 118.8, indicating an overall mild level of dementia.

Patients with idiopathic PD were classified as demented or nondemented according to scores obtained on the DRS, with a score less than 133 defining dementia (Freedman & Oscar-Berman, 1986). Eleven DPD patients had a mean DRS score of 123.8, indicating an overall mild level of dementia. Eleven NPD patients were matched with the DPD group for age, education, and sex. The mean DRS score of 139.5 for the NPD group was within the normal range. Disease duration was equivalent for the two PD groups [$t(20) = .62$, $p = .54$]. Beck Depression Inventory (Beck, 1987) scores did not differ significantly between the DPD ($M = 8.3$) and NPD ($M = 7.2$) groups [$t(20) = .34$, $p = .74$]. Medication usage at the time of assessment for the DPD group included levodopa ($n = 9$), anticholinergic agents ($n = 2$), and no medications ($n = 1$); for the NPD group, medications included levodopa ($n = 9$) and anticholinergic agents ($n = 5$).

To examine whether the dementia groups were qualitatively distinct in their cognitive profiles, performance on the DRS subscales was compared. On the overall DRS score and on all five subscales, the DAT group obtained lower scores than the DPD group, although this difference was significant only for the memory subscale [$M = 15.1$ and 20.1, respectively; $t(23) = 3.69$, $p = .001$]. On average, 6.5 and 5.5 points were lost on the DRS fluency task for the DAT and DPD groups, respectively, indicating that this task alone accounts for only a portion of the total points lost.

Thirty-eight demographically matched participants served as controls. The patient and control groups did not differ in age [$F(3,79) = 2.06$, $p = .112$], education [$F(3,79) = 1.88$, $p = .139$], or sex [$\chi^2(3, N = 83) = 7.09$, $p > .05$]. The Mini Mental Status Exam (Folstein et al., 1975) was used as a screen for dementia in the contol group. Points obtained on this scale ranged from 25 to 30 (i.e., above the cutoff of 24/30), with a mean score of 28.4 ($SD = 1.4$).

Table 1. Sample characteristics

Variable	DAT	DPD	NPD	Controls
N	23	11	11	38
Age	70.3 (8.4)	72.5 (3.1)	69.6 (4.9)	73.8 (6.2)
Percent female	47.8	18.2	18.2	36.8
Education, years	13.0 (3.3)	12.5 (3.9)	15.1 (3.5)	12.6 (2.7)
Disease duration, years	2.4 (1.2)	3.6 (2.8)	4.4 (3.0)	—
Dementia Rating Scale	118.8 (13.1)	123.8 (12.9)	139.5 (2.5)	—

DAT = patients with dementia of the Alzheimer type; DPD = patients with dementia with Parkinson's Disease; NPD = nondemented patients with Parkinson's Disease. Standard deviations are shown in parentheses.

https://doi.org/10.1017/S1355617798001374 Published online by Cambridge University Press

Procedures and Scoring

Tests of phonemic fluency (i.e., FAS test; Benton, 1968; Borkowski et al., 1967) and semantic fluency (i.e., animals; Newcombe, 1969) were administered on an individual basis. Sixty-second intervals were given for each of the three phonemic trials and one semantic trial.

Three scores were obtained on each fluency test: (1) total number of words generated, excluding errors and repetitions; (2) cluster size; and (3) switches. Detailed scoring rules are provided by Troyer et al. (1997a). Briefly, on phonemic fluency, clusters were defined as groups of successively generated words that began with the same first two letters, differed only by a vowel sound, rhymed, or were homonyms. On semantic fluency, clusters were defined as groups of successively generated words that belonged to the same semantic subcategory, such as farm animals, pets, aquatic animals, African animals, and insects. Cluster size was counted beginning with the second word in each cluster, and the mean cluster size was calculated for each fluency test. Switches were calculated as the number of transitions between clusters for the phonemic and semantic tests. Errors and repetitions were included in calculations of cluster size and switching because any word that is produced provides information about the underlying cognitive processes regardless of whether or not it contributes to the total correct number of words generated.

All protocols were scored by the first author, and a subset of protocols ($n = 23$) were scored for cluster size and number of switches by an independent rater. Interrater reliabilities, calculated with Pearson correlation coefficients, were within acceptable ranges, and were .98 for phonemic fluency cluster size, .99 for phonemic fluency switching, .85 for semantic fluency cluster size, and .79 for semantic fluency switching.

Analyses

Overall differences between the patient and control groups were assessed with analysis of variance (ANOVA), with an alpha level of .05 used as the cutoff for significance. *Post-hoc* pairwise comparisons between each patient group and the control group were assessed using Dunn's test (i.e., Bonferroni t). An alpha level of .017 (i.e., .05/3) was used for these multiple comparisons.

Because the demographic characteristics (i.e., sex ratio) of the patient groups were not matched exactly, we also performed the same analyses using separate, demographically matched control groups for the DAT group and the two PD groups. These analyses produced the same pattern of results and therefore are not discussed further.

RESULTS

Fluency data are shown in Table 2. ANOVA indicated significant overall group differences on all fluency measures, including the number of words generated on phonemic fluency [$F(3,74) = 10.88$, $p < .001$], and semantic fluency [$F(3,78) = 31.01$, $p < .001$]; clustering on phonemic fluency [$F(3,74) = 5.47$, $p = .002$], and semantic fluency [$F(3,78) = 3.22$, $p = .027$]; and switching on phonemic fluency [$F(3,74) = 3.74$, $p = .015$], and semantic fluency [$F(3,78) = 11.03$, $p < .001$]. Pairwise comparisons indicated a specific pattern of performance by the patient groups in comparison to controls, as described subsequently.

The DAT group generated significantly fewer words than controls on both phonemic fluency [$F(1,74) = 20.40$, $p < .001$], and semantic fluency [$F(1,78) = 75.63$, $p < .001$]. As hypothesized, the DAT group produced smaller clusters than controls (i.e., approximately half as large), both on phonemic fluency [$F(1,74) = 11.64$, $p = .001$], and semantic fluency [$F(1,78) = 8.38$, $p = .005$]. There was no significant group difference in the number of switches on phonemic fluency [$F(1,74) = 4.83$, $p = .031$], whereas the DAT group switched less frequently than controls on semantic fluency [$F(1,78) = 20.45$, $p < .001$].

The DPD group generated significantly fewer words than controls on both phonemic fluency [$F(1,74) = 19.05$, $p < .001$], and semantic fluency [$F(1,78) = 36.72$, $p < .001$].

Table 2. Fluency data

	DAT	DPD	NPD	Controls
Measure	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
Phonemic fluency				
Words generated	26.7** (14.1)	24.5** (10.5)	38.7 (9.7)	40.8 (9.6)
Switches	21.3 (10.3)	19.7* (9.8)	28.5 (6.7)	26.5 (6.8)
Cluster size	0.2* (0.2)	0.2* (0.1)	0.4 (0.2)	0.5 (0.4)
Semantic fluency				
Words generated	8.3** (4.2)	9.4** (3.2)	16.1 (4.4)	17.9 (4.2)
Switches	5.1** (2.9)	4.5** (2.1)	8.1 (2.9)	8.3 (2.4)
Cluster size	0.6* (0.4)	1.2 (1.3)	1.0 (0.5)	1.1 (0.6)

DAT = patients with dementia of the Alzheimer type; DPD = patients with dementia with Parkinson's Disease; NPD = nondemented patients with Parkinson's Disease. Comparisons were performed between groups within each fluency task component. Asterisks indicate which patient groups differed from controls.
*$p < .017$; **$p < .001$.

https://doi.org/10.1017/S1355617798001374 Published online by Cambridge University Press

As hypothesized, the DPD group switched less frequently than controls on both phonemic fluency [$F(2,44) = 4.76$, $p = .013$], and semantic fluency [$F(2,44) = 10.76$, $p < .001$], with decreases of approximately 50% in the DPD group in comparison to controls. The DPD group produced smaller clusters than controls on phonemic fluency [$F(2,44) = 5.66$, $p = .007$], but not semantic fluency [$F(2,44) < 1$, $p = .81$].

In contrast to the two dementia groups, the NPD group did not differ from the control group on any fluency variable.

Our analyses indicated that the overall number of words generated did not discriminate the two dementia groups. To examine whether *relative* impairments in the number of words generated on phonemic *versus* semantic fluency discriminated the groups, each patient's score was converted to a standardized score based on the mean performance of the control group. There was no interaction between the standardized scores obtained by the DAT group for phonemic ($z = -1.6$) and semantic ($z = -2.5$) fluency and standardized scores obtained by the DPD group for phonemic ($z = -1.6$) and semantic ($z = -2.0$) fluency [$F(1,26) = 1.96$, $p = .173$].

DISCUSSION

Patients with DAT and patients with DPD generated fewer words than their respective controls and demonstrated equivalent impairment rates on both phonemic and semantic fluency. Thus, the total number of words generated on the two fluency tasks did not distinguish the dementia groups. A dissociation was obtained, however, on measures of clustering and switching, with DAT patients consistently impaired on clustering and DPD patients consistently impaired on switching on both fluency tasks, as hypothesized. The magnitude of many of these group performance differences was 50% or more. More specifically, the variables that best distinguished the two patient groups included (1) semantic fluency cluster size, which was impaired in DAT patients and unimpaired in DPD patients relative to controls; and (2) phonemic fluency switching, which was impaired in DPD patients and unimpaired in DAT patients relative to controls. Global impairments, therefore, were not obtained, indicating that group performance differences could not be attributed simply to the severity of dementia. The differential pattern of performance provides evidence for the potential usefulness of measures of switching and clustering in the assessment of dementia. Despite some similarities in the neuropathological and neurocognitive changes that occur in dementia associated with Alzheimer's and Parkinson's diseases, we were able to obtain some specific effects of these dementias on our fluency variables. This adds to what is already known about the differences in neurocognitive functioning between cortical and subcortical dementias.

The pattern of impairments obtained on switching and clustering was not completely consistent across fluency tasks for the two dementia groups, similar to findings from healthy participants (Troyer et al., 1997a). That is, in addition to the consistent impairments across tasks described previously, DAT patients were impaired on switching on semantic fluency but not phonemic fluency, and DPD patients were impaired on clustering on phonemic fluency but not semantic fluency. The nature of switching and clustering, therefore, appears to be somewhat dependent on the specific fluency task. We address possible reasons for these differences subsequently.

Our finding of smaller cluster sizes on semantic fluency among patients with DAT is consistent with the suggestion that impoverished semantic memory contributes to the fluency impairment in this population (e.g., Mickanin et al., 1994; Monsch et al., 1994; Randolph et al., 1993). That is, producing words within semantic clusters requires the ability to identify semantic subcategories and to generate examples of these subcategories, and this semantic ability is impaired in DAT. Somewhat unexpectedly, DAT patients switched less frequently than controls on semantic fluency. It is possible that DAT-related semantic memory impairments resulted in a difficulty distinguishing subcategories of animals and, thus, a difficulty switching between these subcategories. Severe semantic impairments, in other words, could potentially affect both clustering and switching on semantic fluency. An alternative explanation for the semantic fluency switching impairment is that decreased switching may reflect deficient search processes within semantic memory. As previously reviewed, it is clear that DAT is associated with impairments in semantic search and retrieval processes (e.g., Bayles et al., 1989; Chertkow & Bub, 1990). These processes would be necessary for systematically searching through the category *animals* and retrieving a varied and representative selection of subcategories from which to sample.

On phonemic fluency, smaller cluster sizes among the DAT patients also indicate the presence of impaired lexical–phonemic stores, whereas unimpaired switching on this task suggests that search processes within the lexical system were intact. Therefore, there does not appear to be a general deficit of search processes in DAT.

Among the DPD patients, the finding of decreased switching across fluency tasks is consistent with previous reports of impaired search and retrieval processes in this patient population (e.g., Randolph et al., 1993; Raskin et al., 1992). Although a causal relation cannot be directly tested, it is plausible that decreased switching between subcategories resulted in a decrease in the overall number of words generated on the fluency tasks. This interpretation would be consistent with our original idea that clustering and switching, as two components of fluency, determine the number of words generated. Furthermore, a previous study indicated high correlations between switching and total number of words generated (i.e., $r = .53–.85$) among healthy adults (Troyer et al., 1997a).

Surprisingly, PD group differences were also obtained in cluster size on phonemic fluency. As we have suggested for healthy young adults, the subcategories utilized in phonemic fluency may be less salient than those used in semantic

https://doi.org/10.1017/S1355617798001374 Published online by Cambridge University Press

fluency (Troyer et al., 1997a). It is possible, therefore, that the use of clusters on phonemic fluency is a deliberate, strategic approach to this task, whereas using the more salient clusters on semantic fluency is more automatic given intact semantic memory. Impairments in strategic problem solving have been documented in PD (e.g., Caltagirone et al., 1989; Cooper et al., 1991; Taylor et al., 1986), and it is possible that our PD patients failed to discern the usefulness of generating together words with similar phonemic characteristics.

As previously reviewed, studies examining the extent to which fluency performance is affected among nondemented PD patients have been inconsistent. Our findings provide some support for those studies indicating no impairments among NPD patients in the total number of words generated (Beatty et al., 1989; Caltagirone et al., 1989; Taylor et al., 1986) or in clustering (Auriacombe et al., 1993). Indeed, although we employed only a small sample, our NPD patients did not differ from controls on any fluency variable. Additionally, 5 of the 11 NPD patients were taking anticholinergic medications at the time of testing, indicating that these medications did not significantly impair fluency performance.

The pattern of findings obtained in the present study provides support for the idea that cluster size is related to temporal-lobe functioning whereas switching is related to frontal-lobe functioning. Neuropathological changes in the brain in DAT occur primarily in temporal and parietal regions and secondarily in frontal regions (e.g., McKee et al., 1991). This corresponds to the consistent decrease in cluster size on both fluency tests, and the decrease in switching on semantic fluency only. Brain changes in PD, on the other hand, occur primarily in the frontal–neostriatal systems (e.g., Freedman, 1990; Taylor et al., 1986), and this corresponds to the consistent difficulty with switching on both fluency tests. Both DAT and PD, however, involve relative regional brain changes in the context of diffuse brain changes, and conclusions about the specific regions involved in fluency tasks based on these patient groups are therefore preliminary. An examination of fluency performance among patients with focal brain lesions would permit a more specific analysis of the brain regions involved in clustering and switching.

ACKNOWLEDGMENTS

The present research was supported by grants from the Medical Research Council of Canada (M. Moscovitch and G. Winocur, MA-6694; M. Freedman and M. Moscovitch, MT-13367). A. Troyer was supported by the Ben and Hilda Katz Postdoctoral Research Fellowship at the Rotman Research Institute. Partial data from this paper were presented at the 24th Annual Meeting of the International Neuropsychological Society in Chicago, IL. We thank Brenda Melo, Rebecca Toth, Grace Azevedo, and Moshe Huberman for their assistance with data collection and scoring.

REFERENCES

Auriacombe, S., Grossman, M., Carvell, S., Gollomp, S., Stern, M.B., & Hurtig, H.I. (1993). Verbal fluency deficits in Parkinson's disease. *Neuropsychology*, *7*, 182–192.

Bayles, K.A., Salmon, D.P., Tomoeda, C.K., Jacobs, D., Caffrey, J.T., Kaszniak, A.W., Tröster, A.I. (1989). Semantic and letter category naming in Alzheimer's patients: A predictable difference. *Developmental Neuropsychology*, *5*, 335–347.

Bayles, K.A., Trosset, M.W., Tomoeda, C.K., Montgomery, E.B., & Wilson, J. (1993). Generative naming in Parkinson disease patients. *Journal of Clinical and Experimental Neuropsychology*, *15*, 547–562.

Beatty, W.W., Staton, R.D., Weir, W.S., Monson, N., & Whitaker, H.A. (1989). Cognitive disturbances in Parkinson's disease. *Journal of Geriatric Psychiatry and Neurology*, *2*, 22–33.

Beck, A.T. (1987). *Beck Depression Inventory*. San Antonio, TX: The Psychological Corporation.

Benton, A.L. (1968). Differential behavioral effects in frontal lobe disease. *Neuropsychologia*, *6*, 53–60.

Borkowski, J.G., Benton, A.L., & Spreen, O. (1967). Word fluency and brain damage. *Neuropsychologia*, *5*, 135–140.

Braak, H. & Braak, E. (1991). Neuropathological staging of Alzheimer-related changes. *Acta Neuropathologica*, *82*, 239–259.

Butters, N., Granholm, E., Salmon, D.P., Grant, I., & Wolfe, J. (1987). Episodic and semantic memory: A comparison of amnesic and demented patients. *Journal of Clinical and Experimental Neuropsychology*, *9*, 479–497.

Caltagirone, C., Carlesimo, A., Nocentini, U., & Vicari, S. (1989). Defective concept formation in Parkinsonians is independent from mental deterioration. *Journal of Neurology, Neurosurgery, and Psychiatry*, *52*, 334–337.

Chertkow, H. & Bub, D. (1990). Semantic memory loss in dementia of Alzheimer's type. *Brain*, *113*, 397–417.

Cooper, J.A., Sagar, H.J., Jordan, N., Harvey, N.S., & Sullivan, E.V. (1991). Cognitive impairment in early, untreated Parkinson's disease and its relationship to motor disability. *Brain*, *114*, 2095–2122.

Cummings, J.L., Darkins, A., Mendez, M., Hill, M.A., & Benson, D.F. (1988). Alzheimer's disease and Parkinson's disease: Comparison of speech and language alterations. *Neurology*, *38*, 680–684.

Dubois, B., Pillon, B., Legault, F., Agid, Y., & Lhermitte, F. (1988). Slowing of cognitive processing in progressive supranuclear palsy: A comparison with Parkinson's disease. *Archives of Neurology*, *45*, 1194–1199.

Downes, J.J., Sharp, H.M., Costall, B.M., Sagar, H.J., & Howe, J. (1993). Alternating fluency in Parkinson's disease: An evaluation of the attentional control theory of cognitive impairment. *Brain*, *116*, 887–902.

El-Awar, M., Becker, J.T., Hammond, K.M., Nebes, R.D., & Boller, F. (1987). Learning deficit in Parkinson's disease: Comparison with Alzheimer's disease and normal aging. *Archives of Neurology*, *44*, 180–184.

Flicker, C., Ferris, S.H., Crook, T., & Bartus, R.T. (1987). Implications of memory and language dysfunction in the naming deficit of senile dementia. *Brain and Language*, *31*, 187–200.

Folstein, M.F., Folstein, S.E., & McHugh, P.R. (1975). Mini-Mental State: A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research*, *12*, 189–198.

Freedman, M. (1990). Parkinson's disease. In J.L. Cummings (Ed.), *Subcortical dementia* (pp. 108–122). Toronto, Canada: Oxford University Press.

Freedman, M. & Oscar-Berman, M. (1986). Selective delayed re-

sponse deficits in Parkinson's and Alzheimer's disease. *Archives of Neurology*, *43*, 886–890.
Gruenewald, P.J. & Lockhead, G.R. (1980). The free recall of category examples. *Journal of Experimental Psychology: Human Learning and Memory*, *6*, 225–240.
Gurd, J.M. & Ward, C.D. (1989). Retrieval from semantic and letter-initial categories in patients with Parkinson's disease. *Neuropsychologia*, *27*, 743–746.
Hanley, J.R., Dewick, H.C., Davies, A.D.M., Playfer, J., & Turnbull, C. (1990). Verbal fluency in Parkinson's disease. *Neuropsychologia*, *28*, 737–741.
Hart, S., Smith, C.M., & Swash, M. (1988). Word fluency in patients with early dementia of Alzheimer type. *British Journal of Clinical Psychology*, *27*, 115–124.
Hodges, J.R. & Patterson, K. (1995). Is semantic memory consistently impaired early in the course of Alzheimer's disease? Neuroanatomical and diagnostic implications. *Neuropsychologia*, *33*, 441–459.
Hodges, J.R., Patterson, K., Oxbury, S., & Funnell, E. (1992). Semantic dementia: Progressive fluent aphasia with temporal lobe atrophy. *Brain*, *115*, 1783–1806.
Huff, F.J., Corkin, S., & Growdon, J.H. (1986). Semantic impairment and anomia in Alzheimer's disease. *Brain and Language*, *28*, 235–249.
Hyman, B.T., van Hoesen, G.W., Damasio, A.R., & Barnes, C.L. (1984). Alzheimer's disease: Cell-specific pathology isolates the hippocampal formation. *Science*, *225*, 1168–1170.
Jacobs, D.M., Marder, K., Côté, L.J., Sano, M., Stern, Y., & Mayeux, R. (1995). Neuropsychological characteristics of preclinical dementia in Parkinson's disease. *Neurology*, *45*, 1691–1696.
Martin, A. & Fedio, P. (1983). Word production and comprehension in Alzheimer's disease: The breakdown of semantic knowledge. *Brain and Language*, *19*, 124–141.
Mattis, S. (1988). *Dementia Rating Scale*. Odessa, FL: Psychological Assessment Resources.
McKee, A.C., Kosik, K.S., & Kowall, N.W. (1991). Neuritic pathology and dementia in Alzheimer's disease. *Annals of Neurology*, *30*, 156–165.
McKhann, G., Drachmann, D., Folstein, M., Katzman, R., Price, D., & Stadlan, E.M. (1984). Clinical diagnosis of Alzheimer's disease. *Neurology*, *34*, 939–944.
Mickanin, J., Grossman, M., Onishi, K., Auriacombe, S., & Clark, C. (1994). Verbal and nonverbal fluency in patients with probable Alzheimer's disease. *Neuropsychology*, *8*, 385–394.
Monsch, A.U., Bondi, M.W., Butters, N., Paulsen, J.S., Salmon, D.P., Brugger, P., & Swenson, M.R. (1994). A comparison of category and letter fluency in Alzheimer's disease and Huntington's disease. *Neuropsychology*, *8*, 25–30.
Monsch, A.U., Bondi, M.W., Butters, N., Salmon, D.P., Katzman, R., & Thal, L.J. (1992). Comparisons of verbal fluency tasks in the detection of dementia of the Alzheimer type. *Archives of Neurology*, *49*, 1253–1258.
Nebes, R.D. (1989). Semantic memory in Alzheimer's disease. *Psychological Bulletin*, *106*, 377–394.
Newcombe, F. (1969). *Missile wounds of the brain*. London: Oxford University Press.
Ober, B.A., Dronkers, N.F., Koss, E., Delis, D.C., & Friedland, R.P. (1986). Retrieval from semantic memory in Alzheimer-type dementia. *Journal of Clinical and Experimental Neuropsychology*, *8*, 75–92.
Owen, A.M., Roberts, A.C., Polkey, C.E., Sahakian, B.J., & Robbins, T.W. (1991). Extra-dimensional versus intra-dimensional set shifting performance following frontal lobe excisions, temporal lobe excisions or amygdalo-hippocampectomy in man. *Neuropsychologia*, *29*, 993–1006.
Pasquier, F., Lebert, F., Grymonprez, L., & Petit, H. (1995). Verbal fluency in dementia of frontal lobe type and dementia of Alzheimer type. *Journal of Neurology, Neurosurgery, and Psychiatry*, *58*, 81–84.
Pietrini, V., Nertempi, P., Vaglia, A., Revello, M.G., Pinna, V., & Ferro-Milone, F. (1988). Recovery from herpes simplex encephalitis: Selective impairment of specific semantic categories with neuroradiological correlation. *Journal of Neurology, Neurosurgery, and Psychiatry*, *51*, 1284–1293.
Randolph, C., Braun, A.R., Goldberg, T.E., & Chase, T.N. (1993). Semantic fluency in Alzheimer's, Parkinson's, and Huntington's disease: Dissociation of storage and retrieval failures. *Neuropsychology*, *7*, 82–88.
Raskin, S.H., Sliwinski, M., & Borod, J.C. (1992). Clustering strategies on tasks of verbal fluency in Parkinson's disease. *Neuropsychologia*, *30*, 95–99.
Rosen, W.G. (1980). Verbal fluency in aging and dementia. *Journal of Clinical Neuropsychology*, *2*, 135–146.
Rosser, A. & Hodges, J.R. (1994). Initial letter and semantic category fluency in Alzheimer's disease, Huntington's disease, and progressive supranuclear palsy. *Journal of Neurology, Neurosurgery, and Psychiatry*, *57*, 1389–1394.
Shuttleworth, E.C. & Huber, S.J. (1988). The naming disorder of dementia of Alzheimer type. *Brain and Language*, *34*, 222–234.
Stern, Y., Richards, M., Sano, M., & Mayeux, R. (1993). Comparison of cognitive changes in patients with Alzheimer's and Parkinson's disease. *Archives of Neurology*, *50*, 1040–1045.
Taylor, A.E., Saint-Cyr, J.A., & Lang, A.E. (1986). Frontal lobe dysfunction in Parkinson's disease. *Brain*, *109*, 845–883.
Tröster, A.I., Salmon, D.P., McCullough, D., & Butters, N. (1989). A comparison of the category fluency deficits associated with Alzheimer's and Huntington's disease. *Brain and Language*, *37*, 500–513.
Troyer, A.K., Moscovitch, M., & Winocur, G. (1997a). 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. (1997b). The effect of focal frontal- and temporal-lobe lesions on verbal fluency clustering and switching [Abstract]. *Journal of the International Neuropsychological Society*, *3*, 37.
Vilkki, J. & Holst, P. (1994). Speed and flexibility on word fluency tasks after focal brain lesions. *Neuropsychologia*, *32*, 1257–1262.
Warrington, E., & Shallice, T. (1984). Category specific semantic impairments. *Brain*, *107*, 829–854.
Wixted, J.T. & Rohrer, D. (1994). Analyzing the dynamics of free recall: An integrative review of the empirical literature. *Psychonomic Bulletin and Review*, *1*, 89–106.