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Known, lost, and recovered: Efficacy of formal-semantic therapy and spaced retrieval method in a case of semantic dementia

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KEYWORDS

Semantic dementia; Intervention; Learning; Aphasia; Formal-semantic therapy; Spaced retrieval.

ABSTRACT

Background: Few studies have addressed rehabilitation in semantic dementia. A potentially promising method is formal-semantic therapy, which consists of tasks in which the names of concepts and their semantic characteristics are presented. It could also be enhanced by spaced retrieval, a learning method improving retention through recalling information after increasing recall intervals.

Aims: This study explores the efficacy of both a formal-semantic therapy and the spaced retrieval method to restore lost concepts in TBo, a woman with semantic dementia.

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Methods & Procedures: The formal-semantic therapy consisted of giving TBo semantic feedback followed by a cueing technique to facilitate naming. Formal-semantic therapy with simple repetition was compared to formal-semantic therapy with spaced retrieval. TBo's performance was measured throughout the study with picture naming and generation of verbal attributes. Two untrained lists were also measured for generalisation effects.

Outcomes & Results: Results indicate that, after therapy, TBo could name 3/8 of the trained items, compared to no items on the untrained lists. She also showed an increase in performance for the evocation of specific semantic attributes of concepts, reaching 6/ 8 of correct responses. Moreover, she maintained her performance up to 5 weeks after the end of the study. Finally, when compared to simple repeated practice, spaced retrieval did not enhance learning and no generalisation was observed between trained and non-trained categories.

Conclusions: Along with recent results reported in the literature, TBo's results confirm that people with semantic dementia can improve their naming performance with training but that this is limited. However, formal-semantic therapy seems very promising for retraining specific semantic attributes. Instead of focusing on naming, we suggest that therapies used in semantic dementia should aim at restoring specific and functionally relevant concepts to enable the individuals to be more autonomous in daily living.

Semantic dementia (SD) is a variant of frontotemporal dementia, characterised by progressive deterioration of semantic memory (Neary et al., 1998). Neuroradiological studies revealed that people with SD have focal atrophy of the temporal neocortex, generally more marked on the left side (Graham, Simons, Pratt, Patterson, & Hodges, 2000; Lambon Ralph, Graham, Ellis, & Hodges, 1998; Neary et al., 1998; Snowden, Goulding, & Neary, 1989). With respect to language, SD is responsible for word comprehension and naming deficits, whereas phonology and syntax are usually well preserved (Neary et al., 1998). Spelling impairment characterised by surface agraphia has also been reported in many cases of

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SD (e.g., Macoir & Bernier, 2002). On neuropsychological tests, these individuals often present with difficulties on any tasks requiring the activation of conceptual knowledge (Kertesz, Davidson, & McCabe, 1998; Papagno & Capitani, 2001; Schwarz, De Bleser, Poeck, & Weis, 1998). However, they show normal or near normal visuospatial capacities, perception, nonverbal reasoning, and problem- solving (Neary et al., 1998; Papagno & Capitani, 2001). People with SD also seem to have near normal episodic memory for perceptual information (Graham et al., 2000; Simons, Graham, Galton, Patterson, & Hodges, 2001) but episodic memory for verbal information is usually impaired (Graham, Patterson, Powis, Drake, & Hodges, 2002). With the progression of the disease, functional autonomy is progressively compromised since these individuals live in a world they can no longer understand. Consequently, cognitive intervention aimed at facilitating relearning of the lost knowledge necessary for everyday life function would appear to be of great interest in helping these people.

There have been very few studies aimed at relearning lost concepts in SD. According to some of these studies (Funnell, 2001; Graham, Patterson, Pratt, & Hodges, 2001; Jokel, Rochon, & Leonard, 2006; Snowden & Neary, 2002), people with SD can learn new verbal information. However, the new learning is generally modest and the participants show a rapid decline in performance after the end of the intervention. In fact, this learning seems to be dependent on many variables. First, the level of severity of the semantic deficit and, more specifically, the residual semantic knowledge could be a possible success factor (Graham, Patterson, Pratt, & Hodges, 1999; Jokel et al., 2006; Snowden & Neary, 2002). For example, AK (Jokel et al., 2006) showed improved retrieval for 60% of concept names for which she showed residual knowledge on a word-to-picture matching task, as compared to a 37% improvement for concepts that she was unable to match correctly. Second, the presence of an episodic referent could also facilitate the relearning of concepts (Snowden & Neary, 2002). More specifically, new learning in people with SD could be tied to daily experiences that allow them to link the semantic information with a specific temporo-spatial context. For example, Snowden and Neary (2002) showed that CR remembered object names better when she frequently encountered those objects in her home environment.

Finally, as pointed out by Graham and colleagues (2001), the learning

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methods used by the participants to relearn lists of object names may also contribute to the modest performances observed. In fact, people with SD who participated in relearning studies (Funnell, 2001; Snowden & Neary, 2002) seemed to have learned the list of object names within a specific temporo-spatial context. For example, when they were required to name relearned objects presented in random order (Snowden & Neary, 2002), their performances decreased significantly. They also had a tendency to produce within-list errors instead of semantic errors (Graham et al., 1999; Snowden & Neary, 2002). Moreover, they presented specific improvement for trained items, without any generalisation to other tasks or modalities (Graham et al., 1999). These observations suggest that the type of learning method used, mainly rote learning, did not actually mobilise the semantic memory system.

In order to facilitate this mobilisation, and thus a more in-depth treatment of concepts, interventions might employ semantic therapies used in non-degenerative fluent aphasia (i.e., aphasia following stroke or traumatic brain injury). These therapies focus on restoring lost concepts and discriminating between these concepts (for a review, see Nickels, 2000). Even if they seem very relevant for people with SD, to our knowledge these therapies have never been used with this population. In semantic therapy, people with aphasia have to perform semantic processing when presented with a spoken or written word stimulus (e.g., semantic question: Is an apple a fruit?). These tasks are known as formal-semantic, in contrast to ''pure'' semantic tasks in which the target name is never produced, by the therapist or the participant (Nickels, 2000). Formal-semantic tasks have been used in aphasia, but not extensively, and have proven to be more effective with naming disorders than pure semantic tasks (de Partz, 2003; LeDorze, Boulay, Gaudreau, & Brassard, 1994).

The following types of improvement have been reported after formal-semantic treatment of aphasic naming disorders: (1) improvement specific to trained items (Behrmann & Lieberthal, 1989; LeDorze & Pitts, 1995; Marshall, Pound, White- Thompson, & Pring, 1990; Nettleton & Lesser, 1991; Wambaugh et al., 2001); (2) generalisation of improvement for trained items in tasks involving different modalities (Grayson, Hilton, & Franklin, 1997; Hillis, 1990)—for example, following a written naming task applied during treatment, HG (Hillis, 1990) showed improvement on

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treated items in tasks that recruit different input and output modalities such as auditory word–picture matching, spoken naming, repetition, and writing to dictation—(3) generalisation of treatment gains to untrained items belonging to the same categories as trained items (Behrmann & Lieberthal, 1989; Hillis, 1990). The study conducted with HG, a woman presenting with mixed aphasia following a traumatic brain injury (Hillis, 1990), illustrates an effective formal- semantic treatment. HG showed a semantic impairment leading to difficulties in differentiating between closely related concepts (e.g., tiger–lion). The purpose of the therapy was to help HG relearn semantic distinctions through a written naming task of drawings with semantic feedback. When an error was produced, the feedback consisted of emphasising the semantic attribute distinctions between the word produced and the target word. Results indicate that the semantic treatment was effective in improving HG's abilities to produce the trained names, not just in written picture naming but also in tasks performed in different modalities (e.g., oral naming, writing to dictation, reading).

As for formal-semantic therapies, the impact of methods on the efficacy of treatment has not yet been explored in SD. As already mentioned, participants involved in treatment studies are generally not exposed to specific learning methods (e.g., organising concepts by categories, increasing recall intervals). Learning methods, which optimise learning in normal learners by facilitating the encoding and retrieval of information (Baddeley, 1994), could be combined with a formal- semantic therapy to potentially enhance the effects of treatment and ensure long- term maintenance. In this respect, spaced retrieval could be of great interest since it combines the well-known effects of distributed practice (Hintzman, Summers, & Block, 1975; Russo, Mammarella, & Avons, 2002) with retrieval effects (Bjork, 1988; Landauer & Bjork, 1978; Wheeler, Ewers, & Buonanno, 2003). *Distributed practice* refers to the fact that training distributed in time is more effective than intensive training done over a short period of time (i.e., massed repetition). *Retrieval effects* refer to the long-term superiority of training done by successive recovery of information as compared to encoding carried out on several occasions. Operationally, in the spaced retrieval method, the participant is asked to recollect information after increasing time intervals, filled by a general spoken conversation or any

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other task. At the beginning of the treatment, time intervals are close enough to ensure learning (15 seconds, 30 seconds, 1 minute). Thereafter, the intervals are spaced according to the participant's performance: if the participant makes a mistake, the error is immediately corrected and the last successful interval is repeated, after which the time series continues (Camp, Foss, Stevens, & O'Hanlon, 1996). This method is very effective with normal learners to ensure learning and long-term retention (Landauer & Bjork, 1978), and has already been successfully used in Alzheimer's disease for relearning different kinds of information, such as face–name learning (Camp & Stevens, 1990), calendar use (Camp et al., 1996; McKitrick, Camp, & Black, 1992), and using a mobile phone (Lekeu, Wojtasik, Van der Linden, & Salmon, 2002). It has also been successfully used for the treatment of naming deficits in neurodegenerative diseases (Brush & Camp, 1998; McKitrick & Camp, 1993). Thus, this method may be promising to ensure learning and long-term retention in SD as well.

The general aim of the present study was to explore, in a woman suffering fromSD, the efficacy of a formal-semantic therapy combined with a spaced retrieval method considered an optimisation factor. More specifically, the objectives were as follows: (1) to explore the efficacy of a formal-semantic therapy in relearning concepts (name and semantic attributes); (2) to assess the impact of the addition of the spaced retrieval method on this therapy compared to a simple repetition method; (3) to explore the long-term maintenance of the effects of the formal-semantic therapy with the spaced retrieval method compared to a simple repetition method; and, finally, (4) to explore possible effects of generalisation within trained categories and between trained and non-trained categories.

CASE REPORT

TBo is a 70-year-old, right-handed housewife, living with her husband in an apartment. She is a native French speaker and has a grade 9 education. In April 2004 she was referred to the Geriatric Program at the Quebec City Centre Hospitalier Universitaire because of word-finding and memory problems. At that time, TBo felt these problems had begun up to 5 years earlier, with progressive worsening. TBo essentially complained of difficulties in finding words during conversation. Her husband also noticed word-finding as well as spelling problems at home that often led to

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frustration and discouragement. Progressively, she stopped taking care of housekeeping (shopping, meal preparation, and domestic tasks). She maintained social contacts with friends and family, although she was sometimes confused about the names of her children and grandchildren as well as their occupations. A single photon emission computed tomography, as well as a magnetic resonance imaging (MRI) study including sagittal FLAIR and T2-weighted sequences and axial FLAIR, proton density, T1 and T2-weighted sequences were performed in November 2003. Both exams showed mild to moderate cortical atrophy, more marked around the left sylvian fissure and a left frontal hypoperfusion. There was no relevant medical history and all the biological and blood tests were normal. The neuropsychological and language examinations were conducted in September 2003 and March 2004 respectively. Testing was performed in French, with norms for the Quebec-French population.

Neuropsychological examination

Neuropsychological testing (see Table 1) showed no clinical signs of visuo-spatial deficits except for the object decision tasks of the Birmingham Object Recognition Battery (Riddoch & Humphreys, 1993). TBo's general nonverbal problem solving was between the 25th and the 50th percentile (Raven, 1938). For episodic memory, she performed within the normal range for tasks using perceptual information, except for part B of the Doors Test (Baddeley, Emslie, & Nimmo-Smith, 1994). She showed abnormal performance on some tasks measuring working memory, and particularly on the letter–number sequencing task (Wechsler, 1997), which measures the executive aspect of working memory. TBo also presented with difficulties in other executive functions, namely inhibition (Stroop test; Golden, 1978) and flexibility (Trail Making Test; Tombaugh, 2004).

Language examination

With regard to language (see Table 2), speech output was fluent, well-articulated, and grammatically correct but presented many signs of word-finding difficulties: aborted sentences, long response latencies, and occasional semantic paraphasias. Letter fluency was poor. Repetition was flawless for both words and nonwords. Reading was slightly impaired but within normal range, and marked by the presence of occasional regularisation errors. Written spelling of nonwords was flawless but TBo's performance on word writing to dictation for regular and irregular words was typical of surface agraphia, with the only errors being phonologically plausible errors and performance affected by orthographic regularity and lexical frequency. A similar pattern of error was also observed on a written picture-naming task. At the syntactico-semantic level, TBo performed normally in the spoken sentence–picture matching task. Her performance was slightly below the cutoff score for the written condition of the task, as well as for the shortened version of the Token Test (De Renzi & Faglioni, 1978). Finally, TBo was severely impaired in all tasks exploring semantic memory. Semantic category fluency (Joanette et al., 1995) was extremely poor and TBo encountered serious difficulties in confrontation naming investigated with the DO 80 (Deloche & Hannequin, 1997). In this task she mainly produced semantic and visual-semantic paraphasias and showed problems of visual identification for two pictures. TBo also showed clear problems with semantic processing on the picture-to-picture association and the written word-to-written word association versions of the Pyramids and Palm Trees Test (Howard & Patterson, 1992).

TABLE 1 *- TBo's general neuropsychological evaluation*

Neuropsychological testing	*TBo*
Visuo-spatial functions	
Benton Visual Form Discrimination (32)	29
Birmingham Object Recognition Battery (BORB):	
Length match task (30)	29
Size match task (30)	27
Minimal feature match (25)	24
Foreshortened match (25)	19
Object decision – easy (32)	30
Object decision – hard (32)	20*
General nonverbal problem solving	
Raven's Coloured Progressive Matrices (36)	25

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Episodic memory	
DMS-48:	
Immediate recognition (48)	100% (276 s)
Delayed recognition – 1 hour (48)	98% (290 s)
Delayed recognition – 7 days (48)	94%
Warrington Face Recognition Test (50)	41
The Doors Test: Easy (12) – Hard (12)	10 – 4*
Spatial and temporal orientation (WAIS-III) (14)	12
Working memory	
Corsi block-tapping – forward	12*
Word span	3
Digit span – forward (WAIS-III)	3
Letter–number sequencing	2*
Executive functions	
Stroop Test:	
Word reading	74
Colour naming	108*
Interference	250*
Trail Making Test – A	4 min*
Trail Making Test – B	-**

** Significantly impaired (more than 2 SD under scores of age- and education-matched control participants). ** Unable to complete the test. References for tests as follows: Benton visual form discrimination (Benton, Sivan, Hamsher, Varney, & Spreen, 1994); Birmingham Object Recognition Battery (Riddoch & Humphreys, 1993); Raven's Coloured Progressive Matrices (Raven, 1938); DMS-48 (Barbeau et al., 2004); The Doors Test (Baddeley et al., 1994); Spatial and temporal orientation (WAIS-III) (Wechsler, 1997); Corsi Block-Tapping Task (Kessels, van Zandvoort, Postma, Kappelle, & de Haan, 2000); Word span (Joanette et al., 1995); Forward digit span (WAIS-III) (Wechsler, 1997); Letter–number sequencing (WAIS-III) (Wechsler, 1997); Stroop Test (Golden, 1978); Trail Making Test (Tombaugh, 2004).*

TABLE 2 *- TBo's language investigation*

Language testing	*TBo*
Lexical aspects of language	
Letter fluency (total PLT)	15*
Immediate and delayed repetition of words and nonwords	N
Reading	
Regular words (5)	5
Irregular words (15)	11
Nonwords (5)	3
Writing to dictation:	

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Regular words (12)	11
Irregular words (15)	5*
Nonwords (5)	5
Written picture naming (15)	1*
Spoken word and sentence–picture matching (MT-86) (47)	37
Written word and sentence–picture matching (MT-86) (13)	8
Token Test (36)	25
Semantic memory	
Semantic Category Fluency (total)	11*
DO 80 (80) (picture-naming test)	57*
Pyramids and Palm Trees Test:	
Picture–picture (52)	37*
Word–word (52)	36*

**Comparison with control participants significantly different, with p < .05. Legend: N 5 normal performance according to norms. References for tests as follows: Letter Fluency (Joanette et al., 1995); MT-86 (Nespoulos et al., 1992); Token Test (De Renzi & Faglioni, 1978); Semantic Category Fluency (Joanette et al., 1995); D0 80 (Deloche & Hannequin, 1997); Pyramids and Palm Trees Test (Howard & Patterson, 1992).*

Summary and diagnosis

Overall, TBo presented with deficits in all tests requiring semantic processing, whereas she performed almost normally on tests exploring visuo-perceptual abilities and visual episodic memory. Along with neuroimaging data, these results were suggestive of a clinical diagnosis of possible SD. TBo's semantic impairment as measured by the Pyramids and Palm Trees Tests was more marked than that of some other people with semantic dementia who have benefited from therapy (e.g., DM, reported by Graham et al., 1999), however her above-chance performance on a number of the additional semantic tests (see below) suggests that she had some remaining semantic knowledge about the sorts of items used in therapy. Since she also presented with difficulties in executive functions and working memory tests, the contribution of a frontal impairment to the clinical profile must also be considered. However, the presence of frontal impairment is not incompatible with a diagnosis of SD. Hypometabolism of the left frontal cortex has been observed in other

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individuals suffering from SD (Hodges, Patterson, Oxbury, & Funnell, 1992; Snowden et al., 1989).

A more detailed investigation of TBo's semantic impairments was conducted to assess her deficits regarding concrete and abstract concepts and attributes.

Investigation of the semantic deficit

We investigated the nature of TBo's semantic impairment through the administra- tion of four semantic tasks: spoken word-to-picture matching, semantic similarity judgement, specific attribute-verification, and picture naming (see Table 3). In these tasks TBo's performance was compared to the results of five control participants by means of modified *t* tests (Crawford & Howell, 1998), which measure whether a single observation is significantly different from the mean of a small control sample. Thefivefemalecontrolshad no cognitive impairment (*MMSE*=27.8; *SD* 5=1.8) and were matched with TBo on age (mean = 71± 1.9) and years of education (mean= 7.2± 2.4) . Modified *t* tests showed no differences between TBo and the control participants for age (t = .69, p = .53) or years of education (t = -.49, p = .33).

TABLE 3 *- TBo's performances on semantic tasks exploring her semantic deficits (mean performance)*

Semantic task	*TBo*	*Control participants*
Specific attribute-verification task (156 items)	92*	130 ± 5.1
Living (76 items; critical value: 45)	42*	59.4 ± 3.21
Manufactured (48 items; critical value: 30)	32*	41.8 ± 1.3
Musical instruments (32 items; critical value: 21)	15*	28.8 ± 1.5
Perceptual attributes (78 items; critical value: 46)	47*	62.2± 1.8
Functional attributes (20 items; critical value: 14)	11*	17.4 ± 2.4
Encyclopaedic attributes (58 items; critical	34*	51.6 ± 2.3

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value: 35)		
Picture naming (148 items)	88*	137± 9.17
Performance by categories:		
Living: (48 items)	20.7*	44.2 ± 4.4
Land animals (13 items)	9*	12 ± 1.2
Birds (9 items)	2*	8.8 ±.45
Insects (6 items)	.67*	5.6 ± .55
Fruits (10 items)	5*	9.2± 1.1
Vegetables (10 items)	4*	8.6 ± 1.67
Manufactured objects: (79 items)	55.7*	73 ± 5.1
Clothes (10 items)	6.7*	9.6 ± .55
Small manufactured objects (23 items)	15.3*	21 ± 1.41
Large manufactured objects (6 items)	3.7	5.6± .89
Tools (10 items)	6*	9.6 ± .55
Utensils and electric household appliances (11 items)	8.3*	10.4 ± 1.34
Furniture (9 items)	6.7	7.8 ± .84
Vehicles (10 items)	7*	9 ± .71
Musical instruments (11 items)	1.67*	10 ± .00
Body parts (10 items)	10	9.8 ± .45

**Comparison with control participants significantly different, with p < O.5(Crawford modified t tests).*

Task 1: Spoken word-to-picture matching. TBo was given a spoken word–picture matching task (Caplan & Bub, 1992) in which she had to choose one of four pictures as a match to a spoken word. The picture set included the correct item and foils that were semantic, visuo-semantic, or unrelated. It comprised 20 pictures of living concepts (animals, fruits, vegetables) and 20 paired pictures of manufactured concepts (tools, household items) that were controlled for

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lexical frequency, familiarity, visual similarity, and word length. TBo's performance was below the mean of the control participants for living concepts only (14/20; 70%; $t = -10.2$; $p = .003$) and was at chance level (critical value = 14, $p = .50$ $a = .95$). Her performance was much better than chance for manufactured concepts and was comparable to control participants (19/20; 95%; $t=21.5$; $p=.11$).

Task 2: Semantic similarity judgement task. TBo was administered a semantic similarity judgement task on written words consisting of 40 concrete living triplets (e.g., *lapin* – *castor* – *lièvre*, "rabbit – beaver – hare") and 40 concrete manufactured triplets (e.g., *sofa* – *divan* – *tabouret*, "sofa – couch – stool") matched for lexical frequency, and familiarity. TBo was asked to point to the word that was least similar in meaning. Her performance was better than chance (critical value = 18, $p = .33$, $a = .95$) but she was well below the mean of the control participants for both living (30/40; 75%; $t = 25.1$; $p=.003$) and manufactured concepts (34/40; 85%; $t = 24.7$; $p = .004$). The difference between living and manufactured concepts was not significant ($t = -1.11$; $p=.27$).

Task 3: Specific attribute-verification vask. In this task, we selected 19 living things, 12 manufactured objects, and 8 musical instruments from the black and white pictures of the Snodgrass and Vanderwart (1980) set and prepared a semantic questionnaire aimed at their specific attributes, i.e., attributes that were common to only some members of the category. For each stimulus, we created four statements, giving a total of 156 statements, aimed at perceptual, encyclopaedic, and functional attributes. Half of these statements were true and half were false. The contrast between true and false statements was designed to require fine-grained distinctions between close category coordinates. The 156 statements were presented three times and in random order.

As shown in Table 3, TBo was well below normal range for every type of statement (all observed p-values <.05). There were no significant differences between her performances on living things, manufactured objects and musical instruments (Kruskall-Wallis's $x^2=3.39$, $p=.184$). There were no significant differences in her performance between perceptual, encyclopaedic and functional attributes (Kruskal- Wallis's $x^2 = 0.014$, $p = .90$). Except for manufactured concepts and perceptual attributes, for which she was slightly above chance level, TBo was not better than chance

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for every type of statements (see Table 3).

Task 4: Picture naming. TBo's ability in picture naming was assessed through a list of stimuli composed of 148 black and white pictures (Snodgrass & Vanderwart, 1980). The experimental list was composed of 48 pictures of living concepts, 79 pictures of manufactured concepts, 11 pictures of musical instruments, and 10 pictures of body parts. Stimuli were presented three times in random order with no time limit. A picture was considered to be named accurately if TBo provided the correct target name or a possible alternative (e.g., cochon ‘‘pig’’▹ porc ‘‘pig’’).

As shown in Table 3, TBo was impaired for all semantic categories. The difference between TBo's and the controls' performance was significant (all observed *p*-values < 01). A significant difference between living, manufactured, musical instruments, and body parts was observed (Kruskal-Wallis's x^2= 32.9, *p* < 01). TBo's performance was significantly lower for living concepts and musical instruments as compared to body parts and manufactured concepts (all observed *p*-values < .001). Her naming performance for musical instruments was particularly poor (15.2%; mean score for controls = 91%). In contrast, she presented with perfect performance for body parts (100%). Significant differences were observed between living subordinate categories (all observed *p*-values < .02). TBo's performance was particularly low for birds and insects (all observed *p*-values < .01. There was no significant difference in her performance between manufactured subordinate categories (Kruskal-Wallis's x^2 = 3.9; *p* 5 .68). Her performance was influenced by frequency and familiarity (frequency: Spearman's *r* = .46, *p* < .0001; familiarity: *r* = .43, *p* < .0001) as well as visual complexity (*r* = 2.32, *p* < .0001). With respect to error analysis, TBo mainly produced semantic paraphasias (54%), followed by vague circumlocutions (19%) and ‘‘don't know’’ responses (16%). She also occasionally produced visual errors (3%; e.g., ball R moon) and sometimes indicated she did not recognise the depicted concept.

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Summary and comments

To summarise, results from the four semantic tasks reveal that TBo presented with a semantic deficit affecting living and manufactured concepts. Results from the picture-naming task pointed to a more serious deficit for living objects and musical instruments than for manufactured objects, while naming abilities for body parts were intact. With respect to semantic attributes, results from the specific attribute- verification task also revealed that TBo presented with a general semantic deficit affecting specific attributes of concepts, whether they were of perceptual, encyclopaedic or functional types.

This profile suggested that the intervention should be oriented not only towards the retrieval of names but also include the relearning of specific semantic attributes of concepts. A specific intervention was planned to help TBo relearn object names and specific attributes with a formal-semantic therapy combined with the spaced retrieval method. The project was approved by the Research Ethics Committee of the Research Center on Aging in Sherbrooke, Canada. Informed written consent was obtained from TBo.

TREATMENT STUDY

SELECTION OF TREATMENT STIMULI

Treatment stimuli were selected on the basis of TBo's performance on the picture- naming task and specific attribute-verification task. To choose items that were consistently failed, we searched for three consecutive failures on the same items in picture naming as well as for three consecutive failures on one or more of the four questions per item of the semantic questionnaire. In total, 41 items were consistently failed according to both criteria and were selected for treatment.

From TBo's performance on the neuropsychological evaluation, the semantic tasks and stimuli selection sessions, we observed that she became easily tired. To avoid fatigue and thus a possible floor effect, we limited the number of stimuli to 24 (see Appendix, Table A1). Three lists of eight stimuli were prepared based on their category membership and matched for familiarity, frequency, and visual complexity scores: a trained set (familiarity = 2.6 ± .64; frequency = 24 ± 27; visual complexity = 3.7

±.79), a control set (familiarity= 2.5±.47; frequency=12.5±14.3; visual complexity = 4.0 ± .68), and a neutral set (familiarity = 2.6 ± .89; frequency = 14.2 ± 18.4; visual complexity = 3.1 ± .66). The trained set consisted of pictures and names belonging to the categories of fruits, birds, insects, and musical instruments. The control set consisted of pictures and names of the same categories and was prepared to assess possible generalisation across items from the same category. The neutral set was prepared to assess possible generalisation across different categories. It consisted of stimuli with no semantic relationships with stimuli from the target and control lists (vehicles, tools, miscellaneous objects, utensils, and kitchen appliances). All pictures were from the set of Snodgrass and Vanderwart (1980) pictures initially used to assess naming.

GENERAL DESIGN OF THE COGNITIVE INTERVENTION

TBo was exposed to an alternating treatment design, ABCBCBCA, with multiple baselines (Ottenbacher, 1986; Wilson, 1987). The study comprised three general phases: the baseline phase (A), which consisted of measures taken before the interventions; the intervention phase (B and C); and the post-treatment phase consisting of measures taken after completion of the interventions (back to A). The intervention phase consisted of an alternation between intervention B, formal-semantic therapy with a spaced retrieval method, and intervention C, formal- semantic therapy without specific learning method, which consisted of a simple repeated practice (see Table 4). The design consisted of measuring trained (target set) and untrained stimuli (control and neutral sets) during the entire study in order to assess the efficacy of the treatment and possible generalisation. TBo was exposed to three sessions of baseline testing, followed by six intervention sessions: three for intervention B and three for intervention C (two sessions per week). She was also exposed to three testing sessions for long-term retention, which took place 1, 3, and 5 weeks after the end of the intervention. The study took place over a period of 3 months. During the maintenance period, TBo did not have access to the material and we instructed her not to practise at home.

The simple repeated practice method was added to explore the possible superiority of spaced retrieval in terms of new learning and long-term retention. To compare the efficacy of the two learning methods, the eight

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treated items were divided into two lists of four items (see Appendix, Table A2), respectively assigned to intervention B (list 1) and intervention C (list 2). The two lists were matched in terms of familiarity (list 1=2.4; list 2=2.9), frequency (list 1 and list 2<50), and visual complexity (list 1= 3.7; list 2= 3.6). They comprise three different categories and were matched on two out of those three categories (list 1: birds, musical instruments, fruits, and vegetables; list 2: insects, musical instruments, fruits, and vegetables).

TABLE 4 *- Treatment study design*

Sessions	*Intervention 1 (B)* *Spaced retrieval and semantic feedback*	*Intervention 2 (C)* *Repetition and semantic feedback*
1	Baseline 1	Baseline 1
2	Baseline 2	Baseline 2
3	Baseline 3	Baseline 3
4	Picture naming – list 1	
5		Picture naming – list 2
6	Picture naming and generation of attributes – list 1	
7		Picture naming and generation of attributes – list 2
8	Picture naming and generation of attributes – list 1	
9		Picture naming and generation of attributes – list 2
10	Long-term retention	Long-term retention

	measures (1 week)	measures (1 week)
11	Long-term retention measures (2 weeks)	Long-term retention measures (2 weeks)
12	Long-term retention measures (5 weeks)	Long-term retention measures (5 weeks)

A: BASELINE

The 24 selected stimuli were tested three times in the following two tasks during baseline sessions: picture naming and generation of verbal attributes from spoken words. The 24 stimuli were presented in random order to TBo. In the naming task, a picture was considered to be named accurately if TBo provided the correct target name only. Generation of verbal attributes consisted of asking TBo to give as many semantic attributes as possible for each of the 24 stimuli. General and specific attributes were accepted. General attributes were defined as attributes shared by all or most of the members of a category and specific attributes were defined as attributes only found for a few members of the category (Caramazza & Shelton, 1998).

For the two baseline tasks, TBo's performance was compared to the results of the same five female controls who took part in the semantic tasks investigating TBo's semantic impairments.

B AND C: INTERVENTION AND MEASURES

B: Formal-semantic therapy and spaced retrieval (sessions 4, 6, and 8). To summarise the procedure, each intervention session began with a presentation phase which consisted of presenting TBo with the four pictures (list 1) along with: (a) their corresponding spoken name, (b) a specific attribute (see Appendix), and (c) the written name of their category. This procedure was repeated twice altogether for the same four items, presented in random order. In session 4 the pictures were presented to TBo, who was asked to recall their corresponding names according to spaced retrieval with increasing time recall intervals. The instructions were: ''Can you tell me the name of this object?'' In the following sessions (6 and 8) she had to name the pictures and also give their attributes. The instructions were: ''Can you tell

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me the name of this object and the things you know about it?'' When the correct response was not produced (wrong answer or no answer), this was scored as an error and TBo was presented with the formal-semantic therapy procedure consisting of a semantic feedback and cueing technique.

Then, 15 minutes after the end of each session (4, 6, and 8), the complete list of 24 selected stimuli was presented to TBo for picture naming and generation of semantic attributes from spoken words.

Spaced retrieval: In session 4 the spaced retrieval method, based on Camp and colleagues' procedure (Camp et al., 1996), began after the presentation phase by showing TBo the first picture and asking her to recall its corresponding name (0- second recall interval). The picture was then hidden and presented for naming 15 seconds later. This procedure was repeated at increasing time recall intervals of 30 seconds, 1 minute, minutes, 2 minutes, $2^{1/2}$ minutes, 3 minutes, $3^{1/2}$ minutes, and so on, until the end of the session was reached. When TBo produced a semantic error, the experimenter used the semantic feedback and graded cueing technique described below. In the subsequent trial the experimenter returned to the last successful recall interval and, if successful, the series of recall intervals was continued. A new target was introduced when the preceding one reached its $1^{1/2}$ -minute recall interval successfully, until all four targets were introduced. Each target then followed its own recall progression until the end of the session was reached. Thus, for the first item, gaps between each recall interval were initially filled with general conversation. When the first item reached its $1^{1/2}$-minute recall interval successfully, the second item was introduced. Thus, the gaps planned for the following intervals of the first item (2 minutes, $2^{1/2}$ minutes, 3 minutes, etc.) were first filled by the interval repetitions of the second item. When the second item reached its $1^{1/2}$ -minute recall interval successfully, the third item was introduced and so on. Thus, the gaps of the remaining intervals of the first item were filled with recalls of the second, third, and then fourth items until the end of the session was reached. Consequently, during the spaced retrieval method condition, the number of times each item was presented was dependent on TBo's progression on each item.

In sessions 6 and 8, TBo had to give the corresponding name of each picture and also its specific semantic attributes. The recall intervals followed the same procedure as used for session 4.

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Formal-semantic therapy: Semantic feedback and cueing technique. The goal of the formal-semantic therapy was to restore the link between the concept and its corresponding name through semantic feedback, directly based on Hillis's (1990) procedure. The feedback was introduced each time TBo made a semantic error when attempting to name a picture. It aimed at emphasising the differences between the object presented and the name given by TBo. For example, if TBo said ''apple'' when presented with the picture of a peach, the experimenter showed her the picture corresponding to the erroneous response and contrasted the different semantic attributes between it and the target item (e.g., ''The apple has a smooth shiny skin and may be grown in Quebec; the peach has a soft textured skin and cannot be grown in Quebec''). When TBo was unable to give a response, a graded cueing technique was used, which consisted of giving the following cues one by one until a correct response was produced: (1) first the category membership of the item, (2) then a semantic cue (specific attribute) if she was still unable to produce the answer, and (3) finally a phonemic cue (first letter or first syllable) if the category membership and the specific attribute did not trigger the response. The correct response was provided if she was still unable to produce it after the third cue.

C: Formal-semantic therapy with simple repetition (sessions 5, 7, and 9). Each session of intervention C began with a presentation phase, identical to the intervention B presentation phase, after which the simple repetition method was introduced. In session 5 each picture was presented in random order to TBo and she was asked to recall their corresponding names. However, since there were many presentations per session and few items, it was obviously impossible to avoid repetition in the stimuli presentation order. In sessions 7 and 9 TBo had to name the pictures and give their attributes. If she produced an error she received semantic feedback and the cueing technique (formal-semantic therapy) following the same procedure as used for intervention B. When the four names were recalled once, the experimenter presented the list for a second time, and so on until the session ended. List 2 was repeated 20 times, which equalled the number of presentations achieved in session 4 with spaced retrieval. Each item was repeated eight times during session 7, and 11 times during session 9, which equalled the number of presentations achieved in sessions 6 and 8 with spaced retrieval. Then, 15 minutes after the end of each session (5, 7, and 9), the 24 selected stimuli were presented to TBo for picture naming and generation of semantic attributes.

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MAINTENANCE, GENERALISATION, AND SPECIFICITY OF INTERVENTION

At 1, 3, and 5 weeks after the end of the therapy, TBo's performance on the 24 items was evaluated with the same two tasks used during the baseline and interventions phases. To confirm a possible ''within-category generalisation effect'', a list of 21 further stimuli, belonging to similar semantic categories as the treated and control stimuli, was presented to TBo for picture naming at each of the maintenance testing sessions. The specificity of the semantic treatment was assessed through a letter fluency task (i.e., word generation in response to a cue letter), a task that did not require much semantic involvement. Some of the treated words began with the same letter used during letter fluency.

STATISTICAL ANALYSES

For the analyses, TBo's performance at baseline testing was compared to the performance of the control participants using modified *t* tests comparing data from a single participant with results from a small control group (Crawford & Howell, 1998). Since normality tests showed that most variables did not follow a normal distribution (Shapiro-Wilks, all observed *p*-values <.02), Kruskal-Wallis's x^2, Friedman's x^2, Mann-Whitney's *U*, and Wilcoxon's *Z* tests were used to analyse TBo's data.

RESULTS

A: RESULTS OF BASELINE TESTING

The performances of TBo and the control participants at baseline testing are presented in Table 5. TBo was unable to name any of the 24 pictures at the three

TABLE 5 *- TBo's baseline performances and comparison with normal controls*

Baseline measures	*TBo (mean of the three trials)*	*Control participants*
Naming – 24 items	0*	20.6 ±3.36
Generation of verbal attributes	from22.1*	59.6 1±6.4

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spoken words		
(total number of characteristics named)		
General attributes – total	17.7	35.6 ±9.1
Target	6.7	13.8 ±3.4
Control	6.3	12.6 ±5.2
Neutral	4.7	9.2 ± 2.9
Specific attributes – total	4.4*	24 ± 7.7
Target	0*	11.2 ± 3
Control	1.7	5.6 ± 3.3
Neutral	2.7	7.2 ± 3

**Comparison with control participants significantly different, with p <.05.*

testing sessions, therefore confirming the stability of her performance for these items. Her ability to generate general semantic attributes was lower than the performance of the control participants but the differences were not statistically significant (all observed p-values> .05). Her performance was, as a whole, stable across the three trials (Friedman's x^2=0.80; p =.67). On the general attributes generation task, her performance was slightly better for trained and control items (6.7 and 6.3) than neutral items (4.7). However, for specific semantic attributes TBo's performance was below the control participants' and stable across the three trials (Friedman's x^2=0; p = 1.0). She was better at generating general than specific attributes and the difference between the two types of attributes was significant (Wilcoxon's Z =–2.4; p=.17). On specific attributes, her performance was slightly better for neutral items (2.7) than trained (0) and control items (1.7).

B AND C: INTERVENTION

TBo's performances were analysed in two parts. First, the effect of the formal-semantic therapy was analysed by comparing her performances on picture naming and generation of attributes on the eight target items (lists 1 and 2 combined) with the other two sets (control and neutral) during baseline, intervention, and post measures. Second, the specific effect of the spaced retrieval method, compared to simple repetition, was analysed by comparing

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TBo's performances on lists 1 and 2 for picture naming and generation of attributes, during baseline, intervention, and post measures.

Efficacy of the formal-semantic therapy: Picture naming. Visual inspection of the graphed data (Figure 1a) showed that TBo presented with a limited but clear increase in performance between baseline and intervention phases on the trained items while the two other stimuli lists remained at baseline level: a mean of 38% of correct responses (3/8) was reached during the learning phases for the target items (0/8 for session 4, 3/8 for sessions 5, 7, and 9, and 2/8 for sessions 6 and 8). Visual inspection also showed maintenance of performance at post-intervention testing. Statistical analysis comparing TBo's mean performance on trained items over the sessions within each phase ($n=8$) (i.e., the mean of sessions 1–3 versus the mean of sessions 4–9 versus the mean of sessions 10–12), indicated a trend towards a significant improvement for the target items between the performance obtained in baseline and the performance achieved during the intervention (Friedman's test, $x^2 = 5.44$; $p = .066$). She maintained her performance up to 5 weeks after the end of the intervention. No significant differences were found between the performance obtained during the intervention and the performance achieved during the weeks following the end of the intervention (Wilcoxon signed rank test, $Z = -.97$; $p = .334$). TBo's naming performance for control and neutral items did not improve (all observed p-values > .20).

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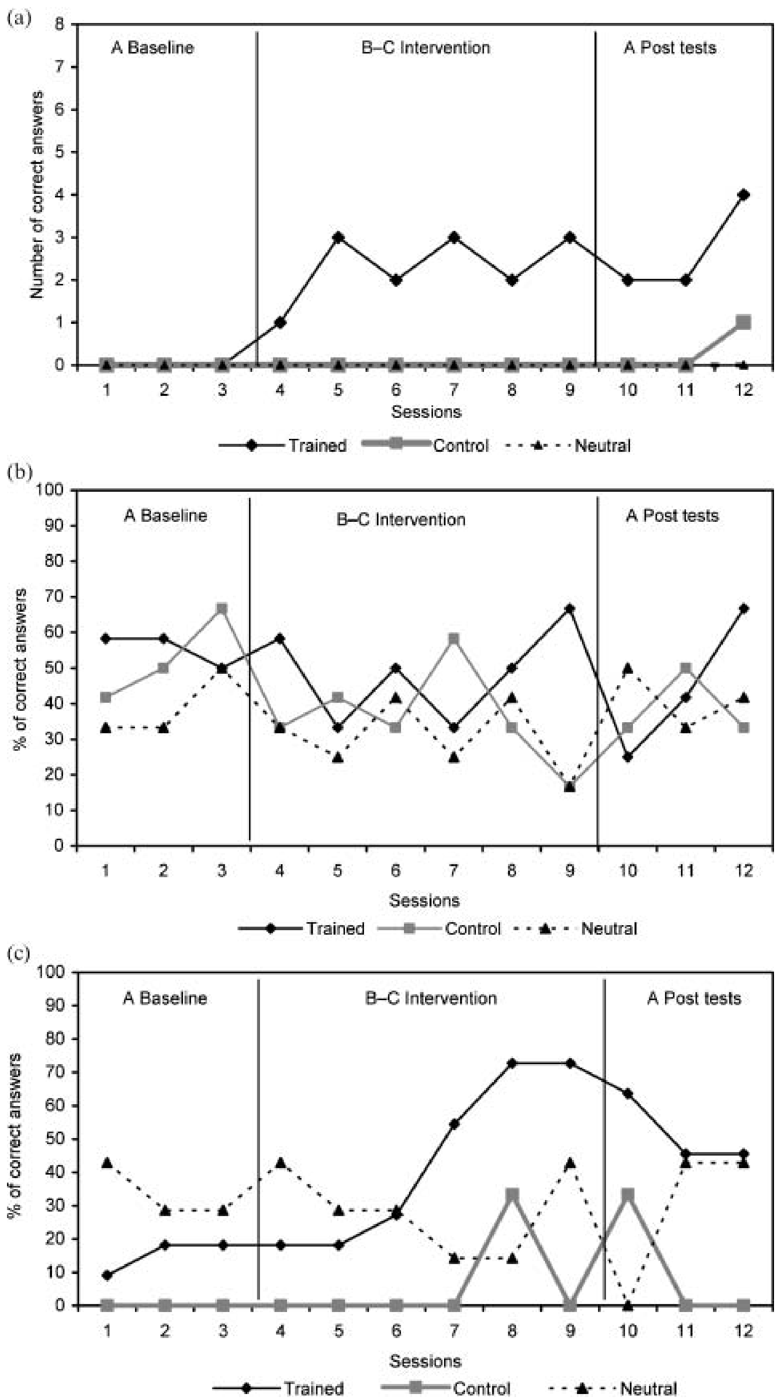

***Figure 1**. TBo's performances on naming and generation of semantic attributes. (a) TBo's performance on the three lists for confrontation naming (n 5 8 items per list).*

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(b) TBo's performances on the three lists for generation of general attributes (n 5 8 items per list; each observation represents TBo's performance compared to control participants). (c) TBo's performances on the three lists for generation of specific attributes (n 5 8 items per list; each observation represents TBo's performance compared to control participants).

The comparison between the performance obtained on the three lists showed a significant difference between intervention and post-intervention phases (Friedman's tests, both $x^2 = 8.0$; all p values < .02). Paired comparisons showed a trend toward a significant advantage of trained items over control and neutral items in both phases (all observed p-values = .06).

Generation of semantic attributes. General and specific attributes were analysed separately (see Figures 1b and 1c). Figures 1b and 1c illustrate TBo's performances in percentages based on the performances of the matched control participants. For example, if the control participants had a mean of 14 general attributes for the target items and TBo gave a mean of 6.7 attributes, we considered that she obtained a performance of 48%. Visual inspection of the graphed data suggests an increase in performance after session 6 for specific attributes only, which corresponded to the time when semantic attributes were more formally introduced in training. Statistical analyses comparing TBo's mean performance per phase ($n = 8$) for general and specific attributes combined, indicated that TBo's performance on trained items showed no significant differences between baseline, intervention, and post- intervention measures (Friedman's test, $x^2 = 2.97$; $p = .23$). More specifically, there was no improvement for the generation of general attributes (Friedman's test, $x^2=0.64$; $p=.73$) but a significant improvement for specific attributes (Friedman's test, $x^2=11.03$; $p=.004$), which showed an increase of 54.5% of correct responses for the target list between baseline and intervention: TBo went from 18.2% (2/11) to 72.7% (8/11) (Wilcoxon's $Z = –2.4$; $p = .011$). Moreover, TBo produced more specific attributes for the target items during post-test (5.7/11) then during baseline (2/11) ($Z = 22.40$; $p = .016$). She produced the same specific attributes provided during learning along with those she was already able to produce during baseline. There was no improvement in performance, for general or specific attributes, for control (Friedman's tests, all observed p-values > .25) and neutral items (Friedman's tests, all observed p-values > .40).

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Comparisons between the three lists on the number of specific attributes generated showed significant differences during the intervention (Friedman's test, $x^2 = 10.08$; $p = .006$) and post-test phases (Friedman's test, $x^2 = 7.28$; $p = .026$). These significant comparisons were attributable to a significant difference in favour of the targets over the other two lists (Wilcoxon's tests, all observed *p*-values $< .05$), with the exception of the comparison between targets and neutrals during the intervention phase (Wilcoxon's $Z = -1.68$; $p = .093$). Furthermore, on post measures 2 and 3, target and control were almost equivalent. It is worth noting that TBo gave more specific attributes during baseline for neutral items than for target items.

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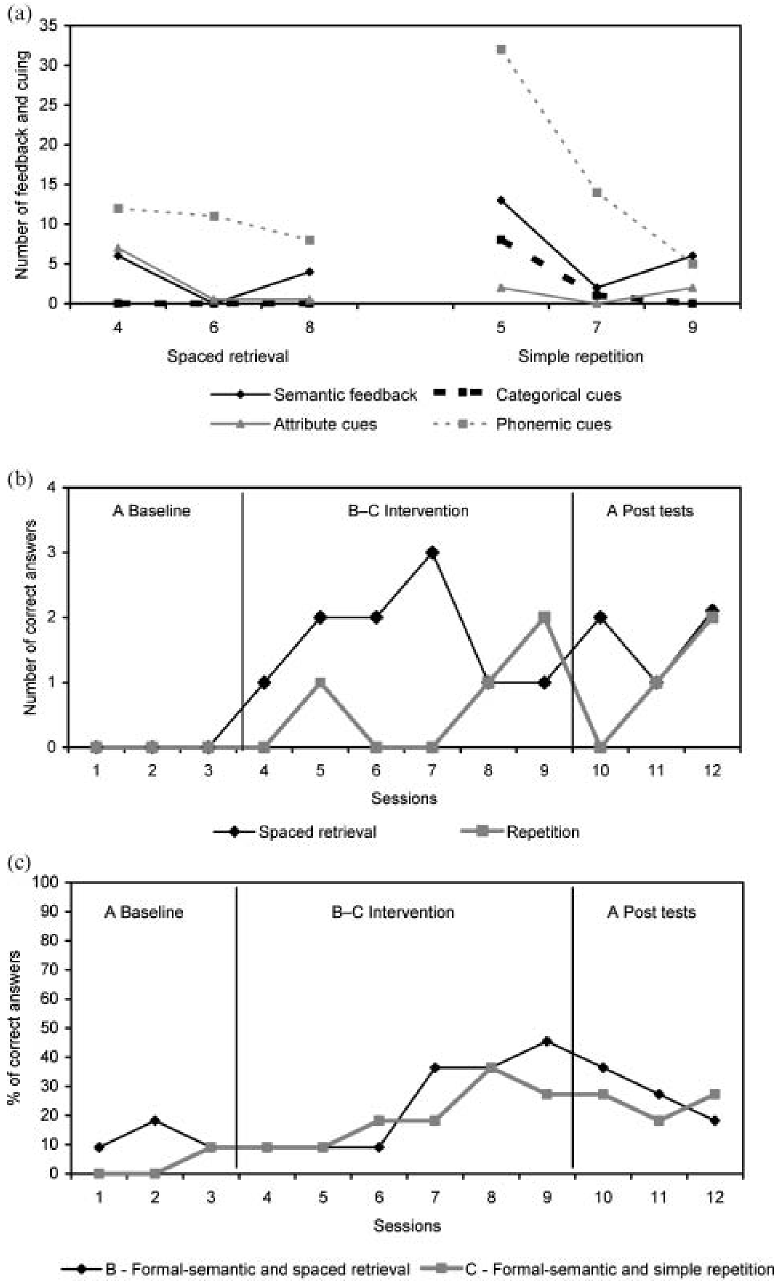

Figure 2. *Comparison of TBo's performance with spaced retrieval and simple repetition. (a) Number of semantic feedbacks and cueings needed with spaced retrieval and simple repetition. (b) TBo's performance on naming with spaced retrieval and simple repetition (each observation represents TBo's performance on the four items of each list). (c) TBo's performance on generation of specific attributes with spaced retrieval and simple repetition (n 5 4 items per condition; each observation represents TBo's performance compared to control participants).*

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Comparison between spaced retrieval and simple repetition. TBo made fewer errors with spaced retrieval than with simple repetition (see Figure 2a). More specifically, during the therapy with spaced retrieval (sessions 4, 6, and 8), she produced a total of 10 semantic errors and received an equal number of semantic feedbacks. On 38 occasions, she was unable to produce any response and was given semantic (7) or phonemic cues (31). With simple repetition (sessions 5, 7, and 9), she produced a total of 21 semantic errors and 64 no-answer errors for which she needed a categorical (9), semantic (4), or phonemic cue (51) in order to name the picture. For the two methods, visual inspection of the graphed data shows that she needed less cueing at the end of the intervention. However, the difference between the number of cueings needed during each phase was not significant, either for the spaced retrieval method (Kruskal-Wallis's $x^2 = .69$; $p = .71$) or for simple repetition (Kruskal-Wallis's $x^2 = 2.0$; $p = .37$).

TBo's performance was analysed by comparing results on list 1 and list 2. Visual inspection (Figure 2b) for the picture-naming task suggests that TBo obtained better results with spaced retrieval than simple repetition. The mean number of correct responses was 1.7/4 (46%) with the spaced retrieval method during the intervention phase and .70/4 (13%) with the simple repetition method. However, the difference between the two methods was not significant (Mann Whitney's $U = 3.5$; $p = .17$). On post-intervention measures, the mean percentage of correct responses was 42% (1.7/4) with spaced retrieval and 25% (1/4) with simple repetition but with no significant difference between the two methods (Mann Whitney's $U = 6.5$; $p = .64$). Finally, for generation of specific attributes, no differences were found between the two learning methods at baseline, intervention, and post measures (Mann Whitney's tests, all observed p-values > .10) (Figure 2c).

GENERALISATION EFFECTS FOLLOWING THE INTERVENTION

For naming, no generalisation effects were recorded between trained items and control items belonging to similar semantic categories. There were also no generalisation effects for the additional 21 items of the extended naming test used during post-intervention measures. In fact, a modest decline in performance was observed for these items before and after the intervention for items belonging to trained categories (mean of 13/21 vs 10/21 items correctly named). This decrease in performance between pre- and post-tests

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was significant when comparing the performance across time (Wilcoxon's $Z = 22.1$; $p = .032$). With respect to generation of semantic attributes, TBo correctly produced specific attributes for two items of the control list that could have been learned from the matched target items (peach – pineapple, and guitar – violin), but this result was only obtained during one of the post-tests and thus was not stable.

LEXICAL ACCESS: SPECIFICITY OF THE INTERVENTION

The specificity of the intervention was assessed through a letter fluency task (P-L-T) performed before and after treatment in which TBo could have produced some of the names pertaining to the target list and control list. She never produced those items during the pre- and post-tests and a decrease in performance was observed (15 and 9 words produced before and after intervention, respectively).

GENERAL DISCUSSION

We have reported the case of TBo, a woman presenting with a general semantic deficit in a context of semantic dementia (SD). The general aim of this study was to explore the efficacy of a formal-semantic therapy combined with a spaced retrieval method to facilitate relearning of lost concepts and long-term retention. The study also explored possible generalisation gains obtained after the intervention.

Results suggest that the formal-semantic therapy led to better naming and generation of specific verbal attributes in TBo compared to baseline and the untrained lists. For the learning method, spaced retrieval was not statistically superior to the simple repetition condition. The beneficial effect of the formal- semantic therapy persisted and was maintained up to 5 weeks after the end of the intervention, with no difference between spaced retrieval and simple repetition. Finally, no generalisation within and between categories was observed. The intervention also appeared to be very specific since no improvement in the letter fluency task was observed.

In spite of these limitations, TBo's response to treatment was comparable to that obtained by other individuals with non-degenerative semantic deficits given formal- semantic therapy for naming. As a whole, participants obtain a

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10% to 65% improvement in performance (Drew & Thompson, 1999; Grayson et al., 1997; LeDorze & Pitts, 1995; Marshall et al., 1990; Nettleton & Lesser, 1991; Wambaugh et al., 2001). TBo's performance was also comparable with that observed in previous studies with individuals with SD. For example, KB, the participant treated by Snowden and Neary (2002), correctly named 30% of the treated items with repeated rehearsal. Similarly, the participant reported by Funnell (2001) learned six new vegetable names with repeated practice. Our results thus confirm that people with SD can improve their naming performance with training, but that this improvement is limited. They also suggest that a formal-semantic therapy does not lead to better results in naming (this study) than does simple practice (other studies).

Formal-semantic therapy, however, seems promising for retraining specific semantic attributes in SD (at least in the short term, as TBo's performance decreased after several weeks with no treatment). In this respect, TBo showed a major increase in performance during the intervention phase, reaching 8/11 (73%) of correct responses by the end of the intervention. The better results obtained by TBo for generation of semantic attributes than for picture naming are noteworthy. It is generally suggested that techniques focusing on semantic attributes and promoting semantic processing may enhance naming (Nickels, 2002). Some authors hypothesised that this enhancement occurs by recreating the semantic network of the target concept. Re-establishing part of that network when trying to name a concept could facilitate the retrieval of the corresponding word in the output lexicon and could lead to its effective spoken production in naming (Coelho, McHugh, & Boyle, 2000). Since TBo's naming performance was worse than her capacity to generate specific attributes, one might think that the number of relearned semantic attributes was insufficient to restore the link between her semantic and phonological representations and increase her naming performance to the level of her generation of semantic attributes. This indicates the importance of further determining the amount of knowledge that has to be relearned in order to restore the link between a concept and its phonological representation in SD as well as in aphasia. As pointed out by Jokel and colleagues (2006), there could also be some kinds of semantic knowledge, like function or sensory experiences, which would be more useful in linking a concept with its name.

One of the aims of this study was also to explore the efficacy of two types of

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learning method to enhance performance in SD when combined with a formal-semantic therapy. In fact, our study was a first attempt to explore the impact of spaced retrieval on performance in SD. The analysis of TBo's performance indicates no statistical advantages of this method over simple repetition. Although the small number of items used in our study could explain the lack of significant results (due to a lack of statistical power), some authors have also recently reported that different repetition schedules are as effective as spaced retrieval with non-degenerative aphasia. Morrow and Fridriksson (2006) observed that individuals with aphasia showed similar success for naming with a strict spaced retrieval method as with random selection of four possible intervals (1, 2, 4, and 8 minutes). In fact Fillingham and collaborators (Fillingham, Sage, & Lambon Ralph, 2005), when comparing different repetition-based treatments, observed that the precise treatment method used does not seem to make a difference to the degree of improvement in naming performance. Rather, they showed that one of the most important factors for naming success in non-degenerative disease could be the number of production attempts during therapy. In the present study TBo performed the same number of naming attempts with the two treatment methods, which could explain the comparable efficacy of spaced retrieval and simple repetition. However, further studies should determine if the number of naming attempts is in fact an important factor in enhancing the efficacy of naming treatment in SD.

The question regarding which treatment method might be more effective in SD was also discussed by Graham and colleagues (2001). These authors suggested that DM, the participant they studied, benefited from learning by using an approach in which errors are kept to a minimum. Spaced retrieval is also hypothesised to be an errorless-learning method when applied in dementia (Camp et al., 1996), although recent evidence shows that some persons with dementia of the Alzheimer's type may produce as many errors with the spaced retrieval method as with other schedules of practice (Hochhalter, Bakke, Holub, & Overmier, 2004). In the present study TBo made fewer mistakes with the spaced retrieval method than with simple repetition, which was more like a trial-and-error approach in which the participant is encouraged to ‘‘guess'' the answer at each trial. If the production of errors was an important contributing factor to the efficacy of treatment in SD, we would have observed better performance with spaced retrieval than with simple repetition.

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However, such a pattern was not observed in TBo. Future studies should explore this errorless hypothesis using more items and more sessions than we used in this exploratory study.

In addition to these aspects, Graham and colleagues (2001) also discussed DM's need to rehearse the list of treated names in a similar order to that used in the presentation. In fact, when this order was changed during testing, DM's performance declined significantly. The authors hypothesised that DM's learning was rote in nature and was highly dependent on the ordered link between the items in the list. In our study the items were, as much as possible, randomly presented to TBo during learning and testing. Although both random presentation (in our study) and rigid presentation order (Graham et al., 1999) led to a significant improvement in performance, it seems that random presentation of items should be used in SDinterventions in order to reduce the participant's reliance on strict, context- dependent learning.

Like other individuals with SD (Graham et al., 2001; Snowden & Neary, 2002), TBo showed item-specific improvement only in naming and generation of verbal attributes. For example, DM, the participant reported by Graham and colleagues (2001), showed no generalisation to untrained items even after extensive practice. Contrary to these disappointing results, some participants with non-degenerative deficits showed generalisation to items pertaining to trained categories (Drew & Thompson, 1999; Grayson et al., 1997) as well as to other modalities (Hillis, 1990) following a formal-semantic therapy. Since no generalisation was observed in TBo, it is thus logical to think that the amount of relearned information was not sufficient to allow naming of the items with which the treated concepts share semantic attributes. Nevertheless, as suggested by Graham and colleagues (2001), generalisation may not be a realistic objective to pursue in SD.

In fact, new learning in SD could be typically bound to a specific spatial and temporal context (Bozeat, Lambon Ralph, Patterson, & Hodges, 2002; Funnell, 2001; Snowden & Neary, 2002; Snowden, Griffiths, & Neary, 1994), especially with the progression of the disease (Funnell, 2001). Thus, new learning could rely more on episodic memory than on semantic memory, and generalisation within the semantic system may not occur. In TBo's case, although she improved in her ability to produce some names, she was only able to produce them within the specific context of the therapy. For example, she could not produce any of the trained items during a letter fluency test. It

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may be that her new learning, as with participant DM (Graham et al., 2001), was simply an association, or a linking, of a name with a picture. The same episodic learning can be hypothesised for TBo's performance on the generation of semantic attributes, in which no generalisation effect was observed, and which may also reflect the simple linking between a verbal description and a name (or a picture). However, TBo's long-term performance indicates that she maintained her naming of 2/8 items over the 5-week maintenance period, especially on naming, even with no further practice. This may suggest that the training resulted in a consolidation of links within her semantic memory and that this recovered knowledge was then independent of the episodic scaffolding provided during training. Our results are not clear enough to support one hypothesis (semantic consolidation) over the other (episodic linking), but future studies should try to explore further the mechanism by which treatment has its effect in SD. For example, following Funnell's (2001) hypothesis that with the progression of the disease, new learning in SD becomes more and more dependent on episodic memory, long-term retention and generalisation of knowledge should be observed in people with early SD and not in more severe cases of SD.

In sum, TBo's results confirm that, in an experimental context, improved retrieval of object names in SD is possible but rather limited. They also suggest that for SD the use of a formal-semantic therapy could be more effective for enhancing relearning of semantic attributes than concept names, although long-term retention of specific semantic attributes decreased in our study. Such a therapeutic objective could thus be more promising in future clinical studies than the usual focus on naming. The use of a particular treatment method does not seem to influence the success of the treatment. Finally, generalisation may not be a realistic objective to pursue in SD. It should be noted that this study was exploratory. Consequently, our results should be interpreted with caution. In fact, significant differences between treatment methods or generalisation effects may not have been observed because there were too few items to d etect small differences or because there were not enough treatment sessions. Other studies, perhaps using more items and more sessions, are necessary to confirm our results.

From a clinical point of view our results, and those reported in the literature,

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raise several questions regarding the best approach to use in SD. First, since therapy was more effective for relearning of semantic attributes than for improving naming abilities, in the short term, the general objective of treatment for people with SD should be reconsidered. Indeed, from a functional perspective there is less need to remember that an apple is called an apple, than to know that this object can be eaten and cooked. The formal-semantic therapy could thus focus on retraining functional attributes of concepts according to what the person needs to know in order to be more independent in daily living. In the context of a degenerative disease, this functional approach seems logical since the intervention should aim at a direct and rapid impact on the person's functional autonomy and quality of life (Van der Linden, Juillerat, & Adam, 2003). Moreover, as pointed out by Nickels (2002), item- specific learning of relevant functional knowledge, instead of generalisation, is a reasonable objective and seems logical in a context of degenerative disease.

Second, as shown in our study and that of Hillis (1990), semantic feedback seems important to facilitate learning of semantic attributes. However, since episodic memory is relatively well preserved in SD, the therapy could also rely on this preserved capacity. Some authors (Bozeat et al., 2002; Funnell, 2001; Snowden & Neary, 2002) have suggested that new learning in SD could be enhanced when tied to a specific spatial and temporal context that a person will encounter frequently in his/ her daily routine. For example, the person could learn how to use the objects, in relation to other objects, in the specific environment where he/she will have to use them. The relearned concepts could thus be anchored in a rich temporo-spatial context. Moreover, if the person with SD can introduce these relearned concepts in his/her daily life, their frequent utilisation could also lead to long-term retention. Such an ecological therapy should lead to better performance in semantic processing of trained concepts and to long-lasting maintenance of the functional use of concepts in daily living.

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APPENDIX

TABLE A1 *- List of the 24 items used during the intervention*

Target items list	*Neutral items list*	*Control items list*
Parrot	Peacock	Anchor
Owl	Eagle	Crown
Guitar	Violin	Toaster
Mushroom	Pepper	Chisel
Peach	Pineapple	Nut
Saxophone	Trombone	Sailing boat [in French ''voi lier'']
Bee	Fly	Helmet
Caterpillar	Beetle	Razor

TABLE A2 *- Specific attributes used for the target items and specific attributes spontaneously generated by TBo following the intervention (for target items only)*

Target items list	*Attributes used during th intervention phase*
List 1:	
Parrot	Has bright colours
Owl	Lives during the night
Guitar	Is made of wood
Mushroom	Grows on the ground
List 2:	
Peach	Does not grow in Québec
Saxophone	Is made of metal
Bee	Lives in a hive
Caterpillar	Transforms itself into a butterfly