

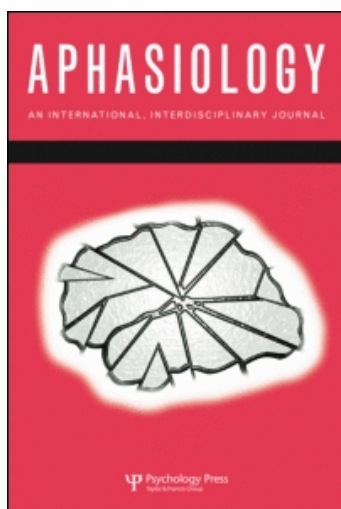
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Access details: Access Details: [subscription number 907420840]

Publisher Psychology Press

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## Aphasiology

Publication details, including instructions for authors and subscription information:

<http://www.informaworld.com/smpp/title-content=t713393920>

### The treatment of object naming, definition, and object use in semantic dementia: The effectiveness of errorless learning

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First Published on: 10 October 2008

**To cite this Article** Robinson, Sheila, Druks, Judit, Hodges, John and Garrard, Peter(2008)'The treatment of object naming, definition, and object use in semantic dementia: The effectiveness of errorless learning',*Aphasiology*,23:6,749 — 775

**To link to this Article:** DOI: 10.1080/02687030802235195

**URL:** <http://dx.doi.org/10.1080/02687030802235195>

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# The treatment of object naming, definition, and object use in semantic dementia: The effectiveness of errorless learning

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*Background:* Patients with semantic dementia are impaired in both object naming and, to a lesser extent, in object use (Bozeat, Lambon Ralph, Patterson, & Hodges, 2002a; Hodges, Graham, & Patterson, 1995). To date there have been relatively few studies examining the relearning of object names, and only one examining the relearning of object use. No study has examined relearning object naming, definition, and use simultaneously.

*Aims:* To explore the relatedness of object naming, definition, and object use in semantic dementia; to explore whether or not therapy is effective; and to explore the effectiveness of errorless learning.

*Methods & Procedures:* Two patients with mild to moderate semantic dementia and two matched control participants were tested in naming, defining, and demonstrating the use of 33 household objects. The quality of the definitions was rated as poor, adequate, or good by three independent raters. Three components of object use were examined: hold, orientation, and movement. The assessment was repeated with the patients following 3 weeks of therapy, and 1 month after completion of therapy. For the therapy objects were divided into individual trained and untrained sets based on familiarity and performance at initial assessment. Patients received therapy sessions twice weekly, and engaged in independent practice. During the therapy sessions, the researcher modelled the name, definition, and use of each item, which the patient then repeated. In the independent practice each patient watched a DVD in which she named and defined the object and used it correctly.

*Outcomes & Results:* Patients were severely impaired on object naming and definition, but less so on object use. Both patients showed some improvement as a result of therapy, which was maintained at follow-up in one case.

*Conclusions:* The results show that relearning in semantic dementia is possible. Factors affecting the results and the interaction between lexical and conceptual impairments are

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Thanks to HD and VH, and their spouses for their participation and perseverance throughout the project.

discussed. An unexpected finding of the study was that patients performed better in verb production both in the preliminary tests and in object definition.

**Keywords:** Semantic dementia; Errorless learning; Object naming; Object use; Therapy.

Semantic dementia is a selective impairment of semantic memory resulting in anomia, impaired single word comprehension, reduced performance on category fluency tests, surface dyslexia and dysgraphia, and generally impaired verbal and nonverbal knowledge. Syntax and phonology are spared, as are autobiographical, episodic and working memory, and visuo-perceptual, spatial, and nonverbal problem-solving skills (e.g., Bozeat et al., 2002a; Bozeat, Lambon Ralph, Patterson, Garrard, & Hodges, 2000; Garrard & Hodges, 2000; Hodges et al., 1999, 1995; Hodges, Patterson, Oxbury, & Funnell, 1992; Lambon Ralph, Graham, & Patterson, 1999; Snowden, Griffiths, & Neary, 1994a; Warrington, 1975). Neuroanatomically, patients present with focal atrophy of the anterior portion of the temporal lobe, the extent of which is correlated with the degree of semantic impairment (Hodges & Miller, 2001).

Levels of performance on different tasks that draw on semantics such as naming, verbal definition, word–picture matching, and drawing show similar patterns of performance (Bozeat et al., 2000; Hodges et al., 1995; Lambon Ralph et al., 1999): idiosyncratic and distinguishing properties of objects that result in impaired performance on narrow semantic distinctions (e.g., dog vs cat) are lost at earlier stages of the dementia, while superordinate distinctions (e.g., living vs nonliving) remain preserved for longer due to retained knowledge of shared properties (Rogers, Lambon Ralph, Hodges, & Patterson, 2004). As semantic impairment worsens, the ability to keep the representation of concepts distinct becomes increasingly difficult, causing overextension from typical category exemplars (e.g., all animals being named as a dog or cat, and drawn in a similar fashion; Funnell, 1995; Rogers et al., 2004).

Word-finding difficulties are pervasive and the type of errors made are dependent to a large extent on the severity of the dementia. A 3-year case study of JL (Hodges et al., 1995), noted changes from within-category and circumlocutory errors to superordinate and even cross-category errors (e.g., phone → *animal*) with disease progression. Moreover, correlations were found between the ability to name and define a word, and words did not reappear once lost from the patient's vocabulary. All these suggest that the underlying reason for the naming deficits is the gradual loss of semantic information.

## OBJECT USE IN SEMANTIC DEMENTIA

In contrast to the severe deficits evident in language tasks, the use of familiar objects appears to be well preserved. Semantic dementia patients manage to organise their everyday life, and continue to cook and enjoy hobbies—both of which require the manipulation of objects—at advanced stages of their dementia when they are no longer able to describe the function of the same objects or name them. This phenomenon is documented largely anecdotally, although Lauro-Grotto, Piccini, and Shallice (1997) described in detail a patient whose naming and verbal comprehension was very poor, but who was able to cook an elaborate meal in a kitchen set up for the purposes of the study in the laboratory.

A number of possible explanations have been put forward to account for the selective preservation of object use in the face of very impaired semantic knowledge. One is that partial semantic knowledge supports object use (Bozeat et al., 2000). A second possibility is that object use is “afforded” by the physical structure of the object (see Gibson’s theory of affordances, 1977). To test the latter hypothesis, Bozeat and colleagues compared the use of objects whose manner of manipulation was reliably predicted (i.e., afforded) by their structural characteristics with that of “non-afforded” objects. They found that patients with severe semantic impairment performed better in using objects that afforded the correct hold and movement, than those that did not (Bozeat et al., 2002a) suggesting that “affordance” indeed supports object use. Admittedly, however, affordance cannot compensate completely for lack of conceptual knowledge. This is nicely demonstrated by one of the patients in the present study who, while demonstrating the use of a watering can appropriately, said *it’s something you put some sort of liquid in it and pour it out of there. Would it be for doing some drinks?* A third possibility is that it is the well-preserved problem-solving skills that contribute to the relative preservation of object use in semantic dementia (see Hodges et al., 2000, who in the Novel Tools Test demonstrated that semantic dementia patients are as good as normal participants in using trial and error techniques). Finally, since it has been shown (e.g., Buxbaum, Schwartz, & Carew, 1997; Lauro-Grotto et al., 1997) that object use within context is better than in isolation, Funnell (2001) suggested that scripts or goal-based activities, such as cooking a meal, making tea, wrapping a present, may support object use, and that such scripts become increasingly reliant on the context of the patient’s personal experience.

In contrast to those studies that emphasise the relative preservation of object use, other studies highlight the fact that the semantic deficits these patients have are also evident in object use, although to a lesser extent (e.g., Bozeat et al., 2002a; Hodges et al., 2000), and Snowden, Griffiths, and Neary (1994b) reported a patient who was better in recognising and using her own objects than those of the experimenter, showing that object use is preserved only in limited contexts, not generally.

## THERAPEUTIC INTERVENTION IN SEMANTIC DEMENTIA

Both for the benefit of the patients and for understanding better the nature of the deficits these patients have, researchers have asked if it is possible to reinstate semantic knowledge in patients with semantic dementia. Graham, Patterson, Pratt, and Hodges (2001) speculated that the relatively well-preserved episodic memory processes involved in repeated practice could be harnessed as a means of repairing semantic deterioration. In their study, patient DM was given 100 words from six categories to practise over a 4-week period. This resulted in a significant increase in the number of items produced in a category fluency task. However, DM always produced the items in an identical order to that learnt, and was unable to define them, showing that learning occurred by rote, and did not involve reacquisition of semantic information.

Snowden and Neary (2002) argued that relearning can only take place if there is residual semantic knowledge that can be reinforced by providing personally relevant contextual information to which the concept can be linked. In their study, one of the two patients was given three learning trials on 10 words unknown at baseline assessment, and 10 for which the patient showed some retained semantic knowledge. At follow-up assessment 2 weeks later, the patient showed mild improvement

(correctly naming 5 out of 10 pictures compared to none at baseline) on items for which some semantic knowledge was retained, but not on the items for which no knowledge was retained at baseline (correctly naming only 1 out of 10) (see also Jokol, Rochon, & Leonard, 2002, who reported more improvement in naming for items for which comprehension was retained than for items for which it was not). With a second patient, Snowden and Neary assessed the effects of providing the patient with personally relevant information. Items for which no semantic knowledge was shown at baseline were associated with similar items in the patient's home, and/or with recent experiences to provide episodic links. If the patient expressed some recognition of the episodic link, naming and definition were more likely to be successful. However, performance even for these items deteriorated when the order of presentation was randomised. Thus, although it seems that acquisition of episodic type (i.e., temporal or rote order) information is more likely to occur than reacquisition of semantic knowledge, reacquisition of object names and their meanings is possible at times, if residual knowledge is available and if links to autobiographical experience are provided.

While there are a number of naming-therapy studies with semantic dementia patients, hitherto only one previous study has been published which explored the possibility of relearning object use. Bozeat, Patterson, and Hodges (2004) trained a semantic dementia patient in the use of 10 previously familiar objects. The use of each object and its recipient was demonstrated, and the patient was asked to copy the movement. Object use was assessed 2 hours, 1 week, and 5 weeks after the training session. There was a dramatic improvement for trained items, with 60% maintenance on the final assessment. A serious shortcoming of this study, however, is that conceptual knowledge of the objects was not tested. Therefore it is not possible to know whether any semantic knowledge of the objects was reinstated as a result of the therapy, or whether the improvements were merely due to procedural memory of a set of action sequences.

In conclusion, while the semantic loss in semantic dementia patients evident in verbal materials is relatively well documented in previous literature (e.g., Funnell, 2001; Garrard, Lambon Ralph, Hodges, & Patterson, 2001; Graham, Lambon Ralph, & Hodges, 1997; Hodges et al., 1995; Lambon Ralph et al., 1999; Lambon Ralph, Graham, Ellis, & Hodges, 1998; Snowden & Neary, 2002), information about object use is sketchy and even contradictory (Bozeat et al., 2002a; Buxbaum et al., 1997; Hodges, Bozeat, Lambon Ralph, Patterson, & Spatt, 2000; Lauro-Grotto et al., 1997; Snowden et al., 1994a), and none of the previous studies explored object use, object knowledge, and object naming of the same items by the same patients. Similarly, our knowledge about the effectiveness of therapeutic intervention with semantic dementia patients is very limited.

## ERRORLESS LEARNING

The present study employed the technique of errorless learning—a method based on Hebbian principles that always provides the correct information during learning in order to prevent strengthening of synaptic connections for an erroneous response. The reason for this choice was that errorless learning has been used with success with patients with amnesia (e.g., Baddeley & Wilson, 1994), schizophrenia (e.g., O'Carroll, Russell, & Lawrie, 1999), Alzheimer's disease (e.g., Clare et al., 2000), and (with limited success) with patients with aphasia (see Fillingham, Hodgson, Sage, & Lambon Ralph,

2003; Fillingham, Sage, & Lambon Ralph, 2006) and semantic dementia (Frattali, 2004). Errorless learning has also proved adaptable to “real-world” settings outside laboratory-controlled conditions. For example, Clare et al. (2000) taught a patient with Alzheimer’s disease the names of his social club members *within* the club setting (although see Kessels & de Haan, 2003, who point out that only a few studies have investigated the efficacy of errorless learning in real-world settings).

The effectiveness of errorless learning for improving naming in aphasic and semantic dementia patients is less encouraging than in amnesia and Alzheimer’s disease. For example, Fillingham et al. (2003, 2006) found that errorless learning in aphasic patients with anomia was equivalent, but not superior, to errorful learning. A possible reason for errorless learning attaining only modest therapeutic gains is the fact that in most studies reviewed in Fillingham et al. (2003) an error-reducing rather than errorless learning paradigm was employed. In error-reducing studies the task is controlled so as to minimise the possibility of errors, though not necessarily to eliminate them completely. In fact it is quite difficult to eliminate all errors even when the intention is to do so.

Alternatively, it is possible that whether or not errorless learning is beneficial is dependent on the patient’s cognitive status. The understanding of the conditions under which errorless learning outperforms errorful learning is still controversial, but some plausible explanations have been put forward. Successful Hebbian learning requires a feedback mechanism that is able to filter out erroneous responses spontaneously or with the help of external feedback. Therefore one needs intact explicit memory, attention, and executive skills to be able to learn in errorful situations. The reason why errorless learning is a better method of learning for amnesic patients is that they can only rely on implicit memory that does not have the capacity to filter out errors in acquiring new information. For these and patients with similar neurological conditions, errorless learning is the best method of learning. The aphasic patients (Fillingham et al., 2003, 2006), on the other hand, possibly did not have serious memory, attention, and executive function deficits, and therefore were able to benefit from both errorless and errorful learning situations, and this is why no difference between the two methods was found. Nevertheless, all aphasic patients preferred the errorless learning paradigm, presumably because it is less frustrating and more rewarding than errorful learning (Fillingham et al., 2006).

In the only therapy study to date using errorless learning with semantic dementia patients (Frattali, 2004), treated words improved only during the treatment phase, and all gains were lost after 3 months. The problem in evaluating this study is that Frattali does not provide the details of the therapy method used, including the number of exposures to the target words per session, a factor that was found to be important for the success of the method (e.g., Fillingham et al., 2006). Thus, the study is neither replicable nor it can be scrutinised in order to identify the reasons for its failure.

## THE PRESENT STUDY

The objectives of the present study are: to identify the deficits in naming, understanding the meaning of objects (as manifested in the definitions provided by the patients), and using objects; to provide treatment of such deficits using (whenever it was possible) the patients’ own objects, the errorless learning paradigm, and video self-modelling; and to assess the benefits of the treatment immediately after intervention and a month later.

In designing the intervention study we were guided by the patchy evidence currently available in treating semantic and other related deficits in dementia. On the strength of the evidence that object naming was significantly better when the input was an object in use rather than a picture (Coccia, Bartolini, Luzzi, Provifiali, & Lambon Ralph, 2004), it was decided to treat object naming, definition, and use simultaneously with the expectation that this would boost the effect of therapy. A 3-week period of intervention was chosen to be comparable to other therapy studies with semantic dementia patients (Graham et al., 2001, 4 weeks; Jokol et al., 2002, 3 weeks; Snowden & Neary, 2002, 3 weeks) and to be practical to engage the patients. In these studies the patients engaged only in self-study, whereas in the present study there were twice-weekly therapy sessions with the first author along with independent practice. In Jokol et al.'s (2002) study, the patient had to learn the names of 30 items per week, while in Snowden and Neary's (2002), the patient learned the names of 20 items. In the present study the number of items included was constrained by the number of objects in the Bozeat et al. (2004) set. A total of 17 items (half of the 33 items in the set) were treated, and 16 were in the control set. Intervention aimed to maximise success by using the patients' own objects (Bozeat, Lambon Ralph, Patterson, & Hodges, 2002b; Snowden et al., 1994b) and the use of personally relevant autobiographical cues when possible (Snowden & Neary, 2002). With the same objective in mind, errorless learning and video self-modelling was used in the self-study sessions as video self-modelling provided additional errorless learning opportunity in the researcher's absence. Self-modelling was used on the evidence that the more a participant perceives a model as similar to themselves, the more likely it is that imitation of the modelled behaviour will occur (Dowrick, 1999; Meharg & Woltersdorf, 1990).

For the baseline study our predictions were the following: on the basis of what is known about the pattern of preservation and impairment in semantic dementia, it was not expected that a patient would be able to correctly name or define an object, but be unable to demonstrate its use. Because patients can exploit their relative intact nonverbal problem-solving abilities in the object use task (Hodges et al., 2000), we thought it possible that patients might be able to correctly figure out an object's use, even if conceptual knowledge about it had been lost. Thus we predicted that object use would be the best-preserved activity. Only limited evidence is available for predicting the relative preservation of naming and definition. In the only study that tested naming and definitions together (Snowden & Neary, 2002) the patient was unable to name or to provide a definition/description at baseline testing for any of the test items. However, Hodges et al. (1992, 1995) found that the patients in their study made many semantic-type errors (within-category, circumlocutory, and superordinate errors) in object naming, which may indicate that, at least, partial semantic knowledge had been preserved. We hypothesised that partial semantic knowledge might be exploited by the patients in defining the objects that they could not name, and therefore we predicted better performance on definitions than naming.

For predicting the outcome of the intervention study, there is only limited previous evidence on which to rely. Snowden and Neary (2002) assessed performance on both naming and definitions, however definitions were not trained, and Bozeat et al. (2004) did not train either naming or definitions, only object use. Since, when naming, the verbal label of the object has to be retrieved in addition to accessing semantic features, and a deficit in naming is known to be the first presenting

symptom in semantic dementia, we hypothesised that naming would be more resistant to therapy than providing a definition. Finally, in Bozeat et al. (2004) the improvement found in object use was maintained to some degree 5 weeks following a single training session. We predicted, therefore, that object use would be most amenable to improvement, and would be better maintained than naming and definition. However, it also needs to be kept in mind that object use is predicted to be best preserved even prior to therapy, and thus the scope for improvement might turn out to be limited.

## CASE HISTORIES

Two patients with mild-moderate semantic dementia were identified through the Memory & Cognitive Disorders Clinic, Addenbrooke's Hospital Cambridge, UK, and the National Hospital for Neurology & Neurosurgery, Queen's Square, London.

HD is a 63-year-old female who lives with her husband and has two adult children. She attended university for 3 years, and worked as a catering manager and Home Economics teacher until her retirement in 1998 after which she continued to work part-time until 2005. Word-finding difficulties were first noticed 3 years prior to the commencement of this study. She presently reports word-finding, reading, and comprehension difficulties. She continues to manage the home, although she cooks a narrower range of dishes than previously. She enjoys landscape gardening, travelling, sailing, and solving Sudoku puzzles.

VH is a 63-year-old female who lives with her husband, with whom she ran a successful business. She has two adult children. VH has a 3-year history of word-finding difficulties, first noticed when she was unable to complete the crossword. She also reports inability to read and comprehension difficulties. Her husband now cooks most meals. VH continues to enjoy travelling and yoga, and has learnt to solve Sudoku puzzles. Two age-matched female control participants also carried out the experimental tasks.

## INITIAL ASSESSMENTS

### General neuropsychological tests

The Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975), the Wechsler Abbreviated Scale of Intelligence (Wechsler, 1999), the Visual Object and Space Perception Battery (Warrington & James, 1986), and the National Adult Reading Test (NART; Nelson, 1991) were carried out to establish base line performance. A summary of the results for general neuropsychological tests are given in Table 1.

Both patients' scores on the MMSE indicated mild to moderate dementia. Impaired language abilities led to a marked discrepancy between Verbal IQ and Performance IQ on the Wechsler Abbreviated Scale of Intelligence (Wechsler, 1999). A pattern of surface dyslexia with phonologically plausible errors was evident on the National Adult Reading Test (Nelson, 1991), which consists of words with irregular grapheme-phoneme correspondence and therefore can no longer assess premorbid intelligence for these patients (e.g., Garrard & Hodges, 2000). Finally, as expected, both patients showed well-preserved visuospatial abilities on the Visual Object and Space Perception Battery (Warrington & James, 1986), and patients failed only those sections that necessitated naming.

TABLE 1  
Results of general neuropsychological tests

<i>Test</i>	<i>Subtest</i>	<i>HD</i>	<i>VH</i>
Mini-Mental State Examination (MMSE)	—	26	22
Wechsler Abbreviated Scale of Intelligence (WAIS)	Full IQ	92	89
	Verbal IQ	76	71
	Performance IQ	112	117
National Adult Reading Test (NART)	Full Scale IQ estimate	98	96
Visual Object and Space Perception Battery (VOSP)	Sections Passed	6/8	6/8

### Conceptual semantics, comprehension, and naming tests

The Pyramids and Palm Trees (picture version, Howard & Patterson, 1992) and Camels and Cactus (Hodges, personal communication) tests were used to test conceptual knowledge. To investigate lexical semantic knowledge, patients were administered the Category Comprehension subtest from a semantic battery consisting of 64 pictures, with three categories of living things and three categories of non-living things (Hodges et al., 2000), which requires choosing the correct picture from an array of six items in response to a spoken name. A second test of lexical semantics was the Noun Verb Comprehension Test (Masterson & Druks, unpublished), which is a company test of the Object and Action Naming Battery (Druks & Masterson, 2000). It consists of a word–picture verification task in which noun and verb items are tested three times: a picture appears once with its correct verbal label, once with an unrelated, and once with a semantically related verbal label. Items are scored correct when all three responses are correct. Naming and word production was tested with the Boston Naming Test (Goodglass, Kaplan, & Baresi, 2000), the Object & Action Naming Test (Druks & Masterson, 2000), and verbal and category fluency.

The results are summarised in Table 2. Both patients fell below the normal range on both the Pyramids and Palm Trees test, and the Camels and Cactus test. Lexical semantic impairment is evident in the low scores achieved in the Category Comprehension Test. No category-specific effects for living and non-living items were evident in this test. Comprehension (of nouns and verbs), though better preserved than naming, was nevertheless impaired. The severity of anomia is shown in the scores in the Boston Naming Test, Object and Action Naming Battery, and category fluency. Interestingly, both patients presented with better-preserved action naming than object naming: HD ( $\chi^2 = 21.782$ ,  $df = 1$ ,  $p \leq .001$ ) and VH ( $\chi^2 = 15.737$ ,  $df = 1$ ,  $p \leq .001$ ). HD also had a verb advantage in the Noun Verb Comprehension Test ( $\chi^2 = 8.154$ ,  $df = 1$ ,  $p = .004$ ).

## EXPERIMENTAL INVESTIGATIONS

### Object naming, definition and use test: Baseline testing

#### *Materials and procedure*

A total of 33 objects from Bozeat et al. (2002a) (for a full list of objects, see Appendix 1) that included kitchen utensils, stationery items, and tools from a wide range of familiarity were used. Three objects (chisel, vice, and power drill) were

TABLE 2  
Results of tests assessing semantic knowledge and naming

<i>Type of knowledge tested</i>	<i>Assessment</i>	<i>Subtest</i>	<i>HD</i>	<i>VH</i>
Conceptual knowledge	Pyramids and Palm Trees	3 pictures	43/52	41/52
	Camels and Cactus Test	Words	34/64	27/64
		Pictures	44/64	28/64
Lexical semantics	Category Comprehension Test	—	33/48	—
	Noun and Verb Comprehension	Noun Comprehension	87.5%	89.3%
		Verb Comprehension	94.7%	91.5%
Naming	Object and Action Naming Test	Objects	33%	34%
		Actions	67%	59%
	Boston Naming Test	—	9/60	10/60
	Letter Fluency	F, A, S	11	6
	Category Fluency*	Animals, Supermarket	7	14 *

\*VH was tested on “supermarket” category only.

omitted from the original set. In order to rate the items in the assessment for (personal) familiarity, a questionnaire was given to the patients’ partners, asking them to rate how frequently the patient used each object on a 5-point scale (1 = daily, 2 = weekly, 3 = monthly, 4 = rarely, 5 = never). Control participants completed the questionnaire themselves.

The participants were presented with each object in isolation, and were asked to name it, describe its function, and demonstrate its use. If they were unable to correctly describe and/or demonstrate the object’s use, they were provided with a typical recipient (e.g., a bottle of wine was given for the corkscrew). If they were still unable to describe and/or use the object, the object with its recipient partly in the goal state was presented (e.g., the corkscrew half-screwed into the cork). Objects were presented in random order, and performance was videotaped for later evaluation. Naming was scored as correct or incorrect. Definitions were rated for their perceived adequacy by three independent raters who were not familiar with the objective of the study. For this purpose, the definitions of patients and controls were intermixed and were presented in a different order to each rater. The raters were told the target label for each definition and were asked to score the definition on a 3-point scale from 0 (poor, does not describe target object) to 2 (good, describes target object well). There was agreement in the ratings given among all three raters for 56% of the items, and agreement between two raters on 40% of the items. Only in 4% of cases did each rater accord a different rating to an item. The sum of the rating scores received by patients and controls were compared using chi-square analysis.

Object use was scored according to a feature database (Bozeat et al., 2002a) that was collated on the basis of 10 control participants using the objects. The database specifies the number of hands used to hold the object, position of the object, and individual movements. These (Hold, Orientation, and Movement) were scored separately. Hold and orientation were scored as correct (1) or incorrect (0). For movement, because their numbers differed across objects, a proportional score was given, with scores ranging from 0 for no correct movements to 1 for all movements correct. For example,

four movements (place on top of apple, push through apple, twist and remove from apple) are cited for *apple corer*, with each movement scoring 0.25.

## Results

The results for individual patients' and controls' in naming and definitions and object use (the scores for object use are the sum of scores for Hold, Orientation, and Movement) are given in Table 3. Table 3 shows that the patients performed poorly in both naming and definition, but were relatively less impaired on object use. In all comparisons, individual patient scores were compared with the mean of the two controls' scores.

*Naming.* The two patients performed significantly worse than the control participants in object naming ( $\chi^2 = 44.345$ ,  $df = 1$ ,  $p \leq .001$ ). The errors of the control participants, who produced few, were predominantly circumlocutions (e.g., corkscrew  $\rightarrow$  *cork remover*). The patients' errors were almost always errors of omission. However, they did show an awareness of their naming deficits (e.g., *I probably won't know the name of it*) and sometimes referred to the object with a generic noun or pronoun (e.g., pencil sharpener  $\rightarrow$  *That's a tiny little thing, isn't it?*; garlic press  $\rightarrow$  *I've got my one here*). Even when able to describe an object's use (e.g., garden fork  $\rightarrow$  *dig it, but the word, the name of it, no*) the patients did not attempt to guess the item's name, or form a de-verbal noun (e.g., garden fork  $\rightarrow$  *digger*).

*Definitions.* Table 4 presents the number of definitions that were rated as poor (0), adequate (1) and good (2). The patients' definitions were significantly more likely to be rated as poor than those of controls ( $\chi^2 = 48.205$ ,  $df = 1$ ,  $p \leq .001$ ), and significantly less likely to be rated as good ( $\chi^2 = 72.794$ ,  $df = 1$ ,  $p \leq .001$ ). The definitions of the controls were significantly more likely to be rated as good rather than adequate or poor ( $\chi^2 = 306.583$ ,  $df = 1$ ,  $p \leq .001$ ;  $\chi^2 = 430.144$ ,  $df = 1$ ,  $p \leq .001$ ).

The most common error in patient definitions was omission of a noun, or use of a generic instead of a specific noun (e.g., scraper  $\rightarrow$  *for scraping things*), followed by producing an empty definition (e.g., hole punch  $\rightarrow$  *I don't know if that one moves. It obviously does something*). The patients would often use the correct verb to describe the object's function, but either omit the name of the appropriate recipient, or use instead a generic noun (e.g., sellotape  $\rightarrow$  *that's to stick on something* [HD]). Other errors included denial of knowledge of an object's function (e.g., screwdriver  $\rightarrow$  *now*

TABLE 3  
Scores on object naming, definition, and use

Participant	Naming $n = 33$	Definition rating ( $\max = 198$ )*	Object use ( $\max = 99$ )
HD	2	90	95
VH	3	49	68.15
Control 1	32	182	97.5
Control 2	27	179	95.5

\* The maximum score for definition (198) represents the number of items (33) multiplied by the maximum score for an individual item (2) and by the number of raters (3).

TABLE 4  
Number of definitions rated as poor (0), adequate (1), and good (2)

Participant	Score (max = 99)*		
	Poor	Adequate	Good
HD	36	36	27
VH	57	35	7
Control 1	2	12	85
Control 2	4	11	84

\*The maximum score of 99 is derived by 33 items being rated by three raters.

*that's not meaning anything to me*), or producing a merely visual description of the object (e.g., ink stamp → *there's those things that obviously move around, different numbers*). VH also produced some incorrect definitions (e.g., scraper → *that's something you slice things*). For control participants, the most prominent error was use of a generic rather than specific verb (e.g., watering can → usually *used* for pot plants or hanging baskets because it's not too big and you *put* the water in). Examples of definitions and their ratings are given in Appendix 2.

*Object use.* For each patient, the number of objects demonstrating correct hold, orientation, and movement was compared with that of the control participants using chi-square. Scores for individual components of object use are presented in Table 5. VH used fewer objects correctly on all three parameters, and the difference was significant for *orientation* ( $\chi^2 = 13.39$ ,  $df = 1$ ,  $p \leq .001$ ) and *movement* ( $\chi^2 = 16.17$ ,  $df = 1$ ,  $p \leq .001$ ), but not for object *hold*. In contrast, HD's overall object use score was close to that of the control participants, although *movement* was somewhat impaired by comparison.

*Presence of a recipient.* Table 6 shows the extent to which providing a recipient improved object use. The control participants did not require a recipient. HD required a recipient for six objects, whereas VH required a recipient for 17 of the 33 objects. The poor performance with these particular objects is, most probably, evidence of knowledge loss, given that object use was generally better preserved than either naming or definition, and neither of the patients was able to name or define an object for which they required a recipient. The most basic component of object use, *hold*, was at or near ceiling for both patients, even when objects were presented without a recipient, and thus could not be improved on with provision of a recipient.

TABLE 5  
Scores on components of object use ( $n = 33$ )

Participant	Hold	Orientation	Movement
HD	33	33	29
VH	29	18	21.15
Control 1	32	32.5	33
Control 2	33	30.5	32

TABLE 6  
Scores on components of object use before and after provision of a recipient

Patient	No. of objects		Without recipient	With recipient
HD	6	Hold	6	6
		Orientation	6	6
		Movement	2	5.75
VH	17	Hold	14	15
		Orientation	6	12.5
		Movement	8.75	11.46

However, providing a recipient did improve *movement* for HD ( $Z = -2.214$ ,  $p = .027$ ) and *orientation* for VH ( $Z = -2.516$ ,  $p = .012$ ). VH also required the presentation of a recipient in partly completed goal state for three objects (apple corer, compass, screwdriver). This in turn enabled the correct use of two of them (compass and screwdriver).

*The effect of familiarity on naming, definition, and use.* The effect of familiarity was explored by correlating the familiarity ratings of target objects with scores of naming, definition, and overall object use. The control participants used more objects on a daily or weekly basis than did the patients, and listed fewer objects as rarely or never used. The two patients differed slightly in their familiarity ratings. HD used 11 objects on a daily or weekly basis, 7 objects once a month, and 15 objects rarely or never. VH only used 8 objects daily or weekly, 6 objects once a month, and 19 objects, rarely or never. The differences between the patients are in accord with the fact that VH participates less in household activities (e.g., cooking) than pre-morbidly, while HD retains a wider range of activities (e.g., cooking, gardening).

For the control participants, there was no relationship between object familiarity and naming, definition, or object use. There was a significant correlation (Spearman's rho) between familiarity and naming for both HD ( $r = -.335$ ,  $p = .026$ ) and VH ( $r = -.417$ ,  $p = .008$ ). Neither of the patients was able to name items that received a familiarity rating of 5 (never used). There was no correlation between the patients' familiarity with the objects and definition scores. As for object use, both patients achieved higher scores for the use of more familiar objects but the correlation was significant only for HD ( $r = -.377$ ,  $p = .031$ ).

### Summary of initial testing

While control participants performed at or near ceiling in the object naming and definition, the patients were severely impaired in both, with naming being more impaired than definitions. For example, HD named only 2 objects, but was able to define 10 as well or nearly as well, as the controls (e.g., ruler → *You just want to know the size of something*; rubber → *Clean something on that you've written*) and VH named only 3 objects but defined 5 relatively well (e.g., sellotape → *It's something if I were to pull it out, it's sticky and it sticks onto those things*; measuring tape → *It's something you can measure in distance*). While HD produced definitions relating to the function of the object, VH frequently provided autobiographical information (e.g., pencil → *That's what I use when I'm doing Sudoku & it's difficult & then I use*

*pencil*). For both naming and definition, both patients performed significantly less well than the controls.

Although the patients were relatively less impaired on object use, both performed less well than their matched control participants. While for HD the difference was very small, for VH object use in general, and orientation and movement, were significantly different from that of the controls. None of the control participants required a recipient during testing; however both patients required the provision of a recipient for some objects, which subsequently led to improved performance. Finally, familiarity affected naming for the patients, but not the control participants.

## THERAPY

### Materials and procedure

Following the initial assessment, the objects were divided into treatment ( $n = 17$ ) and control sets ( $n = 16$ ) on the basis of two criteria. The first criterion was rated familiarity and the second was naming success. Because each patient had different familiarity ratings for the objects, and was able to name different items, each patient had their own individual treatment and control sets containing an equal number of objects that she could and could not name at baseline, and an equal number of familiar and less familiar objects. These were randomly assigned to either the treatment or the control set. While the researcher hoped to use patients' own objects in therapy, this was possible only for HD; VH was trained with the researcher's objects. Objects were presented together with their typical recipients throughout the therapy sessions.

Researcher-assisted training took place twice per week, with 2 or 3 days between each visit. Training for HD took place over 3 weeks (six therapy sessions). Unfortunately, VH was only available for a 2-week period, and therefore received only four therapy sessions. Objects were presented in random order to avoid order effects, and were presented three times during each session. The following procedure was used.

1. First the researcher explained the procedure: "I will be showing you some objects, and will be telling you their name and what they do. I will ask you to say the name and the description after me. If you need me to repeat, just ask. I will then show you how the object is used and ask you to copy me."
2. The researcher presented the object with its recipient and named it. The patient was prompted to repeat the name if he/she did not spontaneously do so.
3. A definition was provided. Definitions aimed to be personally relevant to the patient when possible. For example, *S. uses this digging the flowerbed* and *B. uses this making scrambled eggs*. The patient was prompted to repeat the definition if he/she did not spontaneously do so.
4. The researcher demonstrated how the object was used, and handed the object to the patient. The patient was prompted to replicate the researcher's actions if he/she did not spontaneously do so.

The first therapy session was videoed, using a Panasonic compact VHS camcorder (GR-FXM15). The data were captured in real time using Capture Flux, edited using Virtual Dub to select only the patients' correct naming, definition, and use of each object, and this was recorded onto a DVD. The DVD was given to the patients in the second therapy session, and they were instructed to watch the DVD once per day

without doing anything additional (such as imitating the action or naming the objects) on the days when the researcher was not visiting.

While it could be argued that the procedure used in the researcher-assisted therapy sessions had potential for errors (and would therefore not be a true errorless learning situation), neither patient made any errors in verbal repetition or demonstrating object use in any of the therapy sessions.

### *Post-therapy assessment*

During post-therapy assessment patients were tested on the trained and untrained objects. Patients were asked to name each object, describe its function, and demonstrate its use. The objects were presented in pseudo-random order that alternated between trained and untrained objects. Testing took place approximately 3 days after the final session, and a follow-up assessment was carried out 1 month later. During the 1-month interval no further therapy sessions or viewing of the DVD took place. In order to establish that the therapy had an effect on the patients' everyday life, it was also intended that during this month the patients' spouses would keep a log to record correct instances of naming and/or using the trained objects. However, they failed to complete the log provided.

## Results

The following comparisons were carried out on the patients' performance. (i) Performance on trained objects post-therapy was compared with that pre-therapy, and with performance on untrained objects, using the Wilcoxon test. (ii) Performance on trained objects was compared immediately post-therapy and 1 month later to explore maintenance of therapy gains. (iii) Performance on untrained objects pre- and post-therapy was also compared to investigate whether there were any carryover effects from trained to untrained objects. (iv) The ratings given to patients' definitions pre- and post-therapy were compared to examine whether definitions of trained objects improved post-therapy. It was not possible to subject the level of improvement as a function of object familiarity to statistical analysis, due to the small numbers involved. Therefore, the data were analysed qualitatively for the effect of object familiarity on response to therapy. Table 7 compares performance in object naming, definition, and use before and after therapy for the two patients.

TABLE 7

Scores on object naming, definition, and use pre- and post-therapy (percentages in brackets)

Patient	No. of objects:	<i>Pre-therapy</i>		<i>Post-therapy</i>		<i>Follow-up</i>	
		<i>Trained</i>	<i>Untrained</i>	<i>Trained</i>	<i>Untrained</i>	<i>Trained</i>	<i>Untrained</i>
		17	16	17	16	17	16
HD	Naming	1 (6)	1 (6)	7 (44)	3 (19)	9 (53)	2 (13)
	Definition	8.5 (50)	8.5 (53)	10.7 (63)	9.8 (61)	11 (65)	8.8 (55)
	Use	16.3 (96)	15.3 (96)	17 (100)	15.5 (97)	17 (100)	14.6 (91)
VH	Naming	2 (12)	2 (13)	1 (6)	1 (6)	1 (6)	1 (6)
	Definition	3.5 (21)	5.5 (34)	10 (59)	7.5 (47)	4.7 (27)	3.7 (23)
	Use	10.3 (61)	11.6 (73)	15 (90)	10 (63)	13 (76)	11 (71)

### Naming

HD, but not VH, showed improvement in naming compared to pre-therapy using the Wilcoxon test ( $Z = -2.449$ ,  $p = .014$ ). Improvement in naming occurred for objects at all levels of familiarity, except for objects that were never used. Following therapy HD also named two untrained objects, both highly familiar to her (hammer, scraper). There were no significant differences in performance on trained objects immediately post-therapy and at follow-up assessment for either of the patients. HD actually named more trained objects at follow-up than at the immediate assessment, whereas naming of untrained objects remained unchanged.

### Definition

Definitions of trained objects were more likely to be rated as *good* post-therapy for both VH and HD ( $\chi^2 = 28.075$ ,  $df = 1$ ,  $p \leq .001$ ;  $\chi^2 = 8.28$ ,  $df = 1$ ,  $p = .004$ ). Unexpectedly this was also the case for untrained objects, although the difference was only significant for VH ( $\chi^2 = 8.178$ ,  $df = 1$ ,  $p = .004$ ). Both patients produced fewer generic nouns and more specific nouns defining objects following therapy than on initial testing. For example, HD's definition of a cheese grater changed from *It's a different size to cut things up* initially, to *You can grate cheese, ginger and you can do some other things*. VH's definition of a corkscrew changed from *I suppose that can turn into something and it would then click it up* to *And that's for opening the bottle of wine*. There was some effect of familiarity in improvement of definitions. Improvements (as seen in raw scores) were greater for objects used daily or weekly than those used less frequently.

There were no significant differences between HD's performance on trained objects immediately post-therapy and at follow-up assessment. However, VH's definitions of both trained and untrained objects were more likely to be rated as *poor* and less likely to be rated as *good* at follow-up assessment than immediately post-therapy, and were not significantly different from ratings at initial testing. The decline in definitions was reflected in production of fewer specific nouns at follow-up testing, particularly for trained objects.

### Object use

For VH there was significant improvement in both *hold* ( $Z = -2.236$ ,  $p = .025$ ) and *orientation* ( $Z = -2.81$ ,  $p = .005$ ) from pre- to post-therapy using the Wilcoxon test. HD could not improve because her pre-therapy score was already good. Table 8 gives the scores for individual components of object use pre- and post-therapy. The table shows that VH's pre-therapy performance on *hold* and *orientation* in the trained set was somewhat lower compared to the untrained set (due to the fact that the two sets were matched on naming and definition, not object use) allowing greater scope for improvement, a fact that needs to be considered when evaluating the effects of training. Post-therapy performance with trained objects was significantly better than with untrained objects for *orientation* ( $Z = -2.828$ ,  $p = .005$ ), and somewhat better (but not significantly so) for *movement* ( $Z = -1.847$ ,  $p = .065$ ). Scores for *movement* of untrained objects were significantly lower at post-therapy than pre-therapy ( $Z = -2.214$ ,  $p = .027$ ), which could possibly be an indication of the progression of semantic decline. Level of familiarity had no significant effect on improvement in object use.

TABLE 8  
Scores for components of object use pre- and post-therapy (percentages in brackets)

Patient	No. of objects:	Pre-therapy		Post-therapy		Follow-up	
		Trained	Untrained	Trained	Untrained	Trained	Untrained
		17	16	17	16	17	16
HD	Hold	17 (100)	16 (100)	17 (100)	15.5 (97)	17 (100)	16 (100)
	Orientation	17 (100)	16 (100)	17 (100)	15.5 (97)	17 (100)	13 (81)
	Movement	15 (88)	14 (88)	16.5 (97)	15.5 (97)	17 (100)	14.7 (92)
VH	Hold	11 (65)	14 (88)	16 (94)	16 (100)	17 (100)	16 (100)
	Orientation	9 (53)	10.5 (67)	16 (94)	8 (50)	13 (76)	10 (63)
	Movement	10.85 (64)	10.3 (65)	12.75(75)	4 (25)	8.58 (50)	8 (50)

HD showed no significant change in any component of object use at follow-up testing. VH, on the other hand, showed decline in scores for *orientation* of trained objects ( $Z = -2$ ,  $p = .046$ ). There was no significant change in object use scores of untrained objects between immediate and follow-up testing, though scores for *movement* were slightly below baseline.

### Summary of therapy results

HD received 3 weeks of therapy (six sessions) with her own objects, and was retested with her own and untrained objects. Unfortunately, VH received only 2 weeks of therapy (four sessions), and the researcher's objects rather than her own were used. Both patients showed some benefits from therapy. Both patients produced significantly more definitions rated as *good* for trained objects. Unexpectedly, they also produced better definitions for untrained objects post-therapy. They also improved in some aspects of object use as a result of therapy. Since *hold* and *orientation* for HD were near ceiling at initial testing there was little scope for improvement for her, but *movement* of trained objects did show improvement post-therapy. For VH, whose object use was more impaired at initial testing, all components of object use improved following therapy, although only *hold* and *orientation* improved significantly. This illustrates that *hold* and *orientation* may be better preserved, and respond better to therapy when impaired, than *movement*. In relation to naming there was a difference. HD's naming of trained objects improved significantly, but VH's did not.

Maintenance of therapy gains was different for the two patients. HD maintained the therapy gains, while VH's gains in definitions and *orientation* of (trained) objects declined significantly, although they remained above baseline. Any improvement in both patients' definitions of untrained objects post-therapy was no longer evident at follow-up. The differences found between the patients' response to therapy in naming and in maintaining therapy gains in object use may be due to VH receiving fewer therapy sessions, and/or to her more severe semantic impairment. As for naming, it is the most severely impaired skill in semantic dementia, and VH's naming was already more impaired at baseline than that of HD. Therefore it is perhaps not surprising that her naming ability did not respond to therapy.

## DISCUSSION

In the present study, unlike in previous therapy studies, object naming, definition, and use have been targeted simultaneously. It was expected that creating an association between an object and its function verbally *and* nonverbally would be beneficial. By doing so we harnessed sensorimotor information and procedural memory to boost the impoverished semantic representations of objects.

The discussion has three parts. In the first part we discuss the results for naming, definitions, and object use pre- and post-therapy and the effects of familiarity on patients' performance. In the second part we discuss what can be learned from the object definition task about the gradual loss of conceptual knowledge in semantic dementia. Finally, in the third part we consider the implications of our results for therapeutic intervention in semantic dementia.

As predicted, we found that at the initial assessment both patients were most impaired on object naming, and least so on object use, with object definition in between. Similarly to Hodges et al. (2000) and Bozeat et al. (2002a), we found that semantic dementia patients were very impaired in naming. We also found, like Lambon-Ralph et al. (1998), that familiarity and success in naming were highly correlated. HD, for example, remained unable to name any object that she never used, even following therapy. Familiarity also had a strong effect on the quality of definitions. HD received only one third of the maximum possible scores for her definitions of unfamiliar objects, and for VH this figure dropped to 5%. Definitions of unfamiliar objects were often vague with no mention of a recipient (e.g., spanner → *To grip something. To pull something out*).

The predictions regarding the relative improvements of object naming, object definition, and object use following therapy were only partly fulfilled. HD's object use was well preserved at baseline, and thus very little improvement was possible. However, contrary to expectations, her naming improved to a greater extent than definitions. The area of greatest improvement for VH was object definition rather than object use, with significant gains for both trained and untrained objects.

One could argue that the improvement of untrained objects may indicate that none of the improvements were due to the training provided but due to some other unidentified factor, perhaps spontaneous recovery. However, given the degenerative nature of semantic dementia this is unlikely, especially given that the more significant improvement was found in the patient with greater semantic impairment. The improvement is more likely to be the effect of practice in defining objects in general, or to represent carryover from trained to untrained objects with similar functions (e.g., ruler and measuring tape).

In relation to object use we were interested in (1) comparing performance on the three component features of object use: hold, orientation, and movement; (2) in the facilitation of naming, definition, and use that the provision of the recipient of an object, and the provision of a recipient in its partly completed goal state, was able to provide; and (3) in the effects of familiarity on object use.

The results of the present study were similar to those in Hodges et al. (2000) and Bozeat et al. (2002a). They also reported higher scores on object *hold* than either *orientation* or *movement*. This shows that object *hold* is the most *afforded* of the three component features. For example, 12 of the objects in our study had a sharp edge. The correct hold of such objects could be figured out by simply avoiding the sharp edge, without accessing semantic knowledge. The problem, however, is that

“affordances” are usually identified post hoc (Bozeat et al., 2002a). In order to use affordances as an explanatory construct, criteria need to be developed a priori for specifying the systematic relationships between physical features and object use attributed to affordances (Hodges et al., 2000).

VH required recipients for 80% and HD for 50% of unfamiliar objects in order to use them correctly. Neither of the patients was able to name an object for which they required a recipient. Providing a recipient did not assist either patient in naming, but it improved definitions in approximately 50% of cases (according to SR’s rating, ad hoc). This was mainly true in defining less familiar objects. It also improved overall object use. Again, there were differences between the patients. As in Bozeat et al. (2002a), only the more impaired patient needed the recipient to provide additional semantic information to support the correct use of the object. HD achieved a higher score in object use and required fewer recipients than VH. This pattern is in accordance with HD’s and VH’s relative levels of semantic impairment. The background tests, the Pyramids and Palm Trees Test, Camels and Cactus Test (Bozeat et al., 2000), and the BPVS (Dunn, 1997) all show that VH’s semantic decline is more serious than that of HD.

When providing a recipient was insufficient to elicit correct object use, the recipient was presented with the object in its partly completed goal state. We hypothesised that this would elicit trial and error problem solving. VH required this cue for three objects in the initial assessment and it enabled her to demonstrate the correct use of two of them. This cue tends to benefit more patients with more severe impairment than the patients in the present study (see Bozeat et al., 2002a).

### Conceptual knowledge in semantic dementia: Findings from the present study

The definition task provided a valuable insight into the patients’ conceptual knowledge. It was especially useful to distinguish between cases when an object was correctly used because conceptual knowledge about the object was available, and cases when the object was correctly used *despite* the lack of conceptual knowledge (e.g., using a watering can appropriately, but saying its function was to pour drinks). The only previous therapy study of object use (Bozeat et al., 2004) was unable to distinguish between these two possibilities. VH, for example, attributed incorrect function to eight objects on initial testing despite using them correctly. She sometimes expressed surprise that an object and its recipient were related, or when problem solving led her to correct use of an object (e.g., hole punch → *So, it makes a hole, it does, it makes that. Gosh!*). Her definitions, at times, were guided by an object’s physical appearance, instead of its function (e.g., scraper → *that’s something you slice things*). Both patients often gave a verbal commentary in an attempt to deduce an object’s function (e.g., ink stamp → *There’s those things that obviously move around, different numbers, different names. They’re dates, aren’t they?*). However, being aware of how an object moved was not enough to deduce its function in the absence of conceptual knowledge (e.g., pizza cutter → *That spins around. I can’t imagine what you’d do with it*).

At times, definitions were poor despite all the indications that the patients knew the object and what its function was, including appropriate demonstration of how the object is used. This happened most likely because of word retrieval difficulties. For example, HD demonstrated the correct use of a peeler with an apple from the

fruit basket on the table, then said *but it's more likely to work for /v/*, referring to vegetables. Similarly, at times patients produced definitions for objects that were consistently rated as 0, but nevertheless indicated (at least some) conceptual knowledge about it (e.g., potato masher → *I can't think of the name now, but it would have to be cooked*).

If an incorrect, empty, or partial definition can be the outcome of either lexical or conceptual deficit, we need to ask if the therapy we provided reinstated semantic knowledge, or facilitated word retrieval. In the present study both patients produced more specific verbs and nouns in their definitions post-therapy compared to pre-therapy (e.g., pre-therapy: cheese grater → *to cut things up*; post therapy: → *You can grate cheese*). How can we decide if the specific nouns and verbs produced in definitions post-therapy are due to improved access to the lexicon, or are due to the relearning the concept of cheese grater? One possible way to demonstrate that reinstatement of semantic knowledge did take place is to examine improvement on trained objects for which no conceptual knowledge was shown at baseline testing. During the initial assessment, VH either denied knowledge of an object's function, or defined it incorrectly in 11 cases. Seven of these objects were correctly defined post-therapy. This may indicate that VH indeed relearned the seven concepts in question. This is particularly encouraging as VH was the more severely impaired patient and received fewer therapy sessions.

On the other hand, the finding that definitions of untrained objects also improved might be a reflection of improved lexical access thanks to the training provided. We compared the increase in the number of specific nouns and verbs produced in definitions with the increase in the number of objects named following therapy. Both patients produced more specific verbs than nouns in their definitions at all stages. HD improved her use of nouns in naming and in defining the objects equally. VH, however, only learned the name of 1 of the 17 trained objects, but provided a specific noun in 7 of 17 definitions. VH's performance post-therapy suggest that training object names together with the verbs associated with them, as happens in definitions, may be more beneficial than training object names in isolation. This point is further strengthened if we remember that both patients showed superior action to object naming (see performance in the Object and Action Naming Battery in Table 2). This may be true for other semantic dementia patients.

## Therapy considerations

Both patients benefited from training, although not all improvements were large enough to be statistically significant because of the small number of items involved. VH showed significant improvements for definition, and for hold and orientation in object use. This is despite the observation of Reilly, Martin, and Grossman (2005) that the greatest potential for maintenance of known vocabulary may be "during the onset of semantic dementia" (p. 337). VH nevertheless was able to define 7 out of 11 objects post-therapy, which she could not at initial assessment despite being 3 years post-diagnosis.

While the patients studied by Bozeat et al. (2004), Jokol et al. (2002), and Snowden et al. (2002) showed a decline in performance on cessation of therapy, HD maintained the effects of therapy at follow-up testing in all aspects, demonstrating its effectiveness. Her maintenance of, and indeed slight improvement in, object naming and definitions at follow-up testing was not predicted. VH, in contrast, lost all effects

of therapy at follow-up. She followed the predicted pattern more closely in that object use was better maintained than either object definition, which still remained above baseline, or object naming, which fell below baseline. The loss of therapy gains could be because of the shorter training period she received, the fact that she was trained with the researcher's rather than her own objects, the severity of her semantic impairment, or a combination of all these factors. We also cannot exclude the possibility of further semantic decline taking place in the interim. VH's maintenance for trained objects that were unknown at initial assessment was slightly poorer than those for which she retained some knowledge. These results support Reilly et al.'s (2005) recommendation that therapy should target a finite set of personally relevant *preserved* words, rather than attempting to re-teach forgotten vocabulary.

Improvement overall in the present study was less marked than in previous studies of object naming and definition (Jokol et al., 2002; Snowden & Neary, 2002), despite the fact that the patients in the present study were of similar length post-onset, and achieved equivalent or superior scores on the PPT (Howard & Patterson, 1992). Several factors could account for this. Both Jokol et al. (2002) and Snowden and Neary (2002) presented the written name in addition to the spoken name of the stimulus item during training. It is possible that providing the written names during training in the present study too might have led to greater gains in naming. HD, in particular, sometimes generated phonological and orthographical cues when attempting to name an item, showing that these cues were beneficial for her (e.g., *Begins with 'c', ends with 'w', it's got four letters first and then five letters. lkl. Fourth letter is a 'w'. No, a 'c'. lkl. No, the fourth letter is a 'k', corkscrew*). Indeed, Reilly et al. (2005) noted that patients would be expected to increasingly rely on bottom-up phonological processing as semantic and lexical networks break down. It would seem appropriate to exploit this preserved potential in further studies. Another possible reason is that, despite a similar period of 3 weeks of intervention, CR (Snowden et al., 2002) and AK (Jokol et al., 2002) spent 20 or 30 minutes per day in self-study, while the patients in the present study were instructed to watch the self-modelling DVD that lasted less than 10 minutes, and thus spent less time each day in self-study. A further advantage of previous therapy studies was that CR and AK were given definitions relevant to their personal experience. In the present study few personally relevant definitions were generated by the patients (or their spouses), possibly because of the nature of the objects included (tools, stationery items etc.) in the set of materials used. Therefore most definitions were simple descriptions of the object's function. In contrast AK was relearning household, clothes, and food items, and CR's target vocabulary was drawn from the Snodgrass and Vanderwart pictures (1980) that were linked with corresponding items in CR's own home. It is possible that allowing the patients to choose the vocabulary that they wished to relearn (which no study to date has done) might have resulted in increased personal relevance and therefore in better learning and better maintenance.

The results of the present study raise a number of suggestions that merit further research. We aimed to bootstrap impoverished semantic representations of objects by simultaneously targeting object naming, definition, and use. This multi-modality input could be further enriched by the use of (i) phonological/orthographic cues, (ii) autobiographically relevant vocabulary and definitions, (iii) demonstration of object use in the context of a meaningful activity (e.g., meal preparation), and (iv) by the incorporation of object names into a sentence to take advantage of better-preserved verbs. More research is needed to determine which of these elements contribute most

to learning in general, although it is important to recognise that individual patients may benefit from different forms of intervention. The finding of a verb advantage in both action naming and verb comprehension is particularly interesting because in most populations action naming and verb production is slower and more error prone than object naming and noun production. Since verb advantage in semantic dementia has theoretical implications to the debate about noun–verb differences (see for a discussion Maetzig, Druks, Masterson, & Vigliocco, in press), it warrants further exploration with a larger sample of patients.

Further research is needed to investigate the relative benefits of different training methods in patients with semantic dementia. Fillingham et al. (2006) noted that aphasia patients with good recognition memory and executive skills in their study responded equally well to both errorful and errorless learning. They suggest that errorless learning may be advantageous for those patients who cannot filter out or inhibit incorrect responses. Since patients with semantic dementia generally have well-preserved executive skills, episodic memory, and problem-solving skills, they could be expected to respond well to errorful learning too. However, Snowden and Neary (2002) and Graham et al. (2001) found strong effects of rote learning in their therapy studies of naming, which might suggest that semantic dementia patients over-rely on episodic memory without recruitment of their residual semantic memory. Errorless learning, which targets implicit memory, may be more effective in harnessing residual semantic abilities, even if only for a short period due to the inevitable progression of semantic decline. A direct comparison to evaluate the relative effectiveness of errorless and errorful learning methods at different stages of degradation in semantic dementia is still to be carried out.

The practical benefits of our intervention in terms of generalisation to everyday tasks remain unclear. It is unfortunate that the patients' spouses did not keep the log of object use, which would have enabled us to evaluate generalisation at least to some degree. The present study is only the second to investigate treatment of object use and object definition, and the first to target these and naming simultaneously. Our objective was to replicate Bozeat et al.'s (2002a) assessment, and Bozeat et al.'s (2004) treatment approach with the addition of the treatment of object definitions as the only change. By incorporating object definition into the study, valuable information about the preservation and impairment of semantic knowledge was gained. However, the use of Bozeat et al.'s (2002a) set of materials, which included items such as *ink date stamp* and a *sanding block* in the therapy set, meant that the objects could not be used in a natural context, although they were presented together with their typical recipient. This is a disadvantage of the present study for assessing the value of intervention for everyday life.

In a future study it would be desirable to replicate the assessment and treatment within a scripted, goal-based activity (e.g., cooking a meal), which facilitates correct object use (Funnell, 2001) rather than in a decontextualised situation, presenting unrelated objects in isolation. This would enable direct measurement of the impact of treatment on the patient's daily life. It would be interesting to assess the effects of such a contextualised treatment centred around goal-based activities on object naming and definition, as well as object use. The present study found poor relearning of object names, but if the goal of therapy is to perform a scripted activity correctly, object names are not crucially important. It might be important to discuss with patients the possibility of achieving different goals in therapy (e.g., correct naming vs correct use of an object). The fact that HD maintained gains better than VH, the

more severely impaired patient, could be seen to support Reilly et al.'s (2005) recommendation of targeting a finite set of personally relevant *preserved* words, or concepts. This would suggest that it might be best to decide on therapy goals, and specific scripts/activities which patients would wish to preserve, at an early stage. In this way, patients might be able to plan for their inevitable semantic decline, and exert some control over their future daily activities.

Replication of this study with more patients is necessary to confirm the beneficial effects of this form of therapy with a larger sample, and to evaluate maintenance of gains over a longer period, given the progressive nature of semantic dementia. The inclusion of patients at different stages of their illness would help to decide when in the trajectory of the semantic decline therapy is most beneficial. Finally, future comparative studies of errorless and errorful therapies are essential for understanding the process of relearning in semantic dementia and for deciding on the most beneficial intervention for the patients.

In conclusion, the present study examined the effectiveness of errorless learning on object naming, definition, and use in semantic dementia. Results for naming and object use replicated previous research findings, but also raised some new issues for further consideration, such as the analysis of definitions given by patients with semantic dementia in order to tap their semantic knowledge, and the finding of a verb advantage. The results of the therapy suggests that errorless learning is effective in improving object naming, definition, and use, and that such learning can be maintained following cessation of therapy. It is hoped that the present study will motivate further investigations of these new issues, and further treatment-based research.

Manuscript received 3 October 2007

Manuscript accepted 29 May 2008

First published online 10 October 2008

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## APPENDIX 1

## LIST OF OBJECTS AND RECIPIENTS USED IN ASSESSMENT

<i>Object</i>	<i>With recipient</i>	<i>With recipient in partly completed goal state</i>
1 Apple corer	Cooking apple	Corer placed partly in apple
2 Bulldog grip	Loose sheets	Held open in situ on paper
3 Cheese grater	Cheese	Some cheese grated
4 Compass (stationery)	Paper and pencil in situ	Partly drawn circle
5 Corkscrew	Bottle wine	Corkscrew partly screwed in
6 Garlic press	Clove garlic	Partly crushed clove in press
7 Hammer	Nail	Partly hammered nail
8 Hand fork	Pot plant	Fork inserted into plant
9 Hole punch	Paper	Paper in situ in punch
10 Ink date stamp	Paper, ink pad	Stamp standing on ink pad
11 Pastry cutter	Pastry	Some shapes already cut
12 Pencil	Paper	Writing/picture on paper
13 Pencil sharpener	Blunt pencil	Partly sharpened pencil in sharpener
14 Pepper mill	Mashed potato	Some pepper already on potato
15 Pizza cutter	Pizza	Partially cut pizza
16 Potato masher	Potato (whole)	Partially mashed potato
17 Pritt stick glue	Card and picture to stick on	Picture partially glued
18 Rubber	Paper with pencil line	Pencil line partly erased
19 Ruler	Page and biro	Line on page
20 Sanding block	Piece rough wood	Paper on wood
21 Scissors	Paper	Paper partly cut
22 Scraper (decorating)	Researcher indicated wall	Scraper aligned to wall
23 Screwdriver	Screw	Partly screwed in screw
24 Sellotape	Torn picture	Example of mended picture
25 Spanner	Nut and bolt (in piece wood)	Spanner in situ on nut
26 Spirit level	Shelf	Spirit level in situ on shelf
27 Stapler	Papers	Papers in situ in stapler
28 Tape measure	Piece wood	Tape measure lying along edge piece wood
29 Tin opener	Can	Tin opener on partly opened can
30 Vegetable peeler	Carrot	Partly peeled carrot
31 Washing up brush	Washing up bowl	Plate and washing-up liquid in bowl
32 Watering can	Plant	Held over plant
33 Whisk (hand)	Egg in bowl	Partly beaten egg

## APPENDIX 2

Examples of definitions by HD and VH and the control participants organised according to their rating (Poor, Adequate, or Good).

HD		
<i>Rating</i>	<i>Item</i>	<i>Definition</i>
Poor	Pencil sharpener	You turn it and..
	Sanding block	To clear that
	Watering can	I've got lots of things that I can put the water in
	Cheese grater	And I've got a big one, in there as well & you can get different shaped ones
	Garlic press	That's for grating something up
Adequate	Sellotape	Well, that's to stick on something needs repairing
	Corkscrew	This could be used to open a tin of water
	Pencil sharpener	You can use a pencil and cut it round
	Spanner	To twist something
	Vegetable peeler	You just take the outside off
Good	Ruler	You just want to know the size of something
	Potato masher	Potatoes, to, when they're cooked, to break it up
	Hammer	You lift things out with that & you can hammer things
	Corkscrew	This is to open a bottle of wine
	Apple corer	And this is to put in an apple to take the centre out
VH		
<i>Rating</i>	<i>Item</i>	<i>Definition</i>
Poor	Rubber	Is it something you eat?
	Screwdriver	That's for taking things out & putting things in.
	Spirit level	I just have no idea what that is or what you use it for?
	Stapler	Now, that, you close that one, don't you, for some reason. It clicks into something.
	Vegetable peeler	That's something you do that
Adequate	Tin opener	Is that how you open that?
	Sellotape*	That's for sticking things
	Bulldog grip	That's going to click things together and keep them and then you can hook them
	Whisk	That's something you stir up things.
Good	Garden fork*	That's em, sort of digging up
	Tape Measure	It's something you can measure in distance
	Rubber	That's for rubbing out pencil you've written
	Pencil	For writing
	Hole punch	So that must make a hole
Corkscrew	And that's for opening the bottle of wine	

\*Rated as "Adequate" by two raters and "Good" by one rater—few items with 100% agreement available.

## CONTROL PARTICIPANTS F1

<i>Rating</i>	<i>Item</i>	<i>Definition</i>
Poor	–	[No example available]
Adequate*	Pepper mill	You use it in cooking. Twist the top & shake it out.
Good	Spirit level	You put it down on a piece of stone or timber & make sure, tells you it's even

\* Rated as *adequate* by two raters and *good* by one rater.

## CONTROL PARTICIPANT F2

<i>Rating</i>	<i>Item</i>	<i>Definition</i>
Poor	Apple corer	You can put it into melons, make little balls & things like that
Adequate	Potato masher	You would just put your eggs in or your potatoes in and just keep pushing round like that until they come nice and fluffy
Good	Spanner	You change it to different sizes so that you would undo nuts and bolts