Brain and Language **79,** 266–296 (2001)
doi:10.1006/brln.2001.2485, available online at http://www.idealibrary.com on IDEAL®

A Selective Deficit for Living Things after Temporal Lobectomy for Relief of Epileptic Seizures

Linda Luckhurst and Toby J. Lloyd-Jones

University of Kent, Kent, United Kingdom

Unilateral left and right temporal lobectomy patients and normal control subjects were tested on confrontation naming, speeded naming, category generation, and category and associate matching tasks. Both groups of patients were disproportionately impaired for living relative to nonliving things in confrontation naming, speeded naming, and category generation. We argue that damage to the temporal lobe impairs lexical retrieval most strongly for living things and that the anterior temporal cortices are convergence zones particularly necessary for retrieving the names of living things. © 2001 Academic Press

Key Words: temporal lobe; semantic memory; lexical retrieval; category-specific deficit; object recognition.

INTRODUCTION

It is now well established that neurologically impaired individuals may show selective difficulties in semantic memory for specific categories of item (e.g., Farah, 1989; Patterson & Hodges, 1995; Shallice, 1988). The most widely reported deficit is for the selective loss of knowledge of living things (e.g., Barry & McHattie, 1995; Basso, Capitani, & Laiacona, 1988; Caramazza & Shelton, 1998; Cardebat, Demonet, Celsis, & Puel, 1996; De Renzi & Lucchelli, 1994; Farah, Hammond, Mehta, & Ratcliff, 1989; Farah, Meyer, & McMullen, 1996; Gaffan & Heywood, 1993; Gainotti & Silveri, 1996; Hart, Berndt, & Caramazza, 1985; Hart & Gordon, 1992; Hillis & Caramazza, 1991; Laws, Evans, Hodges, & McCarthy, 1995; McCarthy & Warrington, 1988; Moss, Tyler, Durrant-Peatfield, & Bunn, 1998; Pietrini, Nertempi, Vaglia, Revello, Pinna, & Ferro-Milone, 1988; Sartori & Job, 1988; Sartori, Job, Miozzo, Zago, & Marchiori, 1993; Sartori, Miozzo, & Job, 1993; Sheridan & Humphreys, 1993; Silveri, Daniele, Giustolisis, & Gainotti, 1991; Silveri & Gainotti, 1988; Sirigu, Duhamel, & Poncet, 1991; Warrington & Shallice, 1984). The reverse dissociation, impairment for nonliving things, has also been reported, albeit less frequently (e.g., Behrmann & Lieberthal, 1989; Cappa, Frugoni, Pasquali, Perani, & Zorat, 1998; Gonnerman, Andersen, Devlin, Kempler, & Seidenberg, 1997; Hillis & Caramazza, 1992; Hillis, Rapp, Romani, & Caramazza, 1990; Moss & Tyler, 1997;

This research was supported by an Economic and Social Research Council Grant to Toby J. Lloyd-Jones (Grant R000222174).

Address correspondence and reprint requests to T.J. Lloyd-Jones, Department of Psychology, University of Kent, Canterbury, Kent CT1 2NP, United Kingdom. Fax: +44 1227 827030. E-mail: T.J.Lloyd-Jones@ukc.ac.uk.

0093-934X/01 $35.00

Sacchett & Humphreys, 1992; Silveri, Gainotti, Perani, Cappelletti, Carbone, & Fazio, 1997; Tippett, Glosser, & Farah, 1996; Warrington & McCarthy, 1983, 1987).

The simple living/nonliving dichotomy does not fully capture the difference between impaired and unimpaired categories. For instance, deficits for living things (e.g., animals, fruit, and vegetables) have been found to co-occur with loss of knowledge about musical instruments but spared knowledge of body parts (Warrington & Shallice, 1984). On the basis of this, it has been reasoned that semantic knowledge is represented in the brain by modality (visual, olfactory, motor/functional, and so on) and that, whereas sensory properties are more important for comprehending living things, functional properties are more important for comprehending nonliving things (e.g., Allport, 1985; Gainotti & Silveri, 1996; Hart & Gordon, 1992; Shallice, 1988; Silveri & Gainotti, 1988; Warrington & McCarthy, 1983, 1987; Warrington & Shallice, 1984).

Nevertheless, for a number of reasons interpretation of these deficits remains controversial. Some authors argue that category-specific deficits in the recognition and naming of living things may be artifactual (e.g., Funnell & Hodges, 1996; Funnell & Sheridan, 1992; Stewart, Parkin, & Hunkin, 1992). For instance, Funnell and Sheridan (1992) propose that semantic category deficits will disappear when correlates such as familiarity, complexity, and name frequency are controlled. Nevertheless, patients have been reported who still show impaired recognition of living things when these confounding factors are eliminated (e.g., Farah & McMullen, 1991; Kurbat & Farah, 1998; Sartori, Job, Miozzo, Zago, & Marchiori, 1993). In addition, the opposite dissociation of impairment for nonliving things would be unlikely to arise were such confounding variables the only factors accounting for these problems.

A second problem is the difficulty in accounting for all category-specific impairments in terms of selective loss of sensory or functional properties of objects. For instance, Samson, Pillon, and de Wilde (1998) report a patient with a living things impairment who is equally impaired at retrieving visual and nonvisual knowledge concerning living things and who is unimpaired at retrieving visual knowledge concerning nonliving things (see also Lambon-Ralph, Howard, Nightingale, & Ellis, 1998). In order to accommodate these findings some authors have emphasized the importance of intercorrelation and distinctiveness among features for the differentiation of exemplars within a category (in addition to the differential importance of certain feature modalities such as visual or associative information; e.g., Gonnerman, Andersen, Devlin, Kempler, & Seidenberg, 1997; Humphreys, Lamote, & Lloyd-Jones, 1995; Lloyd-Jones & Humphreys, 1997a, 1997b; McRae, de Sa, & Seidenberg, 1997).

Finally, of most relevance to the present article, the picture is further complicated by the fact that category-specific deficits for living things may reflect a selective problem in lexical retrieval rather than in retrieval of semantic knowledge. For instance, Farah and Wallace (1992) reported the case of a patient with a specific deficit in naming fruit and vegetables (see also Hart, Bernt, & Caramazza, 1985; Lloyd-Jones & Humphreys, 1997b). Importantly, the problem for this patient seemed confined to naming: He was able to retrieve considerable semantic information about fruit and vegetables he could not name. In addition, the impairment was not confined to visual presentation but extended to spoken definitions and a verbal fluency task.

The neuroanatomical basis for category-specific deficits has been explored through examining anatomical-clinical correlations and through functional imaging of the intact brain. Most studies suggest involvement of temporal cortex in object comprehension and naming, although precise localization of living versus nonliving things remains equivocal. Evidence suggests that the temporal lobes are important for deficits involving living things (see, e.g., Caramazza & Shelton, 1998). However, for nonliving things lesions are more variable and have involved fronto-parietal areas as well. Damasio (1989, 1990) has argued that the anterior temporal lobes are the site of ‘‘convergence-divergence zones’’: neuronal assemblies which ‘‘bind’’ together the sensory and motor features of objects (such as color, shape, auditory, and kinesthetic and somatosensory attributes). Because living things are generally more visually and semantically similar than nonliving things they require greater differentiation for identification. Damasio argues therefore that living things are more dependent on the temporal convergence zones to activate distinguishing information. Tranel, Damasio, and Damasio (1997b) also suggest that such neuronal assemblies (convergence-divergence zones) likely underpin both the retrieval of conceptual knowledge of items and the retrieval of abstract lexical forms corresponding to those items.

It follows from the foregoing discussion that patients who have undergone temporal lobe resection for relief of intractable epileptic seizures may show semantic and/or lexical impairments, and these impairments may be most pronounced for living things. Deficits can be subtle (e.g., Biederman, Gerhardstein, Cooper, & Nelson, 1997; Herman & Wyler, 1988; Stafniak, Saykin, Sperling, Kester, Robinson, O’Connor, & Gur, 1990). Nevertheless, there is evidence of impaired semantic and lexical processing in this subject population (e.g., Landsell, 1968; Wilkins & Moscovitch, 1978). Importantly, however, the only study examining potential semantic category differences following temporal lobectomy found a selective deficit for nonliving things. Under paced object naming conditions, Tippett, Glosser, and Farah (1996) found that right temporal lobectomy patients performed within the normal range, and equally well with living and nonliving things, whereas left temporal lobectomy patients were disproportionately impaired at naming nonliving things.

We add to this controversial literature by providing evidence for a disproportionate lexical impairment for living things in the temporal lobectomy population. We argue that these results are consistent with recent neurobiological evidence as well as Damasio’s theory of temporal convergence zones.

METHOD

Experimental Subjects

Subjects with temporal lobe epilepsy were obtained from the Queen Elizabeth Hospital, Birmingham. Twelve subjects participated, and all had undergone temporal lobectomy for relief of intractable epilepsy. The WADA test (Wada, 1949, 1960) was used to determine language lateralization and whether memory functions would be supported after resection of the focal epileptic lesion. No patient was considered at risk of severe amnesic syndrome, and two patients were left handed (DW and DR); however, all patients were deemed left hemisphere dominant for language (A. R. Walsh, neurosurgeon, personal communication).

For six patients, the epileptic focus and site of resection was in the left hemisphere (CS, DT, SB, NW, SW, and JML). For the remaining six, this was in the right hemisphere (DR, VL, ET, LK, SP, and DW). Mean ages at onset are 7.71 (range: 3 months–18 years) and 11.5 (range: 1–22 years) for left and right groups, respectively. The mean age at operation for the left group was 23.67 years and for the right group 27.33 years. All patients had an educational level of 16 years or above and an average postoperative Full Scale IQ of 99.7 on the WAIS-R (there were no significant differences between pre- and postoperative IQs). All patients reported a reduction in seizures after surgery. For all patients (with the exception of ET), this was deemed a significant decrease, and the mean number and dosage of seizure medications were, over time, reduced accordingly. Individual corticography recordings during surgery dictated the precise dimensions of the excision, resulting in individual differences. However, resection usually involved 4.5–5.0 cm in a left dominant hemisphere and 5.0–7.0 cm in a right nondominant hemisphere. Generally, the superior temporal gyrus was removed and the middle and inferior temporal and fusiform and parahippocampal gyri were excised as far back as the resection line. In addition, the anterior part of the hippocampus (approximately 2–3 cm) and mesially the lateral two-thirds of the amygdala were taken. All patients in this study underwent hippocampal resection and surgery conformed to the standard procedure outlined above. No postoperative MRI data are available to ascertain the exact degree of temporal lobe resection for individual patients. Note, however, that all those undergoing surgical resection were operated on by the same neurosurgeon, which means that the sample is more homogeneous than it might otherwise be (Bennett-Levy, Polkey, & Powell, 1980). Patients were tested on average 10.1 months postsurgery (left group = 9.5 months; right group = 10.6 months).

Between 12 and 20 normal control subjects were also tested, depending on the particular task. They were undergraduate students at the University of Birmingham and participants answering advertisements, whose ages ranged from 18 to 25 years. All had normal or corrected-to-normal vision.

Materials and Procedure

The materials and procedure for picture confrontation naming tasks (untimed and timed), category generation, and category and associate matching tasks are given in each section below. Full lists of stimuli are given in Appendix 1. Individual patient data for each task are given in Appendix 2. The average time gap between testing and the order of presentation of the four tasks was as follows: Untimed Naming A/Category and Associate Matching → 12 weeks' delay → Untimed Naming B/Timed Naming A → 19 weeks' delay → Category generation.

Picture confrontation naming (A): Untimed. Subjects named 76 black-and-white line drawings of common objects taken from the Snodgrass and Vanderwart (1980) picture norms. These were also used in category and associate matching. Half the items were from living categories (animals, vegetables, fruits, insects, and birds) and half were from nonliving categories (clothing, furniture, human body parts, tools, jewelry, vehicles, household items, and toys). For each semantic category, there were equal numbers of high and low name frequency items. Name frequency was defined as high if there were over 10 occurrences per million and low if there were less than 10 occurrences per million in the Kučera and Francis (1967) word frequency count. In addition, living and nonliving items were matched as far as possible for name frequency, name and image agreement, familiarity, complexity, age of acquisition, number of syllables, and number of letters (see Table 1 for values; for name frequency, name agreement, image agreement, familiarity, complexity, and age of acquisition, the higher the number the higher the frequency; the greater the agreement, familiarity, and complexity; and the later the concept was acquired). Stimuli were drawn on sheets of white card (8 × 8 cm). The 76 drawings were approximately the same size. Each stimulus was presented individually, being placed on a table directly in front of the patient. There were no time restrictions. The experimenter wrote down all responses. Each naming response was classed either correct or incorrect: Any alternative name offered was considered an acceptable response if it corresponded to one given by more than 4/40 participants in the picture norms of Snodgrass and Vanderwart (1980). Incorrect responses included (1) a wrong name, (2) an unacceptable alternative, and (3) ''don't know.''

Picture confrontation naming (B): Untimed. Sixty black-and-white line drawings were taken from Snodgrass and Vanderwart (1980) and a variety of other sources (e.g., The Oxford-Duden Picture Dictionary). None of these items was a member of the set used in the picture confrontation naming task (A). Exemplars were of low name frequency: only one item had a name frequency greater than 10 (pig = 11). Pictures were drawn from three categories: animals, fruits and vegetables, and tools. For each category set, 20 items were presented. Line drawings were of approximately equal size (comparable

TABLE 1

Mean Values for Living and Nonliving Things for Measures of Name Frequency, Name and Image Agreement, Familiarity, Complexity, Age of Acquisition, Number of Syllables, and Number of Letters

	Living	Nonliving
Name frequency	16.42	18.16
Name agreement	86.73	85.84
Image agreement	3.78	3.73
Familiarity	2.73	3.58
Complexity	3.54	2.66
Age of acquisition	3.81	4.17
Number of syllables	1.92	1.78
Number of letters	6.06	5.80

to those in confrontation naming task A) and presented four to a sheet of A4 paper on a table in front of the patient. Subjects attempted to name all the objects from a given category before moving onto another picture set. All responses were written down by the experimenter. Items with less than 80% name agreement among controls (e.g., chimpanzee, courgette, and shears) were discounted when calculating correct naming scores for both controls and patients. This left 11 animals, 15 fruit and vegetables, and 15 tools.

Picture confrontation naming (A): Timed. For the timed version of picture confrontation naming (A), the same stimuli were presented on a Macintosh LC computer using the software package VScope (accuracy: ±15 ms, Rensink & Enns, 1992). Seated distance from the computer screen was approximately 90 cm. Patients spoke into a voice microphone that could be handheld or positioned on the desk immediately facing. Each subject was instructed to name, both quickly and accurately, the 76 pictures that would flash up singly and in a random order on the screen before them. In addition, they were told that each trial would follow the other as soon as a response had been given or the time limit of 10 s had elapsed. If an object was unfamiliar or its name unavailable, then patients responded ‘‘don’t know.’’ Finally, the experimenter emphasized the importance of speaking loudly and clearly, avoiding sounds of hesitation as much as possible. Reaction times (RTs) were registered via a digital voice-key (accuracy: 1 ms). The experimenter wrote down all responses. Reaction times were classified correct or incorrect as in the untimed version. Errors included (1) a naming latency falling more than 1.458–2.50 standard deviations above or below the mean for a particular condition depending on sample size, using the nonrecursive cutoff procedure of Van Selst and Jolicoeur (1994); (2) an audible hesitation; and (3) no response. Category 1 errors were not included in the error analyses.

Category generation. Subjects actively generated the spoken names of objects for a particular category label, half of which were of living things and half of which were of nonliving things (categories were as follows: animal, fruit, vegetable, clothing, household items, and furniture). Subjects were instructed to begin immediately after oral presentation of the label and to continue for a 2-min period (timed using a stopwatch). No subjects were hearing impaired. The experimenter stressed the importance of keeping going, even when feeling that as many names had been recalled as possible. Order of category presentation was organized so that names were not generated to two successive categories with living or nonliving members; this avoided any immediate carryover effects from very similar categories. Subjects were told to include whichever objects they considered appropriate to these categories. Names generated to each label were written down by the experimenter and each 30-s interval was noted. Data were classified in the following ways: (1) number of words generated; (2) percentage correct words generated; (3) number of clusters generated; (4) percentage correct clusters generated; and (5) within categories 3 and 4 above, the type of clusters generated; semantic, semantic-phonemic, and phonemic (see Results for further details). Three independent raters judged the category membership of all the object names generated for both patients and normal subjects. Exemplars were presented in alphabetical order and raters indicated whether a given item belonged to one or more of the specified categories. Items generated to a category name were considered appropriate if all three raters agreed over their membership in that particular category.

Category and associate matching tasks. In both tests, targets were the same set of 76 Snodgrass and Vanderwart (1980) pictures as used in picture confrontation naming (A). In a single trial, three black-and-white line drawings were simultaneously presented with the target being located above the other two pictures. Subjects were instructed to point to which of the lower drawings went with the target. In the category-matching test, they were asked which one was the same kind of object, where distracters were from a category unrelated to the target. In the associate-matching task, subjects indicated which one of the two bottom pictures bore an associative relationship to the target (e.g., rabbit > hutch/cage), where in each case distracters were taken from the same category. Each trial was set out on a sheet of A4 paper and the 76 trials in a test were bound together in a booklet. The order of presentation was random but the same for each subject. The experimenter wrote down each response over both tests.

RESULTS

The results for picture confrontation naming (A and B untimed and A timed), category generation, and category and associate matching are given in each section below. Analyses of variance (ANOVAs) were carried out on control and patient untransformed and transformed scores: Transformed scores were *z* scores calculated with appropriate scores of the normal control group. This transformation procedure equates performance on each task, category, and level of name frequency for level of difficulty in healthy persons and provides for possible differences in score distribution (see, e.g., Barr & Brandt, 1996, for a similar use of this procedure). The procedure therefore eliminates, for patient data, differences in stimulus factors (such as familiarity and complexity) that may produce differences between living and nonliving things in the normal population. To maximize statistical power, analyses compared controls with all patients as well as controls with TLE-L and TLE-R patients. Pairwise comparisons, where appropriate, were made using the Newman–Keuls test with the Games and Howell procedure to control for unequal sample sizes and heterogeneity of variance. Only significant main effects and/or interactions are reported.

The results for both by-subjects and by-items analyses are reported (except for category generation). For by-subjects analyses the data were pooled for each subject over the various items presented in each condition. For by-items analyses, the data in each condition were pooled over the various subjects who were presented with that item in that condition. The numbers 1 and 2 attached to an F statistic refer to by-subjects and by-items analyses, respectively.

Finally, we carried out simultaneous multiple-regression analyses for both naming and category generation tasks. We used semantic and linguistic variables (e.g., imageability and name frequency) to examine whether these predicted performance on the dependent variable and to ascertain which were more important in predicting the dependent variable. For the latter, we used the squared semipartial correlation between predictor and the criterion, which, unlike the stepwise regression solution, takes into account interrelationships between variables (see Howell, 1997, pp. 545–546). For naming tasks the dependent variables were percentage error score and response times. For category generation we derived a measure of ‘‘Production frequency.’’ We asked whether the frequency with which an item was produced by patients (e.g., ‘‘apple’’ was produced by nine of nine patients, whereas ‘‘apricot’’ was produced by two of nine patients) is predicted by semantic and/or linguistic variables. We were not able to use every variable on every task (for instance there are no age of acquisition ratings for many of the items used in Task B naming or for many items produced in category generation). Nevertheless, for each task we were able to use both semantic and linguistic variables with a substantial number of cases.

Picture confrontation naming (A): Untimed. Ten TLEs took part. There were equal numbers of left and right hemisphere patients (left: CS, DT, SB, SW, and JML; right: DR, ET, LK, SP, and DW). Patient scores were compared with 20 normal controls. Mean percentage correct scores for controls, TLE-L and TLE-R groups are given in Table 2.

A mixed-design ANOVA to analyze the effects of Group (controls vs patients), Category (living vs nonliving), and Frequency (high vs low word frequency) was carried out.

For untransformed scores, there was a main effect of Group, with fewer correct for patients relative to controls, $F1(1, 28) = 110$, $MSE = 18.06$, $p < .0001$; $F2(1, 72) = 42.28$, $MSE = 56.94$, $p < .0001$. There was also a Category × Frequency interaction marginally significant by items, $F1(1, 28) = 9.92$, $MSE = 13.45$, $p < .01$; $F2(1, 72) = 3.28$, $MSE = 68.56$, $p = .07$. Finally there was a Group × Category × Frequency interaction, marginally significant by items, $F1(1, 28) = 9.92$, $MSE = 13.45$, $p < .01$; $F2(1, 72) = 3.52$, $MSE = 57.09$, $p = .06$.

Further analysis broke down the three-way interaction by subjects, analyzing high and low frequency items separately. For high frequency items there was a main effect of Group, with less accuracy for patients, $F1(1, 28) = 93.65$, $MSE = 10.31$, $p < .0001$. There was also a main effect of Category, with less accuracy for living things, $F1(1, 28) = 4.76$, $MSE = 18.59$, $p < .05$, and a marginally significant Group × Category interaction, $F1(1, 28) = 3.38$, $MSE = 18.59$, $p = .07$, with patients less

TABLE 2

Untimed Picture Confrontation Naming (A): Mean Percentage Correct Scores for Living and Nonliving Categories, for High and Low Name Frequency Items, across Control, TLE-L, and TLE-R Groups

	Living ($n = 38$)		Nonliving ($n = 38$)	
	High	Low	High	Low
Controls	99.4	99.4	100	100
SD	0.56	0.56	0	0
TLE-L	89.4	91.5	90.5	87.3
SD	4.7	2.59	9.66	5.36
TLE-R	88.4	94.7	96.8	90.5
SD	3.70	4.74	2.59	13.9

Note. Standard deviations (*SD*) are given for the TLE-L and TLE-R groups.

accurate on living things relative to controls (88% vs 99.5%) than on nonliving things relative to controls (93.6% vs 100%). For low frequency items there was a main effect of Group, with less accuracy for patients, $F1(1, 28) = 62.75$, $MSE = 16.4$, $p < .0001$. No other main effects or interactions were significant [for the Group × Category interaction, $F1(1, 28) = 2.28$, $MSE = 30.93$, $p = ns$].

A mixed-design ANOVA to analyze the effects of Group (controls vs TLE-L vs TLE-R), Category (living vs nonliving), and Frequency (high vs low word frequency) produced the same results.

There was a main effect of Group, $F1(2, 27) = 66.61$, $MSE = 15.60$, $p < .0001$; $F2(2, 144) = 17.89$, $MSE = 110$, $p < .0001$. There was also a Category × Frequency interaction, marginally significant by items, $F1(1, 27) = 14.02$, $MSE = 12.69$, $p < .001$; $F2(1, 72) = 3.35$, $MSE = 164$, $p = .07$. Finally, there was a Group × Category × Frequency interaction, significant only by subjects, $F1(2, 27) = 6.59$, $MSE = 12.69$, $p < .01$; $F2(2, 144) = 1.25$, $MSE = 110$, $p = ns$.

Further analysis broke down the three-way interaction by subjects, analyzing high and low frequency items separately. For high frequency items there was a main effect of Group, $F1(2, 27) = 53.13$, $MSE = 9.41$, $p < .0001$. There was also a main effect of Category, with less accuracy for living things, $F1(1, 27) = 6.50$, $MSE = 16.76$, $p < .05$, and a Group × Category interaction, $F1(2, 27) = 3.90$, $MSE = 16.76$, $p < .05$. Patients were less accurate for living things relative to controls than for nonliving things relative to controls; however, this was true only for right hemisphere patients (Games and Howell procedure ps $< .05$). For low frequency items there was a main effect of Group, $F1(2, 27) = 35.66$, $MSE = 15.14$, $p < .0001$. No other main effect or interactions were significant [for the Group × Category interaction, $F1(2, 27) = 1.1$, $MSE = 32.07$, $p = ns$].

Patient errors broke down in the following way. For TLE-L, for living things, 35.2% were visual-semantic (e.g., ‘‘orange’’ for lemon), 5% purely semantic (e.g., ‘‘leek’’ for cauliflower), 8.1% were semantic-phonological (e.g., ‘‘carrot’’ for cabbage), and 5.4% were nonresponses. For TLE-L, for nonliving things, 32.4% were visual-semantic errors (e.g., ‘‘hammer’’ for axe), 8.1% were semantic-phonological errors (e.g., ‘‘brush’’ for broom), 2.7% were nonresponses, and 2.7% were purely visual errors (e.g., ‘‘box’’ for toaster). For TLE-R, for living things, 44% were visual-semantic and 4% were nonresponses. For TLE-R for nonliving things, 44% were visual-semantic errors, 4% were purely semantic errors, and 4% were nonresponses.

In sum, an apparent category-specific deficit for living things emerges in this task, but only for high frequency items and predominantly for right hemisphere patients. Unfortunately, in this case, an analysis of transformed scores was not possible as one cannot derive *z* scores when control performance is at ceiling with a standard deviation of zero as was the case for Nonliving things (patient scores are calculated as a standard deviation distance from the control mean). In addition, interpretation of *z* scores with a small standard deviation, as would be the case for living items ($z = 0.96$) can be misleading. For this task alone, therefore, in order to partial out the contributions of variables other than semantic category to the observed difference between living and nonliving things we carried out an analysis of covariance. In addition to the covariates specified in Table 1 (excluding name frequency as it is manipulated as a factor), we added imageability as it is a significant predictor of performance in other tasks in the present article (see below). For the analysis across patients the Group × Category × Frequency interaction approached significance, $F2(1, 59) = 3.05$, $MSE = 64.72$, $p = .06$, suggesting that the category-specific deficit for living things is not an artifact produced by correlated variables. The least-squares means were for Patients: living high = 87.9, living low = 92.8, nonliving high = 95.3, nonliving low = 89.5; for Controls: living high = 99.1, living low = 99.4, nonliving high = 100.2, nonliving low = 100.2. For the analysis including left and right hemisphere patients there were no main effects or interactions, suggesting that the deficit is not specific to right hemisphere patients when correlated variables are controlled. We discuss these results further following picture confrontation naming Task B.

We also carried out simultaneous multiple regressions in order to assess the importance of semantic and linguistic variables in predicting patient errors. The regressors were as in the analysis above. There were no significant findings across patients or when analyzing patient groups individually.

Finally, two items classified as nonliving (‘‘leg’’ and ‘‘lips’’) may be considered ambiguous in their category label. We therefore repeated the original analyses of variance in this task and Timed Task A, dropping these items. The results are unaffected: raw data and full analyses for both tasks are given in Appendixes 2 and 3.

Picture confrontation naming (B): Untimed. Eight TLE’s took part. There were equal numbers of left and right hemisphere patients (left: CS, DT, NW, and JML; right: DR, ET, LK, and DW). Patient percentage correct scores were compared with 20 normal controls (see Table 3).[1] A mixed-design ANOVA to analyze the effects of Group (controls vs patients) and Category (living vs nonliving) was carried out.

For untransformed scores there was a main effect of Group, $F1(1, 26) = 43.01$, $MSE = 73.23$, $p < .001$; $F2(1, 39) = 27.72$, $MSE = 223$, $p < .0001$, with patients impaired relative to normal controls, and there was also a main effect of Category, $F1(1, 26) = 11.05$, $MSE = 65.35$, $p < .01$; $F2(1, 39) = 5.62$, MSE = 316, $p < .05$, with fewer items from living categories named correctly. There was also a Group × Category interaction, $F1(1, 26) = 4.26$, $MSE = 65.35$, $p < .05$; $F2(1, 39) = 4.64$, $MSE = 223$, $p < .05$. Pairwise comparisons using the Games and Howell procedure showed a significant difference between patients and controls for living and nonliving items; the interaction arose because the difference between patients and controls was greater for living items (patient–control difference for living = −22%, difference

---

[1] Patients average postoperative IQ was 99.7. Nevertheless, to be more precise with this task in particular, we compared patient data with a control group of eight normal participants pairwise matched on a WAIS-R Full Scale IQ score (average 99.1). The results were unaffected. Relatively small IQ differences between patients and controls were therefore not responsible for patients’ poorer naming performance with low name frequency comparing living with nonliving items.

TABLE 3

Untimed Picture Confrontation Naming (B): Mean Percentage Correct Scores for Living and Nonliving Categories across Control, TLE-L, and TLE-R Groups

	Living ($n = 26$)	Nonliving ($n = 15$)
Controls	94	96.6
SD	5.88	3.93
TLE-L	68.2	83.3
SD	23.3	3.35
z	−4.31	−3
TLE-R	75.9	86.6
SD	4.97	6.6
z	−3.29	−2.47

Note. Standard deviations (*SD*) are given as are *z* scores (*z*) for TLE-L and TLE-R groups.

for nonliving = −11.6%). For transformed scores there was a main effect of Category, $F1(1, 7) = 6.01$, $MSE = 6.27$, $p < .05$; $F2(1, 39) = 4.11$, $MSE = 6.03$, $p < .05$, with fewer items from living categories named correctly.

A further analysis breaking down patient group into TLE-L and TLE-R also revealed a main effect of Group, $F1(1, 25) = 22.94$, $MSE = 71.3$, $p < .001$; $F2(2, 78) = 12.69$, $MSE = 325$, $p < .0001$. Pairwise comparisons using the Games and Howell procedure showed a significant difference only between TLE-R patients and controls, with a strong trend in the same direction for TLE-L patients ($p < .05$). There was also a main effect of Category, $F1(1, 25) = 11.21$, $MSE = 67.2$, $p < .01$; $F2(1, 39) = 5.62$, $MSE = 748$, $p < .05$, with fewer living items named correctly. For transformed scores there were no main effects or interactions.

In sum, there is a category-specific impairment for living things: across all patients living things are named less accurately. However, this difference was not evident in the analysis comparing left and right hemisphere groups, perhaps because of the relatively small sample size.

Patient errors broke down in the following way. For TLE-L, for living things, 54.8% were visual-semantic, 7.5% purely semantic, 15% were nonresponses, and 1.1% were purely visual errors. For TLE-L, for nonliving things, 15% were visual-semantic errors, 5.5% were purely semantic errors, and 2.1% were nonresponses. For TLE-R, for living things, 58.2% were visual-semantic, 2.1% were purely visual errors, 20.8% were nonresponses, and 1.1% were purely visual errors. For TLE-R, for nonliving things, 13.2% were visual-semantic errors, 1.4% were purely semantic errors, and 3.2% were nonresponses.

There are three points to consider concerning the data for this task. First, the rather large standard deviation for living things in the left hemisphere group (23.3) is due to patient DT performing particularly poorly and patient NW performing at ceiling (see Appendix 2). Second, we adopted a >80% name agreement criterion for this task in order to equate it more fully with Picture Confrontation Task A, where name agreement for controls was 85.7% for living and 86.9% for nonliving things. We considered this a conservative procedure for establishing patient impairment as patients may fare worse on items with low name agreement relative to controls. Nevertheless, if we collate the data ignoring the name agreement criterion, using all the items in the set with three independent judges deciding a correct or incorrect response, the pattern of results is unaffected (indeed the deficit for living things is more apparent, see Appendix 2). Third, a category-specific deficit for living things emerged for high but not low frequency items in Untimed Task A, yet emerges also for the low frequency items used here. This is counterintuitive and may be to do with the particular items selected for each task. One way to test the robustness of this result is to test the living/nonliving difference for patients and controls across both sets of stimuli (Task A and Task B: a total of 115 items). This analysis tells us if the impairment for living things is true for the *majority* of these items of both high and low frequency. When we do this there is a significant Group × Category interaction, $F2(1, 113) = 4.06$, $MSE = 146.3$, $p < .05$, with a larger patient-control difference for living things compared to nonliving things. Furthermore, if we partial out the effect of name frequency in an analysis of covariance, the interaction effect is marginally significant, $F2(1, 112) = 3.42$, $MSE = 143.9$, $p = .06$. This suggests that a category specific impairment is apparent over and above any contributions of name frequency.

Finally, we carried out simultaneous multiple regressions in order to assess the importance of semantic and linguistic variables in predicting patient errors. The dependent variable was patient error score (percentage correct). Regressors were obtained from the Oxford Psycholinguistic Database (Quinlan, 1986) and included Category, Imageability, Word Familiarity, Word Frequency, Number of Syllables, and Number of Letters. Across all patients the simultaneous multiple-regression analysis was significant, $N = 20$, $R^2 = .675$, $F = 4.5$, $MSE = 266$, $p < .05$. Of the variance of naming accuracy, 67.5% was accounted for when all the independent variables were entered into the regression model. Two variables have significant standardized regression coefficients with patient accuracy as follows: Category coefficient $= -38.756$, t ratio $= -4.4$ (± 8.79), $p < .001$; Imageability coefficient $= -.22$, t ratio $= -2.24$ ($\pm .09$), $p < .05$. Number of Letters and Number of Syllables were marginally significant: Number of Letters coefficient $= 11.27$, t ratio $= 2.01$ (± 5.6), $p = .06$; Number of Syllables coefficient $= -23.97$, t ratio $= -1.92$ (± 12.47), $p = .07$. The square of the t ratio (which is equivalent to the squared semipartial correlation statistic; although see Darlington, 1990, concerning squaring or not squaring the statistic) can be used to rank order the regressors in terms of their usefulness. When we do this, Category is the most important, followed by imageability, number of letters, and number of syllables. The effects of the variables are as follows: less accuracy with living things, less imageability, fewer letters, and fewer syllables.

A simultaneous multiple-regression analysis comparing patient groups produced similar (although not identical) results. The variables are presented in their order of importance. For left hemisphere patients, $R^2 = .97$, $F = 5.94$, $MSE = 238$, $p < .005$. Of the variance of naming accuracy, 97% was accounted for when all the independent variables were entered into the regression model. Two variables have significant standardized regression coefficients with patient accuracy: Category coefficient $= -33.35$, t ratio $= -4.01$ (± 8.31), $p < .005$; Number of Letters coefficient $= 13.90$, t ratio $= 2.62$ (± 5.29), $p < .05$. For right hemisphere patients, $R^2 = .65$, $F = 4.10$, $MSE = 441$, $p < .05$. Of the variance of naming accuracy, 65% was accounted for when all the independent variables were entered into the regression model. Three variables have significant standardized regression coefficients with patient accuracy: Category coefficient $= .44.15$, t ratio $= 3.90$ (± 11.31), $p < .005$; Imageability coefficient $= -.28$, t ratio $= -2.23$ ($\pm .12$), $p < .05$; Number of Syllables coefficient $= -33.86$, t ratio $= -2.10$ (± 16.06), $p = .05$. Using the square of the t ratio we see that Category is the most useful predictor, followed by Imageability and Number of Syllables.

Picture confrontation naming (A): Timed. Nine TLE's took part. There were four left and five right hemisphere patients (left: CS, DT, SB, and NW, right: DR, VL, ET, LK, and DW). Patient RTs were compared with 10 normal controls (see Table

TABLE 4

Timed Picture Confrontation Naming (A): Mean Response Times (RT) and Percentage Error Scores (%Err) for Living and Nonliving Categories, for High and Low Name Frequency Items, across Control, TLE-L, and TLE-R Groups

	Living (n = 38)		Nonliving (n = 38)	
	High	Low	High	Low
Controls	1026	987	843	907
%Err	(5.5)	(4.4)	(5.5)	(9.9)
SD	175	147	101	124
TLE-L	1287	1253	1102	1078
Rtz	−1.49	−1.80	−2.56	−1.37
%Err	(23.7)	(19.7)	(9.1)	(17)
%*z*	2.35	2.69	.47	.58
SD	115	36	103	124
TLE-R	1046	1120	1015	1044
Rtz	−.11	−.90	−1.70	−1.10
%Err	(19.8)	(18.7)	(5.2)	(18.8)
%*z*	1.84	2.52	−.03	.74
SD	132	242	200	217

Note. Standard deviations (*SD*) are given as are *z* scores for RT data (Rtz) and for %Err data (%*z*) for TLE-L and TLE-R groups.

4). The results for both by-subjects and by-items RTs and error analyses are reported. It should be noted that the error analyses here do not include slow responses removed according to the cutoff procedure (see above). However, hesitations are included as errors. In order to compare more directly with the untimed version of the task we also collated the data excluding hesitations as errors (see Appendix 3). The results were unaltered. In addition, two items were dropped from the item analyses (as left hemisphere patients failed to name ‘‘saltshaker’’ and right hemisphere patients failed to name ‘‘bee’’). These items were replaced with the mean for items remaining in that particular condition (see Tabachnick & Fidell, 1996, pp. 60–65). If the data are reanalyzed dropping these items, the results are unaffected.

First, a mixed-design ANOVA to analyze the effects of Group (controls vs patients), Category (living vs nonliving), and Frequency (high vs low word frequency) was carried out. Second, a mixed-design ANOVA to analyze the effects of Group (controls vs TLE-L vs TLE-R), Category (living vs nonliving) and Frequency (high vs low word frequency) was carried out. We examine the untransformed data first, followed by the transformed data.

For untransformed RT data there was a main effect of Group, with longer response times for patients compared with controls, $F1(1, 17) = 6.45$, $MSE = 84929$, $p < .05$; $F2(1, 72) = 23.81$, $MSE = 41067$, $p < .01$. There was also a main effect of Category, with longer response times to living compared with nonliving things, $F1(1, 17) = 30.99$, $MSE = 8929$, $p < .0001$; $F2(1, 72) = 7.10$, $MSE = 80561$, $p < .01$.

For untransformed accuracy data there was a main effect of Group, with more errors for patients compared with controls, $F1(1, 17) = 12.48$, $MSE = 150$, $p < .005$; $F2(1, 72) = 40.13$, $MSE = 172$, $p < .0001$. There was also a Group × Category interaction, $F1(1, 17) = 9.07$, $MSE = 55$, $p < .01$; $F2(1, 72) = 4.13$, $MSE = 172$, $p < .05$. The Games and Howell procedure showed significantly more errors for patients compared with controls for both living and nonliving things (ps $< .05$). The interaction arose because the difference between patients and controls was greater for living things (a difference of −15.1%) than for nonliving things (a difference of −4.8%).[2] There was also a Category × Frequency interaction, by subjects only, $F1(1, 17) = 7.35$, $MSE = 54$, $p < .05$; $F2(1, 72) = 2.17$, $MSE = 318$, $p = ns$. The Games and Howell procedure showed significantly more errors to living things compared with nonliving things for high frequency items ($p < .05$).

The subsequent ANOVA on untransformed RT data comparing controls with TLE-L and TLE-R groups produced the same results. There was a main effect of Group, $F1(2, 16) = 4.18$, $MSE = 81752$, $p < .05$; $F2(2, 144) = 15.68$, $MSE = 63066$, $p < .0001$. The Games and Howell procedure showed significantly longer response times for TLE-L patients compared with controls ($p < .05$). However, there was no difference between TLE-R and controls. There was also a main effect of Category, with longer responses to living compared with nonliving things, $F1(1, 16) = 33.48$, $MSE = 7269$, $p < .0001$; $F2(1, 72) = 4.63$, $MSE = 132704$, $p < .05$.

The subsequent ANOVA on untransformed accuracy data comparing controls with TLE-L and TLE-R groups found similar results. There was a main effect of Group, $F1(2, 16) = 5.96$, $MSE = 158$, $p < .05$; $F2(2, 144) = 23.59$, $MSE = 201$, $p < .0001$. The Games and Howell procedure showed significantly more errors for both TLE-L and TLE-R compared with controls (ps $< .05$). However, there was no difference between the patient groups. There was also a Group × Category interaction, $F1(2, 16) = 4.28$, $MSE = 58$, $p < .05$; $F2(2, 144) = 2.25$, $MSE = 201$, $p = ns$, by subjects only. The Games and Howell procedure showed significantly more errors for patients compared with controls for both living and nonliving things (ps $< .05$). The interaction arose because the difference between patients and controls was greater for living things than for nonliving things. Finally, there was a main effect of Category, with more errors to living things compared with nonliving things, $F1(1, 16) = 4.75$, $MSE = 58$, $p < .05$; $F2(1, 72) = 1.73$, $MSE = 685$, $p = ns$, and a Category × Frequency interaction, $F1(1, 16) = 7.52$, $MSE = 56$, $p < .05$; $F2(1, 72) = 2.15$, $MSE = 685$, $p = ns$, by subjects only. The Games and Howell procedure showed significantly more errors to living things compared with nonliving things for high frequency but not for low frequency items ($p < .05$).

Importantly, transformed RT and accuracy data produced a similar pattern of results. For transformed RT data across patient groups there were no main effects or interactions. For transformed accuracy data across patient groups there was a main effect of Category, with more errors to living things, $F1(1, 8) = 12.43$, $MSE = 2.61$, $p < .01$; $F2(1, 72) = 3.77$, $MSE = 18.98$, $p = .05$, and by items only a Category × Frequency interaction, $F1(1, 8) = .009$, $MSE = .49$, $p = ns$; $F2(1, 72) = 11.20$, $MSE = 18.98$, $p < .05$. The subsequent ANOVA comparing TLE-L and TLE-R groups similarly found a main effect of Category, by subjects only, $F1(1, 7) = 10.87$, $MSE = 2.98$, $p < .05$; $F2(1, 72) = 2.73$, $MSE = 13.18$, $p = ns$. By items only, there was a Category × Frequency interaction, $F1(1, 7) = .01$, $MSE = .55$, $p = ns$; $F2(1, 72) = 10.69$, $MSE = 13.18$, $p < .005$. The Category × Frequency interactions arose because the difference between living and nonliving things was greater for low frequency items (all ps $< .05$).

---

[2] To be extremely conservative concerning this result, we provide converging evidence from an alternative statistical procedure for controlling for stimulus factors that can influence naming performance. Living and nonliving items were matched least effectively on familiarity and complexity (see Table 1). We therefore included these variables in an analysis of covariance. The nuisance variables did not interact with the variables of interest. Moreover, although the difference between patients and controls was reduced for living items, a greater patient–control difference for living relative to nonliving items was still apparent in the least-squares means (for living items a difference of −16.4%, for nonliving items a difference of −8.5%).

In sum, more patient naming errors were made to living compared with nonliving things compared to controls in both untransformed and transformed data (and this was not qualified by word frequency in the subjects analysis).

Patient errors broke down in the following way. For TLE-L, for living things, 37.2% were visual-semantic, 7% purely semantic, and 18.6% were nonresponses. For TLE-L, for nonliving things, 14% were visual-semantic errors, 9.3% were purely semantic errors, 7% were nonresponses, 4.6% were semantic-phonological errors, and 2.3% were purely visual errors. For TLE-R, for living things, 40.5% were visual-semantic, 3.8% were purely semantic, 11.5% were nonresponses, and 3.8% were purely visual errors. For TLE-R for nonliving things, 17.3% were visual-semantic errors, 11.6% were purely semantic errors, 9.6% were nonresponses, and 1.9% were purely visual errors.

Finally, we carried out simultaneous multiple regressions in order to assess the importance of semantic and linguistic variables in predicting patients' response times and errors. Regressors were obtained from the Oxford Psycholinguistic Database (Quinlan, 1986) and Snodgrass and Vanderwart (1980) and included Complexity, Contour overlap (see Humphreys, Riddoch, & Quinlan, 1988), Category, Imageability, Name agreement, Image agreement, Age of acquisition, Word familiarity, Word frequency, Number of syllables, and Number of letters. The only simultaneous multiple-regression analysis to approach significance was on right hemisphere patient response times. The overall simultaneous multiple regression was not significant, $N = 71$, $R^2 = .20$, $F = 1.21$, $MSE = 85870$, $p = ns$. However, for Imageability, where less imageability produces longer RTs, the standardized regression coefficient was significant; coefficient = 112.05, t ratio = 2.13 (±52.47), $p < .05$.

Category generation. Ten normal controls and nine patients took part. There were unequal numbers of left and right hemisphere patients (left: CS, DT, SB, NW, and SW; right: DR, VL, ET, and DW). One participant in the control group and one patient (SW) failed to perform the task adequately and therefore they were not included in the analyses. See Table 5 for the data summary.

For each participant, the word score (i.e., number of words correct) was obtained by counting the total number of correct object names, excluding errors. We also collated the percentage word score, obtained by dividing the total word score by the overall word score (i.e., number of words generated, including errors). Scores were calculated across living and nonliving categories. For individual items, errors were

TABLE 5

Category Generation: Total Word Scores for Living and Nonliving Categories across Control, TLE-L, and TLE-R Groups

	Living (three categories)	Nonliving (three categories)
Controls	73.1	66.2
SD	12.7	15.1
TLE-L	57	58.5
SD	10.1	9.83
z	−1.26	−.50
TLE-R	49.7	54.2
SD	9.09	3.69
z	−1.84	−.79

Note. Standard deviations (*SD*) are given as are *z* scores (*z*) for TLE-L and TLE-R groups.

classified as (1) words not from the appropriate category, (2) perseverations, and (3) proper names. Superordinate and subordinate names were included following the criterion for category membership (see Methods). Data were arcsine transformed.

In addition, three independent raters judged the presence of semantic (S), semantic-phonemic (S-P), and phonemic (P) clusters across each list of items generated to a given category name (inclusive of errors). Semantic clusters were (1) two successive words from the same semantic subcategory (e.g., hamster and guinea pig are pets as opposed to farm animals) or (2) two successive words sharing a within-category associative relation (e.g., cat and dog). Semantic-phonemic clusters were two successive words sharing a semantic and a phonemic relationship (e.g., tortoise and turtle). Phonemic clusters were two successive words beginning with the same phoneme (e.g., camel and carrot) or which rhymed (e.g., dog and log). Clusters of each sort were determined legitimate if all three raters agreed over their cluster type. Errors were classified as above and clusters that contained an error were excluded from analysis. The cluster score was obtained by counting the total number of clusters, excluding errors. The cluster ratio was also calculated by dividing the cluster score by the total word score.

Simultaneous multiple-regression analyses were also carried out on a measure of ‘‘production frequency.’’ We asked whether the frequency with which an item is produced by patients (e.g., ‘‘apple’’ was produced by nine of nine patients, whereas ‘‘apricot’’ was produced by two of nine patients) is predicted by semantic and/or linguistic variables.

Word score and percentage word score. A mixed-design ANOVA to analyze the effects of Group (controls vs patients) and Category (living vs nonliving) was carried out. A subsequent mixed-design ANOVA to analyze the effects of Group (controls vs TLE-L vs TLE-R) and Category (living vs nonliving) was also carried out.

For untransformed word scores there was a main effect of Group, with patients generating fewer exemplars than controls, $F(1, 15) = 7.55$, $MSE = 245$, $p < .05$. There was also a trend toward a Group × Category interaction $F(1, 15) = 3.48$, $MSE = 59$, $p = .08$. The trend was for production of more living compared with nonliving exemplars for controls (73 vs 66 exemplars respectively) with a smaller trend in the opposite direction for patients (53 vs 56 exemplars respectively). For transformed word scores, there was a main effect of Category, with patients generating fewer exemplars for living compared with nonliving categories, $F(1, 7) = 15.61$, $MSE = .21$, $p < .01$. For percentage word scores there were no significant main effects or interactions for untransformed or transformed scores.

For the mixed ANOVA comparing TLE-L and TLE-R groups with controls the results were similar. For untransformed word scores there was a main effect of Group, $F(2, 14) = 3.92$, $MSE = 157$, $p < .05$. The Games and Howell procedure showed significantly fewer exemplars generated by TLE-R patients compared with controls; however, there was a trend in the same direction for TLE-L patients. For transformed word scores there was a main effect of Category, with patients generating fewer exemplars for living compared with nonliving categories, $F(1, 6) = 11.14$, $MSE = .24$, $p < .05$. For percentage word scores there were no significant main effects or interactions for untransformed or transformed scores.

Cluster score and cluster ratio. A mixed-design ANOVA to analyze the effects of Group (controls vs patients), Category (living vs nonliving), and Cluster type (semantic vs semantic-phonemic vs phonemic) was carried out. A subsequent mixed-design ANOVA to analyze the effects of Group (controls vs TLE-L vs TLE-R), Category (living vs nonliving), and Cluster type (semantic vs semantic-phonemic vs phonemic) was also carried out. The main result was that there were no differences between controls and patients, or between TLE-L and TLE-R patients, in clustering ability.

For untransformed cluster scores there was a main effect of Cluster type, $F(2, 30) = 92.91$, $MSE = 11.33$, $p < .0005$. The Games and Howell procedure showed more semantic compared with semantic-phonemic and phonemic clusters ($p < .01$). No other main effects or interactions were significant. For transformed scores there were no main effects or interactions.

For untransformed cluster ratio scores there was a main effect of Cluster type, $F(2, 30) = 127.12$, $MSE = .003$, $p < .0005$. The Games and Howell procedure showed more semantic compared with semantic-phonemic and phonemic clusters and more semantic-phonemic compared with phonemic clusters (all ps $< .01$). There was also a main effect of Category, with more clusters generated for living compared with nonliving categories, $F(1, 15) = 6.37$, $MSE = .001$, $p < .05$. For transformed scores there were no main effects or interactions.

The mixed ANOVA comparing TLE-L and TLE-R groups with controls showed similar results. For untransformed cluster scores there was a main effect of Cluster type, $F(2, 28) = 73.13$, $MSE = 11.54$, $p < .0005$. The Newman–Keuls procedure showed more semantic compared with semantic-phonemic and phonemic clusters ($p < .01$). No other main effects or interactions were significant. For transformed scores there were no main effects or interactions. For untransformed cluster ratio scores there was a main effect of Cluster type, $F(2, 28) = 106.25$, $MSE = .003$, $p < .0005$. The Games and Howell procedure showed more semantic compared with semantic-phonemic and phonemic clusters and more semantic-phonemic compared with phonemic clusters (all ps $< .01$). There was also a main effect of Category, with more clusters generated for living compared with nonliving categories, $F(1, 14) = 7.5$, $MSE = .001$, $p < .05$. For transformed scores there were no main effects or interactions.

Simultaneous multiple-regression analyses. We carried out simultaneous multiple regressions in order to assess the importance of semantic and linguistic variables in predicting patients' production frequency. Regressors were obtained from the Oxford Psycholinguistic Database (Quinlan, 1986) and included Category, Imageability, Word familiarity, Name frequency, Number of letters, and Number of syllables. To make the data set manageable, we dropped items that had only been produced by one patient (e.g., ‘‘chandelier,’’ ‘‘culottes,’’ ‘‘buffalo,’’ ‘‘chilibean,’’ and ‘‘satsuma’’). This left a total of 106 items (52 living and 54 nonliving).

Across all patients the simultaneous multiple regression analysis was significant, $N = 106$, $R^2 = .195$, $F = 4$, $MSE = .0057$, $p < .001$. Of the variance of production frequency, 19.5% was accounted for when all the independent variables were entered into the regression model. Two variables have significant standardized regression coefficients with patient production frequency: Category coefficient $= -.17$, t ratio $= 3.16$ ($\pm .05$), $p < .005$; Word familiarity coefficient $= .002$, t ratio $= 3.11$, $p < .005$. The significant standardized regression coefficient for Word frequency approached significance, coefficient $= 0.0003$, t ratio $= -1.69$ ($\pm .0001$), $p = .09$. Using the square of the t ratio we see that Category is the most useful predictor followed by Word familiarity.

For left hemisphere patients, the simultaneous multiple-regression analysis was significant, $N = 96$, $R^2 = .214$, $F = 4.04$, $MSE = .56$, $p < .005$. When all the independent variables were entered into the regression model, 21.4% of the variance of production frequency was accounted for. Three variables have significant standardized regression coefficients with patient production frequency: Word familiarity coefficient $= .003$, t ratio $= 3.40$ ($\pm .001$), $p < .005$; Word frequency coefficient $= .0004$, t ratio $= -2.184$ ($\pm .0001$), $p < .05$; Category coefficient $= -.134$, t ratio $=$

-2.09 ($\pm.064$), $p < .05$. Using the square of the t ratio we see that Word familiarity is the most useful predictor followed by Word frequency and Category.

For right hemisphere patients, the simultaneous multiple-regression analysis was significant, $N = 81$, $R^2 = .214$, $F = 3.35$, $MSE = .07$, $p < .01$. When all the independent variables were entered into the regression model, 21.4% of the variance of production frequency was accounted for. Two variables have significant standardized regression coefficients with patient production frequency: Category coefficient $= -.194$, t ratio $= 2.911$ ($\pm.06$), $p < .005$; Word familiarity coefficient $= .002$, t ratio $= 2.666$ ($\pm.001$), $p < .01$. Two other variables were marginally significant: Word frequency coefficient $= -.0004$, t ratio $= -1.98$ ($\pm.0002$), $p = .05$; Number of syllables $= .119$, t ratio $= 1.774$ ($\pm.06$), $p = .08$. Using the square of the t ratio we see that Category is the most useful predictor, followed by Word familiarity, Word frequency, and Number of syllables.

Category and associate matching tasks. For category and associate matching, 10 normal controls and 12 TLEs took part. There were an equal number of left and right hemisphere patients (left: CS, DT, SB, NW, SW, and JML; right: DR, VL, ET, LK, SP, and DW). Patient scores were within the normal range. Mean percentage correct scores for the category matching task were 98.9 and 99.56% for TLE-L and TLE-R groups, respectively (the corresponding z scores were -1.54 and $-.32$). Mean percentage scores for the associate matching task were 95.4 and 96.7% for TLE-L and TLE-R respectively (the corresponding z scores were $-.26$ and $.36$).

DISCUSSION

The main results were as follows. For category and associate matching, patients were within the normal range. For picture confrontation naming (A), picture confrontation naming (B), timed picture confrontation naming (A), and category generation, patients showed evidence of impairment relative to controls. We first summarize performance on each of these tasks.

In untimed picture confrontation naming (A), patients showed a category-specific deficit for living things: Patients were less accurate in naming living than nonliving things relative to controls. However, this was the case only for high frequency items. We were unable to perform z transformations of the data; however, an analysis of covariance partialing out effects of other variables produced a (marginally significant) confirmation of this result.

In untimed picture confrontation naming (B), of low name frequency items, patients were less accurate than controls. Furthermore, TLE-R patients were less accurate than TLE-L patients. Importantly, the difference between overall patient and control performance was significantly greater for living things. z-Transformed scores confirmed this deficit for naming living things (although this result did not emerge in the comparison between patient groups, perhaps due to the relatively small sample size). Simultaneous multiple regressions revealed that Category was the most important predictor of patient accuracy followed by Imageability. Number of letters and Number of syllables in the object name were marginally significant. Analysis comparing each patient group suggests that the influence of Imageability on performance is carried predominantly by right hemisphere patients.

When patients were examined under timed picture confrontation naming conditions (picture confrontation naming A), deficits emerged in both response times and accuracy, and category-specific deficits emerged in terms of accuracy. More specifically, (1) patients produced significantly longer response times compared with controls, although there was no difference between TLE-L and TLE-R groups; (2)

patients were less accurate than controls; (3) the difference between patient and control percentage correct was greater for living (−15.2%) than for nonliving things (−4.8%); (4) *z*-transformed accuracy scores showed that when accuracy scores are adjusted for performance of healthy controls on the two categories, patients are less accurate with living compared with nonliving categories; and finally (5) there was also a trend in the transformed accuracy data for patient category differences to be greater for low frequency items. The only simultaneous multiple-regression analysis to approach significance was on right hemisphere patient response times, where greater imageability produces longer response times (although the overall regression was not significant).

The results across the three naming tasks are consistent in showing an impairment specific to living things; however, they appear contradictory in terms of Name frequency. The contradiction is most likely due to the selection of items (see Appendix 1 for a full list of stimuli). When we analyze the data across both sets (A) and (B) (a total of 115 items in all) an impairment for living things remains, showing that the effect is true for the *majority* of items (this is also the case if we then partial out effects of Name frequency, although the result is marginally significant at $p = .06$). We maintain therefore that there is a selective impairment for living things over and above any contributions of Name frequency.

In category generation, temporal lobectomy patients generated fewer correct exemplars than controls. The data further showed that, (1) whereas controls generated more living compared with nonliving exemplars, patients generated equivalent numbers of exemplars from the two categories. In effect, therefore, patients generated relatively fewer living exemplars compared with the control group. This interaction was marginally significant ($p = .08$). However, when scores were *z* transformed, taking into account the generation difficulty of both categories for healthy controls, patients generated significantly fewer exemplars from living compared with nonliving categories. (2) TLE-R patients generated significantly fewer exemplars than TLE-E patients, and (3) although patients generated less exemplars overall relative to controls, the proportion correct was the same; (4) patients' clustering ability was within the normal range. Simultaneous multiple regressions on patient Production frequency revealed that Category was the most important predictor of Production frequency followed by Word familiarity. Word frequency was marginally significant. Analysis of each patient group suggests that the importance of Word familiarity on performance is carried predominantly by the right hemisphere group.

Let us turn now to localization of the selective impairment for living things. Performance on category and associate matching was within the normal range (note that the associate matching task in particular was reasonably difficult as distractors were taken from the same category, e.g., rabbit > hutch/cage). This suggests an unimpaired semantic system with intact categorical structure and interitem associations. In addition, for category generation patient clustering ability was within the normal range. A major source of evidence for loss of semantic structure revealed by category generation is the manner in which participants produce exemplars from a given category (e.g., Rohrer, Wixted, Salmon, & Butters, 1995). As unimpaired individuals produce exemplars of a relatively broad category (e.g., animals), items from the same subset (e.g., farm animals) are often retrieved consecutively. However, semantically impaired individuals often produce fewer items per ''cluster,'' and more superordinate responses rather than specific items, compared with controls (e.g., Martin & Fedio, 1983; Troster, Salmon, McCullough, & Butters, 1989). Careful analysis of total number of clusters and cluster ratio (cluster score/total word score) revealed equivalent numbers of semantic clusters (relative to semantic-phonemic or purely phonemic clusters) produced by patients and controls. Production of the same number of clusters and the same proportion of clusters to overall word production is not consistent with an impaired semantic or executive system. Rather, unimpaired category and associate matching and unimpaired clustering ability in category generation simultaneous with impaired object naming and reduced production of category exemplars in fluency is strongly suggestive of a postsemantic lexical deficit. It is also worth noting that a word familiarity but not imageability influence on category generation is also consistent with a postsemantic locus to the impairment in this task.

There are, however, three lines of evidence that appear contrary to this interpretation: (a) a predominance of visual-semantic category errors in naming, (b) strong effects of imageability in untimed picture confrontation naming (Task B) and (c) equivalent impairment for left and right hemisphere patients.

The majority of errors in picture confrontation naming Task A and Task B were visual-semantic errors, which may suggest a visually based deficit. However, we do not believe this to be the case as performance on visual category and associative matching was within the normal range and performance on category fluency was impaired. In addition, we may have expected a larger number of visual-only errors based on overall shape or segmentation. However, the average number of such errors was extremely small (an average of 1% across tasks). Finally, visual variables of complexity and contour overlap did not predict picture naming RTs or errors. A stronger argument is that semantic category errors reflect semantic impairment. However, in fact such errors may reflect either semantic or postsemantic impairment (for a full discussion of this issue see Nickels, 1994).

Similarly, effects of imageability on performance may be accounted for in terms of either a semantic or postsemantic deficit depending on the functional model that is adopted (i.e., a logogen or connectionist class of model; Nickels, 1994). According to a discrete stage logogen model (Morton, 1970) a semantic deficit would predict an effect of semantic variables such as imageability on the production of semantic errors in picture naming and production in verbal fluency. In contrast, if the deficit is postsemantic we would *not* expect an effect of semantic variables on these tasks. Concerning linguistic variables, the logogen model predicts effects of these variables on the production of semantic errors with *both* semantic and postsemantic deficits. For instance, concerning a semantic deficit ''an underspecified semantic representation will activate a range of semantically related items . . . and the lexical item likely to be accessed will be that which reaches threshold first. . . . For high frequency targets, even if the address is underspecified they may be successfully accessed, whereas for lower frequency targets a semantically related word of higher frequency may be accessed instead'' (Nickels, 1994, p. 122). If we interpret this data according to the logogen model, therefore, patients are most likely exhibiting a semantic deficit. Importantly, however, due to interactive activation between levels of representation in a connectionist model, this kind of account may predict effects of imageability on production of semantic naming errors and production in verbal fluency *even when* the deficit is localized subsequent to the semantic level (for a full account see Martin & Saffran, 1992, p. 265; Nickels, 1994, p. 128). Therefore, if we interpret the data in terms of a temporally continuous model, patients in the present study may be exhibiting either a semantic or postsemantic deficit.

This leaves the neurobiological argument concerning left and right hemisphere patients. A major PET and lesion study by Damasio, Grabowski, Tranel, Hichwa, and Damasio (1996) suggests that, whereas the neural systems required to retrieve semantic knowledge are localized in both the left and right cerebral hemispheres, neural systems required to retrieve object names are localized almost exclusively to the left hemisphere (more particularly for ''animals'' in the anterior inferior temporal lobe, known in other studies as ''fusiform'' regions, and for ''tools'' in the posterior-lateral-inferior-temporal as well as posterior-temporal-parietal cortices). In particular, Damasio et al. argue that the anterior sector of the left temporal cortices (areas 38, 21, 20, and 37) play an important role in lexical retrieval. These areas are not concerned with grammatical, semantic, or phonological aspects of language but rather play a postsemantic mediational role in lexical retrieval (analogous to ‘‘lemma’’ retrieval; Levelt, 1989). It follows, therefore, according to this account, that were the living things deficit in the present population in the process of lexical retrieval, we would expect it to emerge for the left temporal lobectomy group alone. This was not the case. However, the strength of this proposal lies in the claim that postsemantic neural systems required to retrieve object names for living things are exclusively localized to the left hemisphere. If doubt can be cast on this proposal then the evidence against a postsemantic deficit in the present population is seriously weakened. In fact, as Murtha, Chertkow, Beayregard, and Evans (1999) note, the PET study of Damasio et al., was unusual in that the subtraction condition for picture naming always consisted of a judgment task whereby subjects judged whether pictured faces were presented correct way up or upside down. Caution must therefore be taken in drawing conclusions about lexical retrieval in the presence of such a baseline task which likely involves complex decisions. Furthermore, no other PET study of picture naming has found activation in the anterior inferior left temporal region. Recently, however, Murtha et al. found (in one baseline condition only; picture naming minus ‘‘anticipation’’) a band of activation extending *bilaterally* throughout the fusiform gyri into the posterior temporal lobes, but it did not extend into the anterior inferior temporal cortex. In addition, in a recent magnetoencephalograph study, Levelt, Praamstra, Meyer, Helenius, and Salmelin (1998) found activation presumed to be correlated with lexical retrieval in occipital, parietal, and temporal areas *bilaterally,* with a strong clustering of sources (seven of eight subjects) in the right parietal cortex, along the end of the superior temporal sulcus. In sum, it is clear that the results of Damasio et al. are controversial and it therefore remains an open question as to whether components of lexical retrieval are localized unilaterally or bilaterally.

In conclusion, on balance we suggest a postsemantic functional locus to the category-specific deficit for living things in the present population.

The data do not appear to be consistent with Tippett, Glosser, and Farah (1996). Under paced picture naming conditions Tippett et al. found that (1) right temporal lobectomy patients performed within the normal range and equally well with living and nonliving things and (2) left temporal lobectomy patients were disproportionately impaired at naming nonliving things. Several important points need to be made here. First, averaging over participants can obscure individual differences (cf. Caramazza, 1996; Gonnerman, Andersen, Devlin, Kempler, & Seidenberg, 1997; Pietrini, Nertempi, Vaglia, Revello, Pinna, & Ferro-Milone, 1988). Tippett et al. do not report individual cases, however, in the present case no individual patient showed a statistically significant selective deficit for nonliving things, either averaged over nonliving things or for individual nonliving categories, for any task. Second, the present study used a small sample of temporal lobectomy patients, and therefore it may be argued that with a larger sample differences between left and right temporal lobectomy groups may emerge. However, this does not compromise the fact that a deficit across left and right patients was evident specifically for living things. Third, in addition to task and stimuli differences between the studies, time of testing may be relevant. For instance, on testing 6 months postoperatively, Hermann and Wyler (1988) found poorer fluency performance for right relative to left hemisphere patients. In contrast, Martin, Loring, Meador, and Lee (1990) assessed patients 1 week after surgical resection and found the left group to have impaired fluency relative to the right group. In the Tippett et al. study, 20 subjects were tested 3–6 weeks postsurgery, and 11 were seen at follow-up 1 or more years later (it is not clear whether there was any systematic difference between left and right groups). In the present study, the mean time of postoperative testing was 10.1 months (with the left group 9.5 months and the right group 10.6 months on average postsurgery). Finally, the functional locus of the deficit may be different in the two studies: The Tippett et al. study provides no converging evidence as to the functional locus of impairment in their temporal lobectomy group.

The present data is generally consistent with functional-anatomical correlations in patients and functional neuroimaging studies in patients and normals of the involvement of temporal cortex in object comprehension and naming. However, some of the results from these studies are equivocal (see Caramazza & Shelton, 1998; Gainotti, Silveri, Daniele, & Guistolisis, 1995; Saffran & Schwartz, 1994, for reviews).

Most functional-anatomic correlations for semantic deficits with living things show damage to the left temporal lobe, and the right temporal lobe in patients recovering from herpes simplex encephalitis. However, some patients have also sustained damage to the frontal and inferior parietal areas, or more extensive damage due to trauma (see Caramazza & Shelton, 1998). The pattern of functional-anatomic correlations is less clear for semantic deficits involving nonliving things. Lesions are more variable and have involved fronto-parietal areas as well as the temporal lobe.

The results from neuroimaging studies comparing living and nonliving things complicate the picture (i.e., Martin, Wiggs, Ungerleider, & Haxby, 1996; Perani, Cappa, Bettinardi, Bressi, Gorno-Tempinin, Mataresse, & Fazio, 1995; Tranel, Damasio, & Damasio, 1997a). Although all these studies support a neurological separation between living and nonliving things, and despite some agreement, the specific localization across studies is different. For living things, Perani, Cappa, Bettinardi, Bresi, Gorno-Tempini, Mataresse, and Fazio (1995) and Martin, Wiggs, Ungerleider, and Haxby (1996) found activation of the occipital lobes bilaterally and the inferior temporal lobe, bilaterally for Pirani et al. and left only for Martin et al. For nonliving things, Perani et al. found mostly left-sided activation of the lingual parahippocampal gyri, middle occipital gyrus, and dorsolateral frontal regions; Martin et al. found activation of the fusiform gyri of the temporal lobes (bilaterally) and the left inferior frontal region and left precentral gyrus. It is likely that task and stimuli differences contribute to the conflicting findings. In the Perani et al. study, subjects viewed two objects simultaneously and judged whether they depicted the same basic-level stimuli (i.e., whether they were both dogs). Living and nonliving conditions were compared with matching visual textures and nonnameable two-dimensional shapes. In contrast, the Martin et al. study compared silent naming of living and nonliving objects with staring at visual noise patterns and novel nonsense objects (subjects also named aloud, however, this condition was not used for comparison of the brain areas activated with silent object naming).

Most of the cases outlined above have been interpreted as involving deficits to the semantic system. Importantly, however, many of these studies fail to distinguish clearly between retrieving semantic knowledge (in order to recognize the object) and retrieving object names. As mentioned above, Damasio et al. (1996; see also Farah & Wallace, 1992; Hart, Bernt, & Caramazza, 1985; Lloyd-Jones & Humphreys, 1997b) have suggested that category-specific deficits may also emerge from damage to lexical representations mediating between conceptual and phonological knowledge. Damasio et al. (1996) localize name retrieval for animals to the left temporal lobe and for tools to more dorsal areas (though see Caramazza, 1996, for comments). The present data support the notion of category-specific lexical deficits, but suggest that unilateral as opposed to bilateral localization may be premature. Concerning the hemisphere of resection, the data presented here are equivocal. Left patients generated fewer exemplars than right patients in category generation (consistent with previous studies; e.g., Milner, 1964; Perret, 1974; Ramier & Hecaen, 1970) but were more accurate in untimed naming of low frequency pictures. Moreover, there was no interaction with semantic category: left and right patient groups were equally impaired on living things relative to nonliving things when compared with controls. This null result may be due to sample size, with a larger sample living things deficits may emerge more strongly for left compared with right temporal lobectomy patients.

Damasio (1989, 1990) has argued that the anterior temporal lobes are the site of ''convergence–divergence zones'': neuronal assemblies which ''bind'' together the sensory and motor features of objects. Because living things are generally more visually and semantically similar than nonliving things they require greater differentiation for identification. As a result, living things are more dependent on the temporal convergence zones to activate distinguishing information. Furthermore, Tranel, Damasio, and Damasio (1997b) have suggested that the separation of neural systems that support the retrieval of semantic information for different categories of object is paralleled by a similar separation of neural systems supporting the retrieval of word forms corresponding to those same categories of object. If we assume that temporal lobe epileptics' picture naming and category generation deficits following damage to the temporal lobes are mediated by impairment affecting lexical retrieval, then our data are broadly consistent with both neuroanatomical evidence and the theory of convergence zones.

APPENDIX 1

Full Lists of Stimuli for Each Task[a]

	Naming A (Category and Associate matching): Full list	
CLOCK	NL	H
CUP	NL	H
DRUM	NL	H
NUT	NL	H
PENCIL	NL	H
RING	NL	H
STOVE	NL	H
TELEVISION	NL	H
AIRPLANE	NL	H
AXE	NL	H
BED	NL	H
BOWL	NL	H
LOCK	NL	H
PIPE	NL	H
REFRIGERATOR	NL	H
SCREW	NL	H
SHOE	NL	H
LIPS	NL	H
LEG	NL	H
BUTTON	NL	L
KITE	NL	L
NAIL	NL	L
NECKLACE	NL	L
RULER	NL	L
SALTSHAKER	NL	L
STOOL	NL	L
TOASTER	NL	L
VASE	NL	L
ASHTRAY	NL	L

APPENDIX 1 (*continued*)

	Naming A (Category and Associate matching): Full list	
BLOUSE	NL	L
BROOM	NL	L
CHISEL	NL	L
DOORKNOB	NL	L
HELICOPTER	NL	L
KETTLE	NL	L
PLIERS	NL	L
SCISSORS	NL	L
THIMBLE	NL	L
BEE	L	H
CAT	L	H
CHICKEN	L	H
DOG	L	H
FOX	L	H
ONION	L	H
POTATO	L	H
RABBIT	L	H
SHEEP	L	H
BEAR	L	H
CORN	L	H
COW	L	H
DEER	L	H
FLY	L	H
HORSE	L	H
LION	L	H
ORANGE	L	H
PEPPER	L	H
LEMON	L	H
CELERY	L	L
ELEPHANT	L	L
GORILLA	L	L
MOUSE	L	L
MUSHROOM	L	L
OWL	L	L
SPIDER	L	L
SQUIRREL	L	L
ZEBRA	L	L
BEETLE	L	L
CAMEL	L	L
CARROT	L	L
GIRAFFE	L	L
KANGAROO	L	L
LETTUCE	L	L
PEAR	L	L
RHINO	L	L
TIGER	L	L
STRAWBERRY	L	L

Naming B: Full list

Animals
- PIG
- BADGER
- KOALA BEAR
- CHIMPANZEE
- ANTELOPE
- DONKEY
- HIPPOPOTAMUS
- GUINEA PIG
- PANDA

APPENDIX 1 (*continued*)

Naming B: Full list

- GOAT
- SKUNK
- LEOPARD
- MONKEY
- LLAMA
- MOLE
- RACCOON
- WOLF
- BOAR
- BEAVER
- OTTER

Fruits and vegetables
- ARTICHOKE
- BANANA
- COURGETTE
- LEEK
- RASPBERRY
- BUNNER BEAN
- SPROUT
- MARROW
- COCONUT
- GARLIC
- GRAPES
- APPLE
- PINEAPPLE
- POMEGRANATE
- ASPARAGUS
- BROCCOLI
- PEACH
- AUBERGINE
- WATERMELON
- CHERRY

Tools
- MALLET
- SPADE
- FILE
- HAMMER
- TROWEL
- ROLLER
- RAKE
- WOOD SAW
- CLAMP
- LADDER
- GARDEN FORK
- DRILL
- PLANE
- PLIERS
- CEMENT
- TROWEL
- SCREWDRIVER
- SCYTHE
- SHEARS
- WRENCH

---

[a] NL = Nonliving; L = Living; H = High frequency; L = Low frequency.

APPENDIX 2

Raw Data for Each Task

TABLE A1
Untimed Naming Task A

	Living		Nonliving	
Patient	High	Low	High	Low
Left				
CS	89.4	94.7	78.9 (83.3)	78.9
DT	84.2	89.4	100 (100)	89.4
SB	94.7	89.4	100 (100)	89.4
SW	94.7	94.7	78.9 (83.3)	84.2
JML	84.2	89.4	94.7 (94.4)	94.7
X	89.4	91.5	90.5 (92.2)	87.3
SD	4.7	2.59	9.66 (7.54)	5.36
Right				
DR	94.7	94.7	94.7 (94.4)	94.7
ET	84.2	89.4	94.7 (94.4)	94.7
LK	89.4	100	94.7 (94.4)	63.1
SP	89.4	100	100 (100)	100
DW	84.2	89.4	100 (100)	100
X	88.4	94.7	96.8 (96.6)	90.5
SD	3.70	4.74	2.59 (2.74)	13.9

[a] Scores in brackets are those with Lips and Leg removed.

TABLE A2
Untimed Naming Task B (>80%
Name Agreement Criterion)

Patient	Living	Nonliving
Left		
CS	50	80
DT	42.3	86.7
NW	100	86.7
JML	80.7	80
X	68.2	83.3
SD	23.3	3.35
Right		
DR	80.7	93.3
ET	73.1	80
LK	80.7	80
DW	69.2	93.3
X	75.9	86.6
SD	4.97	6.6

TABLE A3
Untimed Naming Task B (No Name Agreement Cutoff Criterion)

Participant	Living ($n = 40$)	Nonliving ($n = 20$)
Controls		
1	97.5	95
2	92.5	90
3	92.5	95
4	92.5	90
5	87.5	85
6	100	95
7	82.5	90
8	82.5	80
9	82.5	100
10	87.5	90
11	95	90
12	97.5	95
13	85	90
14	92.5	95
15	90	95
16	82.5	90
17	95	95
18	80	90
19	85	95
20	100	90
X	90	91.75
SD	6.22	4.26
Left		
CS	35	70
DT	27.5	80
NW	100	81.2
JML	45	75
X	51.8	76.5
SD	28.5	4.43
Right		
DR	45	75
ET	62.5	80
LK	57.5	75
DW	45	80
X	52.5	77.5
SD	7.70	2.5

TABLE A4
Timed Naming Task A

	Living		Nonliving	
	High	Low	High	Low
Left				
CS	1459 (32)	1291 (37)	1221 (10.5)	976 (26)
DT	1136 (42.1)	1259 (26)	938 (21)	1031 (15.8)
SB	1292 (10.5)	1270 (15.8)	1103 (5.2)	1014 (15.8)
NW	1263 (10.5)	1193 (0)	1146 (0)	1291 (10.5)
X	1287 (23.7)	1253 (19.7)	1102 (9.17)	1078 (17)
SD	115	36	103	124
Right				
DR	969 (26)	829 (32)	807 (0)	821 (26)
VL	829 (15.8)	879 (13.8)	770 (10.5)	820 (15.8)
ET	1109 (21)	1289 (15.8)	1187 (0)	1156 (15.8)
LK	1118 (26)	1469 (32)	1273 (5.2)	1397 (15.8)
DW	1208 (10.5)	1137 (0)	1039 (10.5)	1026 (21)
X	1046 (19.8)	1120 (18.7)	1015 (5.2)	1044 (18.8)
SD	132	242	200	217

TABLE A5
Timed Naming Task A[a]

	Living		Nonliving	
	High	Low	High	Low
Controls	(5.5)	(4.4)	(5.5)	(9.9)
Left				
CS	(32)	(37)	(10.5)	(26)
DT	(42.1) 31.5	(26)	(21) 10.5	(15.8)
SB	(10.5)	(15.8)	(5.2)	(15.8) 10.5
NW	(10.5)	(0)	(0)	(10.5)
X	21.1	19.7	6.5	15.7
SD	10.6	13.6	4.3	6.3
Right				
DR	(26)	(32)	(0)	(26) 21
VL	(15.8)	(13.8)	(10.5) 5.2	(15.8) 10.5
ET	(21)	(15.8)	(0)	(15.8)
LK	(26)	(32)	(5.2)	(15.8)
DW	(10.5)	(0)	(10.5) 5.2	(21) 10.5
X	18.8	18.7	4.2	14.7
SD	6	12.1	2.5	3.9

[a] Alterations to error scores when Body Parts is removed. Total errors, including hesitations, are in brackets; incorrect/nonresponses are shown outside brackets).

TABLE A6
Category Generation

Participant	Living	Nonliving
Left		
CS	41	51
DT	69	75
SB	60	51
NW	58	57
X (*SD*)	57 (10.1)	58.5 (9.83)
Right		
DR	47	53
VL	65	56
ET	46	59
DW	41	49
X (*SD*)	49.7 (9.09)	54.2 (3.69)

APPENDIX 3

Untimed and Timed Naming Task A Analyses Dropping Body Parts and Excluding Hesitations

Analysis 1: Untimed Naming Task A (excluding Body Parts)

All patients

- Main effect of Group: $F1(1, 28) = 121.84$, $MSE = 15.66$, $p < .0001$; $F2(1, 70) = 44.7$, $MSE = 58.18$, $p < .0001$
- Category × Frequency interaction: $F1(1, 28) = 12.81$, $MSE = 12.25$, $p < .005$; $F2 = ns$
- Group × Category × Frequency interaction: $F1(1, 28) = 12.81$, $MSE = 12.25$, $p < .005$; $F2(1, 70) = 2.88$, $MSE = 58.18$, $p = .09$

Left versus Right patients versus Controls

- Main effect of Group: $F1(2, 27) = 70.03$, $MSE = 14.04$, $p < .0001$; $F2(2, 140) = 17.91$, $MSE = 112$, $p < .0001$
- Category × Frequency interaction: $F1(1, 27) = 17.44$, $MSE = 12.01$, $p < .0005$; $F2 = ns$
- Group × Category × Frequency interaction: $F1(2, 27) = 7.32$, $MSE = 12.01$, $p < .005$, $F2 = ns$

Analysis 2: Timed Naming Task A (excluding Body Parts)

Untransformed RTs

- All patients
  - Main effect of Group: $F1(1, 17) = 6.68$, $MSE = 83520$, $p < .05$; $F2(1, 70) = 24$, $MSE = 41849$, $p < .0001$
  - Main effect of Category: $F1(1, 17) = 31.72$, $MSE = 8825$, $p < .0001$; $F2(1, 70) = 5.98$, $MSE = 81407$, $p < .05$
- Left versus Right patients versus Controls
  - Main effect of Group: $F1(2, 16) = 4.28$, $MSE = 80520$, $p < .05$; $F2(2, 140) = 15.73$, $MSE = 64297$, $p < .0001$
  - Main effect of Category: $F1(1, 16) = 33.95$, $MSE = 7294$, $p < .0001$; $F2(1, 70) = 3.68$, $MSE = 133550$, $p < .05$

Transformed RTs

No main effects or interactions.

Analysis 3: Timed Naming Task A Untransformed Errors (data when hesitations removed)

All patients

- Main effect of Group: $F1(1, 17) = 24.04$, $MSE = 111$, $p < .0001$; $F2(1, 70) = 37.65$, $MSE = 165$, $p < .0001$
- Main effect of Category: $F1(1, 17) = 7.98$, $MSE = 33.73$, $p < .05$; $F2 = ns$
- Group × Category interaction: $F1(1, 17) = 15.39$, $MSE = 33.73$, $p < .005$; $F2(1, 70) = 5.14$, $MSE = 165$, $p < .05$
- Main effect of Frequency marginally significant: $F1(1, 17) = 4.4$, $MSE = 26.33$, $p = .05$; $F2 = ns$

Left versus Right patients versus Controls

- Main effect of Group: $F1(2, 16) = 11.59$, $MSE = 117$, $p < .005$; $F2(2, 140) = 22.76$, $MSE = 205$, $p < .0001$
- Main effect of Category: $F1(1, 16) = 13.85$, $MSE = 35.84$, $p < .005$; $F2 = ns$
- Group × Category interaction: $F1(2, 16) = 7.24$, $MSE = 35.84$, $p < .01$; $F2 = ns$
- Main effect of Frequency: $F1(1, 16) = 5.44$, $MSE = 27.66$, $p < .05$; $F2 = ns$

Transformed Errors

- All patients
  - Main effect of Category: $F1(1, 8) = 13.47$, $MSE = 2.606$, $p < .01$; $F2(1, 70) = 4.32$, $MSE = 18.9$, $p < .05$
  - Category × Frequency interaction: $F1(1, 18) = .04$, $MSE = .604$, $p = ns$; $F2(1, 70) = 11.99$, $MSE = 18.9$, $p < .05$
- Left versus Right patients versus Controls
  - Main effect of Group: $F1 = ns$; $F2(1, 70) = 6.5$, $MSE = 1.64$, $p < .05$
  - Main effect of Category: $F1(1, 7) = 11.88$, $MSE = 2.95$, $p < .05$; $F2(1, 70) = 2.16$, $MSE = 3.06$, $p = ns$

REFERENCES

Allport, D. A. (1985). Distributed memory, modular subsystems and dysphasia. In S. Newman & R. Epstein (Eds.), *Current perspectives in dysphasia.* Edinburgh: Churchill Livingstone.

Barry, C., & McHattie, J. V. (1995). Problems naming animals: A category-specific anomia or a misnomer? In R. Campbell & M. A. Conway (Eds.), *Broken memories: Case studies in memory impairment.* Oxford: Blackwell.

Barr, A., & Brandt, J. (1996). Word-list generation deficits in dementia. *Journal of Clinical and Experimental Neuropsychology,* **18,** 810–822.

Basso, A., Capitani, E., & Laiacona, M. (1988). Progressive language impairment without dementia: A case with isolated category-specific naming defect. *Journal of Neurology, Neurosurgery, and Psychiatry,* **51,** 1201–1207.

Behrmann, M., & Lieberthal, T. (1989). Category-specific treatment of a lexical-semantic deficit: A single case-study of global aphasia. *British Journal of Disorders of Communication,* **24,** 281–299.

Benbadis, S. R., Dinner, D. S., Chelune, C. G., Piedmonte, M., & Luders, H. O. (1995). Autonomous versus dependent: A classification of bilateral language representation by intra-carotid amobarbital procedure. *Journal of Epilepsy,* **8,** 255–263.

Bennett-Levy, J., Polkey, C. E., & Powell, G. E. (1980). Self report of memory skills after temporal lobectomy: The effect of clinical variables. *Cortex,* **16,** 543–557.

Biederman, I., Gerhardstein, P. C., Cooper, E. E., & Nelson, C. A. (1997). High level object recognition without an anterior inferior temporal lobe. *Neuropsychologia,* **35,** 271–287.

Cappa, S. F., Frugoni, M., Pasquali, P., Perani, D., & Zorat, F. (1998). Category-specific naming impairment for artefacts: A new case. *Neurocase,* **4,** 391–397.

Caramazza, A. (1986). The case for single patient studies. *Journal of Clinical and Experimental Neuropsychology,* **8,** 126.

Caramazza, A. (1996). Neuropsychology: The brain's dictionary. *Nature,* **380,** 485–486.

Caramazza, A., & Shelton, R. S. (1998). Domain-specific knowledge systems in the brain: The animate–inanimate distinction. *Journal of Cognitive Neuroscience,* **10,** 1–34.

Cardebat, D., Demonet, J. F., Celsis, P., & Puel, M. (1996). Living/non-living dissociation in a case of semantic dementia: A SPECT activation study. *Neuropsychologia,* **34,** 1175–1179.

Damasio, A. R. (1989). Time locked multiregional retroactivation: A systems level proposal for the neural substrates of recall and recognition. *Cognition,* **33,** 25–62.

Damasio, A. R. (1990). Category-related recognition defects as a clue to the neural substrates of knowledge. *Trends in Neuroscience,* **13,** 95–98.

Damasio, H., Grabowski, T. J., Tranel, D., Hichwa, R. D., & Damasio, A. R. (1996). A neural basis for lexical retrieval. *Nature,* **380,** 499–505.

Darlington, R. B. (1990). *Regression and linear models.* New York: McGraw–Hill.

De Renzi, E., & Lucchelli, F. (1994). Are semantic systems separately represented in the brain? The case of living category impairment. *Cortex,* **30,** 3–25.

Farah, M. J. (1989). The neural basis of mental imagery. *Trends in Neuroscience,* **12,** 395–399.

Farah, M. J., Hammond, K. M., Mehta, Z., & Ratcliff, G. (1989). Category-specificity and modality-specificity in semantic memory. *Neuropsychologia,* **27,** 193–200.

Farah, M. J., McMullen, P. A., & Meyer, M. M. (1991). Can recognition of living things be selectively impaired? *Neuropsychologia,* **29,** 185–193.

Farah, M. J., Meyer, M. M., & McMullen, P. A. (1996). The living/nonliving dissociation is not an artefact: Giving an a priori implausible hypothesis a strong test. *Cognitive Neuropsychology,* **13,** 137–154.

Funnell, E., & Hodges, J. R. (1996). Deficits of semantic memory end executive control: Evidence for differing effects upon naming in dementia. *Aphasiology,* **10,** 687–709.

Funnell, E., & Sheridan, J. (1992). Categories of knowledge? Unfamiliar aspects of living and nonliving things. *Cognitive Neuropsychology,* **9,** 135–153.

Gaffan, D., & Haywood, C. A. (1993). A spurious category-specific visual agnosia for living things in normal human and nonhuman primates. *Journal of Cognitive Neuroscience,* **5,** 118–128.

Gainotti, G., & Silveri, M. C. (1996). Cognitive and anatomical locus of lesion in a patient with a category-specific semantic impairment for living beings. *Cognitive Neuropsychology,* **13,** 357–390.

Gainotti, G., Silveri, M. C., Daniele, A., & Guistolisis, L. (1995). Neuroanatomical correlates of category-specific semantic disorders: A critical survey. *Memory,* **3,** 247–265.

Gonnerman, L. M., Andersen, E. S., Devlin, J. T., Kempler, D., & Seidenberg, M. S. (1997). Double dissociation of semantic categories in Alzheimer's disease. *Brain and Language,* **57,** 254–279.

Hart, J., Berndt, R. S., & Caramazza, A. C. (1985). Category-specific naming deficit following cerebral infarction. *Nature,* **316,** 439–440.

Hart, J., & Gordon, B. (1992). Neural subsystems for object knowledge. *Nature,* **359,** 60–64.

Hart, J., Lesser, R. P., Fisher, R. S., Schwerdt, P., Bryan, R. N., & Gordon, B. (1991). Dominant-side intracarotid amobarbital spares comprehension of word meaning. *Archives of Neurology,* **48,** 55–58.

Herman, B. P., & Wyler, A. R. (1988). Neuropsychological outcome of anterior temporal lobectomy. *Journal of Epilepsy,* **1,** 35–45.

Hillis, A. E., & Caramazza, A. (1991). Category-specific naming and comprehension impairment: A double dissociation. *Brain,* **114,** 2081–2094.

Hillis, A. E., Rapp, B., Romani, C., & Caramazza, A. (1990). Selective impairment of semantics in lexical processing. *Cognitive Neuropsychology,* **7,** 191–243.

Humphreys, G. W., Lamote, C., Lloyd-Jones, T. J. (1995). An interactive activation approach to object processing effects of structural similarity, name frequency and task in normality and pathology. *Memory,* **3,** 535–586.

Kroll, J. F., & Potter, M. C. (1984). Recognizing words, pictures, and concepts: A comparison of lexical, object, and reality decisions. *Journal of Verbal Learning and Verbal Behaviour,* **23,** 39–66.

Kučera, H., & Francis, W. N. (1967). *A computational analysis of present-day American English.* Providence, RI: Brown Univ. Press.

Kurbat, M. A., & Farah, M. J. (1998). Is the category-specific deficit for living things spurious? *Journal of Cognitive Neuroscience,* **10,** 355–361.

Lambon-Ralph, M. A., Howard, D., Nightingale, G., & Ellis, A. W. (1998). Are living and non-living category-specific deficits causally linked to impaired perceptual or associative knowledge? Evidence from a category-specific double dissociation. *Neurocase,* **4,** 311–338.

Landsell, H. (1968). Effects of extent of temporal lobe ablations on two lateralized deficits. *Physiology and Behaviour,* **3,** 271–273.

Laws, K. R., Evans, J. J., Hodges, J. R., & McCarthy, R. A. (1995). Naming without knowing and appearance without associations: Evidence for constructive processes in semantic memory? *Memory,* **3,** 409–433.

Levelt, W. J. M. (1989). *Speaking: From intention to articulation.* Cambridge, MA: MIT Press.

Levelt, W. J. M., Praamstra, P., Meyer, A. S., Helenius, P., & Salmelin, R. (1998). A MEG study of picture naming. *Journal of Cognitive Neuroscience,* **10**(5), 553–567.

Lloyd-Jones, T. J., & Humphreys, G. W. (1997a). Perceptual differentiation as a source of category effects in object processing: Evidence from naming and object decision. *Memory and Cognition,* **25,** 18–35.

Lloyd-Jones, T. J., & Humphreys, G. W. (1997b). Categorizing chairs and naming pears: Category differences in object processing as a function of task and priming. *Memory and Cognition,* **25,** 606–624.

Martin, R. C., Loring, D. W., Meador, K. J., & Lee, G. P. (1990). The effects of lateralized temporal lobe dysfunction on formal and semantic word fluency. *Neuropsychologia,* **28,** 283–289.

Martin, A., & Fedio, P. (1983). Word production and comprehension in Alzheimer's disease: The breakdown of semantic knowledge. *Brain and Language,* **19,** 124–141.

Martin, N., & Saffran, E. M. (1992). A computational account of deep dysphasia: Evidence from a single case study. *Brain and Language,* **43,** 240–274.

Martin, A., Wiggs, C. L., Ungerleider, L. G., & Haxby, J. V. (1996). Neural correlates of category-specific knowledge. *Nature,* **379,** 649–652.

McCarthy, R. A., & Warrington, E. K. (1988). Evidence for modality-specific meaning systems in the brain. *Nature,* **334,** 428–430.

McRae, K., de Sa, V. R., & Seidenberg, M. S. (1997). On the nature and scope of featural representations for word meaning. *Journal of Experimental Psychology: General,* **126,** 99–130.

Milner, B. (1964). Some effects of frontal lobectomy in man. In J. M. Warrant & K. Akert (Eds.), *The frontal granular cortex and behaviour* (pp. 313–334). New York: McGraw–Hill.

Morton, J. (1970). Word recognition. In J. Morton & J. C. Marshall (Eds.), *Psycholinguistic series* (Vol. 2). London, Elek.

Moss, H. E., & Tyler, L. K. (1997). A category-specific semantic deficit for nonliving things in a case of progressive aphasia. *Brain and Language,* **60,** 55–57.

Moss, H. E., Tyler, L. K., Durrant-Peatfield, M., & Bunn, E. M. (1998). Two eyes of a see-through: Impaired and intact semantic knowledge in a case of selective deficit for living things. *Neurocase,* **4,** 291–310.

Murtha, S., Chertkow, H., Beayregard, M., & Evans, A. (1999). The neural substrate of picture naming. *Journal of Cognitive Neuroscience,* **11**(4), 399–423.

Nickels, L. (1994). *Spoken word production and its breakdown in aphasia.* Psychology Press.

Patterson, K., & Hodges, J. R. (1995). Disorders of semantic memory. In A. D. Baddeley, B. A. Wilson, & F. Watts (Eds.), *Handbook of memory disorders.* Chichester, UK: Cambridge Univ. Press.

Perani, D., Cappa, S. F., Bettinardi, V., Bressi, S., Gorno-Tempinin, M., Mataresse, M., & Fazio, F. (1995). Different systems for the recognition of animals and man made tools. *NeuroReport,* **6,** 1637–1641.

Perrett, E. (1974). The left frontal lobe of man and the suppression of habitual responses in verbal categorical behaviour. *Neuropsychologia,* **5,** 601–614.

Phillips, N. A., & McGlone, J. (1995). Grouped data do not tell the whole story: Individual analysis of cognitive change after temporal lobectomy. *Journal of Clinical and Experimental Neuropsychology,* **17,** 713–724.

Pietrini, V., Nertempi, P., Vaglia, A., Revello, M. G., Pinna, V., & Ferro-Milone, F. (1988). Recovery from herpes simplex encephalitis: Selective impairment of specific semantic categories with neuroradiological correlation. *Journal of Neurology, Neurosurgery and Psychiatry,* **51,** 1284–1293.

Ramier, A. M., & Hecaen, H. (1970). Role respectif des atteindes frontales et de la lateralization lesionelle dans les deficits de la ‘‘fluence verbale.’’ *Revue Neurologie,* **123,** 17–22.

Raskin, S. A., Sliwinski, M., & Borod, J. C. (1992). Clustering strategies on tasks of verbal fluency in Parkinson’s disease. *Neuropsychologia,* **30,** 95–99.

Rensink, R. A., & Enns, J. T. (1992). *VScope software package.* University of British Columbia, Canada.

Rohrer, D., Wixted, J. T., Salmon, D. P., & Butters, N. (1995). Retrieval from semantic memory and its implications for Alzheimers disease. *Journal of Experimental Psychology: Learning, Memory and Cognition,* **21,** 1127–1139.

Ruff, R. M., Light, R. H., Parker, S. B., & Levin, H. S. (1997). The psychological construct of word fluency. *Brain and Language,* **57,** 394–405.

Sacchett, C., & Humphreys, G. W. (1992). Calling a squirrel a squirrel, but a canoe a wigwam: A category-specific deficit for artefactual objects and body parts. *Cognitive Neuropsychology,* **9,** 73–86.

Saffran, E. J., & Schwartz, M. F. (1994). Of cabbages and things: Semantic memory from a neuropsychological point of view—A tutorial review. *Attention and Performance,* **XV,** 507–536.

Samson, D., Pillon, A., & De Wilde, V. (1998). Impaired knowledge and nonvisual attributes in a patient with a semantic impairment for living entities: A case of true category-specific deficit. *Neurocase,* **4,** 273–290.

Sartori, G., & Job, R. (1988). The oyster with four legs: A neuropsychological study on the interaction of visual and semantic information. *Cognitive Neuropsychology,* **5,** 105–132.

Sartori, G., Job, R., Miozzo, M., Zago, S., & Marchiori, G. (1993). Category-specific form-knowledge deficit in a patient with herpes-simplex virus encephalitis. *Journal of Clinical and Experimental Neuropsychology,* **15,** 280–299.

Sartori, G., Miozzo, M., & Job, R. (1993). Category-specific naming impairments? Yes. *Quarterly Journal of Experimental Psychology Human Experimental Psychology,* **46,** 489–504.

Shallice, T. (1988). *From neuropsychology to mental structure.* Cambridge, UK: Cambridge Univ. Press.

Sheriden, J., & Humphreys, G. W. (1993). A verbal-semantic category-specific recognition impairment. *Cognitive Neuropsychology,* **10,** 143–184.

Silveri, M. C., Daniele, A., Giustolisis, L., & Gainotti, G. (1991). Dissociation between knowledge of living and nonliving things in dementia of the Alzheimer type. *Neurology,* **41,** 545–546.

Silveri, M. C., & Gainotti, G. (1988). Interaction between vision and language in category-specific semantic impairment. *Cognitive Neuropsychology,* **5,** 677–709.

Silveri, M. C., Gainotti, G., Perani, D., Cappelletti, J. Y., Carbone, G., & Fazio, F. (1997). Naming deficit for non-living items: Neuropsychological and PET study. *Neuropsychologia,* **35,** 359–367.

Sirigu, A., Duhamel, J. R., & Poncet, M. (1991). The role of sensorimotor experience in object recognition: A case of multimodal agnosia. *Brain,* **114,** 2555–2573.

Snodgrass, J. G., & Vanderwart, M. (1980). Standardized set of 260 pictures: Norms of name agreement, usage agreement, familiarity, and visual complexity. *Journal of Experimental Psychology: Human Learning and Memory,* **6,** 174–215.

Stafniak, P., Saykin, A. J., Sperling, M. R., Kester, D. R., Robinson, L., O'Connor, M. J., & Gur, R. (1990). Acute naming deficits following dominant temporal lobectomy: Prediction by age at 1st risk seizures. *Neurology,* **40,** 1509–1512.

Stewart, F., Parkin, A. J., & Hunkin, N. M. (1992). Naming impairments following recovery from herpes simplex encephalitis: Category-specific? *Quarterly Journal of Experimental Psychology, Human Experimental Psychology,* **44,** 261–284.

Tippett, L. J., Glosser, G., & Farah, M. J. (1996). A category-specific naming impairment after temporal lobectomy. *Neuropsychologia,* **34,** 139–146.

Tranel, D., Damasio, H., & Damasio, A. R. (1997a). A neural basis for the retrieval of conceptual knowledge. *Neuropsychologia,* **35,** 1319–1327.

Tranel, D., Damasio, H., & Damasio, A. R. (1997b). On the neurology of naming. In H. Goodglass & A. Wingfield (Eds.), *Anomia: Neuroanatomical and cognitive correlates: Foundations of neuropsychology.* New York: Academic Press.

Troster, A. I., Salmon, D. P., McCullough, D., & Butters, N. (1989). A comparison of the category fluency deficits associated with Alzheimer's and Huntington's disease. *Brain and Language,* **37,** 500–513.

Van Selst, M., & Jolicoeur, P. (1994). A solution to the effect of sample size on outlier elimination. *The Quarterly Journal of Experimental Psychology,* **47,** 631–650.

Vilkki, J. (1989). Hemi-inattention in visual search for parallel lines after focal cerebral lesions. *Journal of Clinical and Experimental Neuropsychology,* **11,** 319–331.

Wada, J. (1949). A new method for the determination of the side of cerebral speech dominance: A preliminary report on the intracarotid injection of sodium amytal in man. *Igaku Sei Butssugaku,* **14,** 221–222.

Wada, J., & Rasmussen, T. (1960). Intracarotid injection of sodium amytal for the lateralization of cerebral speech dominance: Experimental and clinical observations. *Journal of Neurosurgery,* **17,** 266–282.

Warrington, E. K., & McCarthy, R. (1983). Category-specific access dysphasia. *Brain,* **106,** 859–878.

Warrington, E. K., & McCarthy, R. (1987). Categories of knowledge: Further fractionation and an attempted integration. *Brain,* **110,** 1273–1296.

Warrington, E. K., & Shallice, T. (1984). Category-specific semantic impairment. *Brain,* **107,** 829–853.

Wilkins, A., & Moscovitch, M. (1978). Selective impairment of semantic memory after temporal lobectomy. *Neuropsychologia,* 73–79.