Implicit Word Cues Facilitate Impaired Naming Performance: Evidence from a Case of Anomia

César Avila

Department of Psicologia Bàsica, Universitat Jaume I, Castellón, Spain

Matthew A. Lambon Ralph

Department of Experimental Psychology, University of Bristol, United Kingdom

Maria-Antònia Parcet

Department of Psicologia Bàsica, Universitat Jaume I, Castellón, Spain

Daniel Geffner

Servicio Neurología, Hospital General de Castellón, Castellón, Spain

and

José-Manuel Gonzalez-Darder

Servicio Neurocirugía, Hospital General de Castellón, Castellón, Spain

Word-finding difficulties observed in some patients with anomia have been attributed to an insufficient activation of phonology by semantics. There are, however, few direct tests of this hypothesis. This paper reports the case of FR, who presented with anomic aphasia following temporal lobe epilepsy and a cavernoma in the left superior temporal lobe. His anomic deficit was characterized by: (1) no apparent associated semantic impairment; (2) item consistency for accuracy and errors across different administrations; (3) accuracy strongly correlated with word frequency; and (4) a partial, albeit weak, knowledge of the gender of unnamed items. We conducted a naming experiment in which target pictures were implicitly primed by briefly presented masked words. Results showed that the prior presentation of the written target name improved accuracy. When compared with unprimed trials, the presence of the primes also increased phonological errors and decreased semantic errors. We argue that automatic phonological activation derived directly from the implicit written primes interacted with the remaining phonological input from the picture's semantic representation leading to increased accuracy and a change in the balance of error types. © 2001 Academic Press

INTRODUCTION

Patients with anomia can be split into three broad categories. *Semantic* anomia follows directly from disruption to conceptual knowledge (semantic memory) in the context of degenerative disorders (e.g., semantic dementia: Hodges, Graham, & Patterson, 1995) or following CVA (anomia with lexical comprehension disorders: Gai-

Address correspondence and reprint requests to César Avila at Department of Psicologia Bàsica, Campus de la Carretera de Borriol, Apartado de Correos 224, Castellón 12080, Spain.

notti, Silveri, Villa, & Micelli, 1986), especially where the infarct is sufficiently large to include Brodmann areas 22, 21, and 37 in the middle and posterior temporal lobe (Chertkow, Bub, Deaudon, & Whitehead, 1997). *Phonological* anomia is an appropriate description for the anomia observed in most cases of CVA where word-finding difficulties are most commonly associated with a generalized deficit of phonology (Gagnon, Schwartz, Martin, Dell, & Saffran, 1997; Goodglass et al., 1997). The term *classical* anomia can be reserved for those patients whose anomia does not seem to be associated with semantic or phonological deficits (Geschwind, 1967; Lambon Ralph, Sage, & Roberts, 2000). These patients appear to retrieve appropriate conceptual knowledge but are unable to activate phonology sufficiently to produce the target word. There are two possible reasons for such a pattern: semantic knowledge for the target item is complete but subsequent activation of the phonological form is prevented in some way (Graham, Patterson, & Hodges, 1995; Kay & Ellis, 1987); the alternative explanation rests on the assumption that the degree and quality of semantic activation required for comprehension vs. production is quite different (Gainotti, Silveri, Daniele, & Giustolisi, 1995). Lambon Ralph, McClelland, Patterson, Galton, and Hodges (in press) were able to demonstrate this fact in both longitudinal analyses of patients with progressive and selective semantic deterioration (semantic dementia) and a simple computational network. With mild damage to the system that supports conceptual knowledge, overt performance is characterized by predominant word-finding difficulties associated with little or no measurable decline in comprehension—semantic activation is sufficient to support differentiation among semantic competitors at the level of conceptual knowledge but even weak damage at this stage of processing means there is insufficient input to phonology to drive speech production (which is exacerbated by the arbitrary relationship between semantic and phonological representations: Lambon Ralph et al., 2000). The question of whether one or both of these explanations for classical anomia is correct will not concern us in this paper. The central issue to be addressed here revolves around the nature of the remaining phonological activation in this type of anomic patient.

The fact that a patient cannot produce a specific name does not imply that there is no activation of the representations, which underpin the target word form. Perhaps the most obvious evidence for this comes from tip-of-the-tongue (ToT) phenomena observed in some patients with anomia (Kay & Ellis, 1987). Some patients can reliably give the gender of nouns or the correct auxiliary of an intransitive verb (e.g., the Italian anomic, Dante: Badecker, Miozzo, & Zanuttini, 1995; Miozzo & Caramazza, 1997). Other patients can indicate the number of syllables in the target form and whether it is a compound word or not (Lambon Ralph, Sage, & Roberts, 2000), while others can give the first letter of the item's name (Nickels, 1992).

There are a number of other methods by which partial activation of phonology by semantics can be inferred. These all involve the use of another input modality (e.g., written words or spoken words/phonemic units) to provide additional phonological activation that summates with that derived directly from semantics (Bajo & Cañas, 1989; Hillis & Camarazza, 1991; Lambon Ralph, Cipolotti, & Patterson, 1999). In the spoken domain, the most obvious example is that of phonemic cueing in which some of the phonemes in the target name (given by the experimenter) are sufficient to improve naming performance in the anomic patient. Although some anomic patients do not respond to a single phonemic cue (Howard, 1995; Kay & Ellis, 1987; Lambon Ralph, 1998), a significant improvement in naming performance can be observed given longer phonemic cueing even for items that the patient consistently fails to name across repeated testing sessions (Lambon Ralph, 1998; Lambon Ralph, Cipolotti, & Patterson, 1999). The critical point is that, at least in these cases, the length of the successful cue was still too short to identify the target name uniquely

(i.e., shorter than the uniqueness point). It follows that the additional phonological activation required to produce the full form of the name must have come from the remaining partial activation in the damaged speech production system of the patient. In effect, the degree of remaining activation must be inversely related to the number of phonemes required for successful cueing to occur. A closely related technique is the use of the gating paradigm (a subject has to try to identify a word from a spoken stimulus that is repeated each time with a 50-ms increase in length) with and without a target picture present (Graham et al., 1995).

In the written domain, there is evidence for summation of phonological activation in terms of repetition priming from a written word. This technique consists of presenting a written word to be read aloud and, after a delay, presenting a picture to be named. Lambon Ralph (1998; Lambon Ralph et al., 2000) compared the plain administration of the Boston Naming Test with two different repetition priming conditions in two patients with classical anomia. In the short-delay condition, patients read the prime written word, named an unrelated picture, read another word, and were presented with the target picture (approximate delay of 30 s). In the long-delay condition, the patients were asked to read a list of the target names and performed a distractor task for 15 min, and then the naming test was administered. Results showed a significant beneficial effect of short-term delay, repetition priming for both patients. In the long-term delay condition, however, only one (the milder) of the two patients demonstrated improved naming performance.

If there is some form of interaction/summation between sources of phonological activation (residual activation from semantics plus activation from phonemic cues or written words), then it should be possible to exacerbate impaired naming performance temporarily by providing incorrect phonological activation. At least three techniques have been described that can lower naming performance in anomic patients: semantic priming, semantic blocking, and phonemic miscueing (see Lambon Ralph et al., 2000). Semantic priming consists of presenting semantic related written primes to be read aloud before the picture target is presented for naming. In anomic patients, this procedure reduced naming performance significantly (see also Podraza & Darley, 1977). Semantic blocking consists of presenting pictures blocked into semantic categories and comparing performance with a baseline of random presentation. Results showed poorer naming accuracy in the blocked condition and performance was found to deteriorate gradually during each block. Finally, phonemic miscueing, which consists of giving a phonemic cue corresponding to a semantically associated distractor, also yielded an impairment of naming performance (see also Howard & Orchard-Lisle, 1984).

Although word reading and phonemic cueing can be successful ways to improve naming, the mechanisms underlying both are complex and may not simply reflect automatic activation of target phonology. In the present study, we wanted to test a more "online" technique, like masked, cross-modal repetition priming. In this procedure, a word prime is briefly presented before the picture. In primed trials, the word is the name of the subsequent picture, whereas in unprimed trials a string of X's precede the picture. In normal participants, the priming effect consists of faster naming latencies for primed than unprimed trials even though the identity of the primes cannot be reported overtly (Ferrand, Grainger, & Segui, 1994). This study suggests that the implicit repetition priming effect is attributable more to phonological than semantic activation: Ferrand et al. found that homophone primes yielded similar magnitudes of priming to identity primes (the target name). They also found that homophone primes of high frequency yielded stronger priming on low-frequency picture targets than identical primes.

In this study we report data from an anomic patient, FR, and in particular the

use of masked, cross-modal repetition priming in an attempt to facilitate naming performance, implicitly and automatically. The report is split into three separate sections. The first gives background neuropsychological data. The second shows the performance of FR across three different administrations of the Boston Naming Test—in order to highlight consistency and psycholinguistic correlates of FR's naming performance. The third section presents the results of a masked repetition priming study.

CASE REPORT

Clinical History

FR was a 31-year-old right-handed man, with 10 years of education. His main language was Spanish, but he was also fluent in Catalan. He had worked in the sales store, and production departments of different ceramics companies since 1982. At the time of this study, FR owned his own company for marketing and selling ceramic products. At the age of 18, he began to have epileptic seizures but these did not apparently interfere with his normal life. Initially, crises were generalized tonicoclonics of occasional frequency and were predominantly nocturnal. In 1992, a CT highlighted a left temporal cavernoma. A subsequent angiography did not show pathological vessels suggesting a cavernous angioma. Initial treatment included Valproic acid, 1500 mg/day. Over the years, seizures became more frequent and severe, and Tegretol was added but was found to be ineffective. Then, Rivotril and Lamictal, 25 mg twice a day, were included in his treatment. In the last few years, complex partial epileptic crisis (pseudo-absences with amnesia of the episode) increased in frequency to two to three crises per day.

FR entered the hospital to evaluate potential neurosurgery (November 1998). On general and neurological examination, FR did not show any pathological signs. Analytic tests were normal and EEG revealed focal abnormality in the left temporal lobe. MRI showed a left superior temporal gyrus intraaxial lesion of 3×2 cm, with preservation of the hippocampal formation (see Fig. 1). This lesion was compatible with a cavernoma. The present study was carried out between January 1999 and February 2000. FR received surgery in March 1999. After surgery, his rate of seizures reduced but there was no alleviation of his anomia.

Neuropsychological Examination

The results of the initial neuropsychological evaluation are summarized in Table 1. Intelligence and general ability were assessed by means of the Wechsler Adult Intelligence Scale (Wechsler, 1981). In general, intellectual abilities were well preserved, but FR showed a slight impairment on the Arithmetic test. Visual agnosia was excluded using the Overlapping Figures Test of Poppelreuter [Luria's Neuropsychological Investigation (Christensen, 1979)]. Perception was checked by means of the Visual Form Discrimination Test and the Judgment of Line Orientation Test (Benton, Hannay, & Varney, 1975). Vigilance was evaluated using an A-X paradigm of the Continuous Performance Test Performance, which showed that all these functions were well preserved. Memory was assessed by means of several tests: verbal recall by the Auditory-Verbal Learning Test (AVLT; Rey, 1964); to study the contribution of meaning to retention and recall, we used a story recall test [Logical Memory of the Wechsler Memory Scale (WMS; Wechsler, 1945)]; visual recall was assessed by a delayed (30 min) reproduction of a drawn figure [Rey Figure Copy and Recall (Rey, 1955)] and Visual Reproduction of the WMS; verbal immediate recall was

FIG. 1. Magnetic resonance image of the patient FR.

evaluated using digit span (WAIS); visual retention by the Benton Visual Retention Test (BVRT; Benton, 1953); and finally, remote memory was checked by verbal recall of public events and famous persons. Performance in all the memory tests was within normal limits, with the exception of the delayed recall of the Rey Figure. Frontal and executive functions were evaluated through the Wisconsin Card Sorting Test (Heaton, 1981), the Trail Making Test (Reitan, 1958), and verbal fluency (for the letter f and category of animals over a period of 90 s). Scores on these executive and motor tests were within the normal range with the exception of letter fluency.

General language was assessed by the Boston Diagnostic Aphasia Examination (BDAE; Goodglass & Kaplan, 1972), the Token Test (De Renzi & Vignolo, 1962), the Boston Naming Test (BNT; Goodglass, Kaplan, & Weintraub, 1983), and the Peabody Picture Vocabulary Test (Dunn, Padilla, Lugo, & Dunn, 1986). Phonological processing was studied using nonword stimuli in three different tasks: immediate repetition, 30-s delayed repetition, and reading.

TABLE 1
Neuropsychological Evaluation

WAIS scores	
Information	8
Comprehension	14
Arithmetic	6
Similarities	13
Digit Span	10
Vocabulary	12
Verbal IQ	100
Digit Symbol	12
Picture Completion	15
Block Design	10
Picture arrangement	12
Performance IQ	116
Total IQ	108
Perception and attention	
Poppel-Reuter Test	10/10
Visual Form Discrimination Test	16/16
Judgment of Line Orientation	27/30
Continuous Performance Test	
Omissions	5/60
Commission errors	0
Memory	
Verbal Remote	12/13
Auditory–Verbal Learning Test	
Learning	46
Recall	12
Rey-Osterrieth Figure Copy	99/100
Rey-Osterrieth Figure 30-min delayed recall	25/100
Visual Retention Test Benton	14/15
Ideomotor praxis	46/46
Executive functions	
Trail Making Test	
Time	120
Errors	2
WCST	
Categories	5
Perseverative Errors	38
Phonemic Verbal Fluency	4
Semantic Verbal Fluency	15
Language	
Peabody Picture Vocabulary Test (125)	112/125
Boston Naming Test	27/60
Token Test	34/36
Boston Diagnostic Aphasia Examination	
Fluency	
Articulation rating	7/7
Phrase length	7/7
Verbal agility	12/14
Automatic speech	
Automatized sequences	7/8
Reciting, singing, and rhythm	6/6
Repetition	
Words	10/10
Sentences	16/16
Writing	
Mechanics	5/5
Serial writing	47/47
Primer-level dictation	15/15
Spelling to dictation	10/10

TABLE 1—*Continued*

Written Confrontation Naming	10/10
Sentences to dictation	12/12
Narrative writing	5/5
Auditory Comprehension	
Word discrimination	70/72
Body-part identification	14.5/20
Commands	15/15
Complex ideational material	11/12
Naming	
Responsive naming	30/30
Confrontation naming	92/93
Fluency in controlled association	11/23
Naming of body parts	24/30
Reading	
Sentence reading	10/10
Word reading	30/30
Reading comprehension	
Word-picture matching	10/10
Symbol discrimination	10/10
Sentences and paragraphs	10/10
Word recognition	8/8
Oral spelling	5/8
Nonword reading	
1 syllable	10/10
2 syllables	10/10
3 syllables	10/10
4 syllables	10/10
Nonword repetition	
1 syllable	10/10
2 syllables	10/10
3 syllables	10/10
4 syllables	10/10
Nonword 30-s delayed repetition	
1 syllable	10/10
2 syllables	10/10
3 syllables	10/10
4 syllables	10/10

Results showed that diverse language functions, such as reading, writing, and repeating words and sentences, were within normal limits. FR had problems with naming items in the BNT and on some phonological tasks, such as the oral spelling task of the BDAE and phonetic verbal fluency. Results of nonword repetition and reading tests showed no phonological deficit. In language comprehension, FR's performance was normal. As derived from Table 1, overall performance on neuropsychological tests was consistent with the existence of a classical anomia as the main symptom of FR.

Global Naming Performance

The BNT was presented three times, 2 weeks apart, with the items occurring in the same order. The third administration was given 10 days after surgery. On this third occasion, phonemic cues included in the BNT were given for unnamed items. Semantic cues included in the BNT were not given since FR showed near-perfect knowledge of the items.

The first examination with the BNT was used to screen for anomia and FR obtained a score of 27/60 items. It is important to stress that the patient was not aware of this deficit until exploration; FR presented with normal and fluent speech apparently unaffected by his anomia. Scores on the second and third administrations of the BNT were 30/60 and 24/60. Table 2 summarizes the main results obtained in this study. The contingency analysis showed that FR demonstrated considerable item consistency across administrations. The consistency coefficients were significant and very similar to those of previous studies (Howard, 1995; Lambon Ralph, 1998). The significant correlation with log transformed written word frequency (Alameda & Cuetos, 1995) was also similar to that of previous reports (unfortunately, the Spanish version of the BNT did not include other relevant information, such as familiarity, imageability, age of acquisition, and so on).

Phonemic cues were given for the 36 errors in the last administration but only cued the correct name on 11% of the trials. Errors were mainly omissions (41%), but FR also made circumlocutions (16%) and semantic (14%), phonological (16%), and semantic/phonological errors (14%). It is important to stress that semantic errors and circumlocutions were immediately rejected—suggesting excellent underlying conceptual knowledge for the target pictures. However, phonological errors were not consistently recognized as errors. Interestingly, in addition to consistency of accuracy across trials, FR also demonstrated consistency for phonologically related paraphasias. For example, FR said “arca” (chest) instead of *arpa* (*harp*) and “arcilla” (clay) instead of *ardilla* (*squirrel*) on the three administrations.

In summary, our patient seemed to be similar to previous cases of classical anomia. His anomia was characterized by: (1) good performance on tests of semantic knowledge; (2) weak effect of a correct phonemic cue; and (3) high consistency in errors. The only apparent difference was that FR produced a number of phonologically related paraphasias, whereas this error type was not observed in the previously reported cases of classical anomia. It is possible that these errors reflect (a) the greater phonological similarity between semantically related words in Spanish than in English or (b) a subtle phonological impairment that disturbed picture naming but did not affect performance on tasks such as nonword reading and delayed repetition.

TABLE 2
FR’s Performance and Word Frequency Correlates for the Three
Administrations of the Boston Naming Test

	<i>r</i>
Correlation with word frequency	
Log Alameda and Cuetos frequency (first)	0.47*
Log Alameda and Cuetos frequency (second)	0.35*
Log Alameda and Cuetos frequency (third)	0.31*
Percentage of items named correctly	
0/3 times	42%
1/3 times	12%
2/3 times	17%
3/3 times	30%
Item consistency	Contingency coefficient
1 vs. 2	0.61
1 vs. 3	0.53
2 vs. 3	0.43

* *p* < 0.5.

Implicit Priming Study

The priming task was administered on a PC using a Beta version of the INQUISIT software to present the stimuli (Millisecond Software). Naming responses were recorded by the experimenter. The target picture stimuli comprised all 260 pictures of the Snodgrass and Vanderwart set (Snodgrass & Vanderwart, 1980). These pictures were divided into two different sets matched for various psycholinguistic variables (word frequency, from Alameda & Cuetos, 1995, and familiarity, visual complexity, name agreement, image agreement, picture–name agreement, syllable and letter length, and distribution of semantic categories, obtained from Sanfeliu & Fernández, 1996). The task was administered twice, in two different sessions separated by 1 year, so that each picture was presented with and without its prime word. One set of pictures was preceded by the written name of the picture (i.e., primed), whereas the other set of pictures was preceded by “XXXXXX” (i.e., unprimed). In the first administration, pictures of set 1 were primed and pictures of set 2 were unprimed. In the second administration, pictures of set 1 were unprimed and those of set 2 were primed.

The following sequence occurred on each trial: (a) the experimenter confirmed that the subject was ready and pressed the space bar; (b) an initial 600-ms presentation of a blank rectangle in the center of the screen marking where stimuli were going to appear; (c) a mask of \$\$\$\$\$\$ for 53.1 ms; (d) a mask of @@@@ for 53.1 ms; (e) a mask of &&&&&&& for 53.1 ms; (f) either the written target name (in uppercase) or a string of XXXXXXXX for 33.4 ms; (g) a mask of &&&&&&& for 53.1 ms; (h) a mask of @@@@ for 53.1 ms; (i) a mask of \$\$\$\$\$\$ for 53.1 ms; and (j) the target picture, presented until subject response. Words used in primed trials were obtained from a Spanish translation of the Snodgrass and Vanderwart names provided by Sanfeliu and Fernandez (1986).

During the first administration, FR was asked to give detailed definitions of the target picture when he could not give its name in order to demonstrate intact semantic knowledge for that item. During the second administration, he was instructed to give naming responses without explanation. A 5-s time limit per item was imposed. In the second administration and for each unnamed picture, FR was asked to indicate the gender of the target’s name and then progressive phonemic cues were given. Following Lambon Ralph (1998), the cues were repeated with an additional phoneme every 5 s until FR correctly named the target or the cue contained the entire picture (at which point the task would change to single word repetition rather than assisted picture naming).

Performance on unprimed trials. Four pictures were removed from analyses: *chisel* because the English name was incorrectly translated as “screwdriver”; *spinning wheel* and *raccoon* because FR did not recognize the items; and *fence* because of technical problems during administration. FR correctly named 169 of the remaining 256 items. Table 3 shows the simple correlations between accuracy and the different psycholinguistic properties of the items. Multiple regression analysis was conducted to clarify which factors independently predicted picture naming accuracy. This revealed that, once log-rated frequency was entered into the regression (accounting for 26% of the variance), no other variable had any additional predictive value.

Contingency across administrations. Across primed and unprimed trials, FR correctly named 178 and 182 items on the two administrations of the task. The contingency coefficient between the two administrations of the test was 0.47 after a 1-year interval and after surgery. Thus, no significant differences were found between both administrations of the task.

TABLE 3

Simple Correlations between Various Psycholinguistic Variables and Performance on Unprimed and Primed Picture Naming, Accuracy of Gender Assignment, and the Length of the Successful Phonemic Cue

	Unprimed (<i>n</i> = 256)	Primed (<i>n</i> = 256)	Gender (<i>n</i> = 64)	Cue length (<i>n</i> = 60)
Log Alameda and Cuetos frequency	0.53*	0.39*	0.17	−0.37*
Rated visual complexity	−0.07	−0.01	−0.21	−0.03
Rated name agreement	−0.18*	−0.07	−0.11	0.15
Rated image agreement	−0.04	−0.20*	0.23	−0.01
Picture–name agreement	−0.07	−0.18*	0.18	0.08
Rated familiarity	0.20*	0.15	0.10	0.05
Rated imageability	−0.18*	−0.08	−0.11	0.15
Number of letters/phonemes	−0.18*	−0.11	−0.02	0.03
Number of syllables	−0.20*	−0.15	−0.03	0.02

* *p* < 0.01.

Comparing primed and unprimed trials. FR correctly named 191 items on primed trials and 169 items on unprimed trials. There were 155 items consistently named on primed and unprimed trials, 51 items consistently unnamed on both trials, and 50 items named in only one of the two trials. For these latter trials, successful naming occurred in 36 primed and 14 unprimed trials, $X^2 = 9.68, p < .003$.¹ Simple ANOVAs were conducted to compare psycholinguistic characteristics of the pictures named only on the primed trials, pictures named only on unprimed trials, and pictures never named. Results only yielded a significant difference for Image Agreement, $F(2, 90) = 5.30, p < .007$, indicating that pictures named on primed trials had a lower agreement ($M = 3.56$) than pictures named in unprimed trials ($M = 4.05$) and never named ($M = 3.9$).

Analyses of errors on primed and unprimed trials. The distribution of naming errors was analyzed as a function of the type of trial (see Appendix 1 for semantic and phonological errors on primed and unprimed trials). The rate of omission errors was similar for primed and unprimed trials (62% vs. 63%). However, as shown in Fig. 2, when compared with unprimed trials, priming trials produced an increment on phonological errors and a decrement on semantic errors [$\chi^2 = 4.71, p < .05$].

ToT. FR was asked to indicate the gender for unnamed items in the second administration of the task. Of the 74 errors, there were eight trials with a delayed correct response (i.e., after the time limit). Thus, there were 66 estimations of gender, of which 42 were correct. This performance was significantly above chance [$X^2 = 4.91, p < .03$]. There was no difference between primed and unprimed trials on gender assignment [$\chi^2 = 0.91, p > .10$]. Thus, we have obtained, as often observed in at least some patients with anomia, a “tip-of-the-tongue” effect—though we note here that FR was far from perfect. Spearman’s correlations between gender assignment accuracy and psycholinguistic characteristics appear on Table 3. No correlation reached significance.

¹ Analysis by sessions revealed that priming effects were significant or approached significance in both sessions when controlled for word frequency. For words with frequencies higher than 40 per 2 million ($N = 115$), priming effects were not found—overall mean accuracies were 90 and 89% for sessions 1 and 2, respectively. When considering low-frequency words, priming effects were observed. In session 1, primed and unprimed pictures yielded mean accuracies of 58.8 and 43.8%, respectively ($\chi^2 = 2.99, p = .08$). In session 2, accuracies for primed and unprimed trials was 65.6 and 48.5%, respectively ($\chi^2 = 3.93, p = .05$).

FIG. 2. Semantic and phonological errors in primed and unprimed trials.

Phonemic cueing. This was studied on 62 trials (four more correct responses were given after responding to gender). Of the 62 errors, FR failed to give the name for 6 pictures before the entire label had been given. Ten of 56 items were cued with the initial phoneme, 16 with two phonemes, 9 with three phonemes, 14 with four phonemes, 2 with five phonemes, and 5 with six phonemes. Appendix 2 shows errors in naming after multiple cueing. Spearman's correlations were calculated between the number of phonemes needed to retrieve the correct name and different psycholinguistic variables (Table 3). These analyses revealed that the length of the target name was not correlated with the number of phonemes in the successful cue [$r(62) = .03$, $p > .10$, for letter length and $r(62) = .01$, $p > .10$, for syllable length]. However, log-transformed written word frequency was significantly correlated [$r(56) = -0.39$, $p < .01$] such that low-frequency target names required a longer cue for successful naming. No other psycholinguistic factor was significantly correlated with the number of phonemes in the successful cue. A multiple regression analysis was conducted to clarify which factors independently predict the length of the successful cue for each item. This revealed that once log-rated frequency was entered into the regression ($R^2 = 19\%$), no other variable had any additional predictive value.

GENERAL DISCUSSION

We have presented data on FR's naming disorder. Although he had clear word-finding difficulties in confrontational naming tasks, FR could give detailed and accurate definitions for all the pictures he could not name. Additional evidence for FR's good comprehension was found in general neuropsychological assessment and from the fact that FR was able to reject his own semantic paraphasia. This pattern of anomia without measurable semantic impairment is the same as in those patients previously reported with classical anomia (Howard, 1995; Lambon Ralph et al., 2000). We suspect that FR's anomia stemmed primarily from a lack of semantic activation of phonology (either in the form of a weakened connection between semantics and phonology or from a mild semantic deficit that lead to a clear anomia but was too mild to result in a measurable comprehension impairment: see, Lambon Ralph et al., in press). Although FR did not show phonological deficits in nonword repetition and reading tasks, we cannot, however, completely rule out the possibility that he also had a mild phonological deficit contributing to his anomia since he made a considerable number of phonologically related paraphasias. FR had a number of other characteristics in common with previously reported cases of classical anomia: FR presented with high consistency on picture naming performance across different administra-

tions, a predominance of omission errors, and his naming accuracy was strongly correlated with word frequency (see Howard, 1995; Lambon Ralph, 1998; Miceli et al., 1991).

As noted in the Introduction, the fact that a patient cannot overtly produce the name of a picture does not imply that there is no activation of nonsemantic information about the target word form. This assumption is supported by FR's results. First, FR was able to indicate, albeit not perfectly, the gender of unnamed items. Second, FR was able to produce the name of picture when he was assisted using progressive phonemic cueing. Critically, the length of the successful cue was nearly always shorter than the full phonological form of the target name. This suggests that FR was weakly activating phonology from semantic input, which was able to combine or summate with the activation provided from the cue resulting in overt naming. This result also indicates that FR's high level of consistency across trials resulted from consistently weak activation of otherwise intact word representations rather than a loss of lexical forms (for a more extensive discussion of this issue, see Lambon Ralph, 1998). We also found evidence to suggest that the weak activation of phonology underpinning FR's anomia was systematically graded across word forms. Not only was naming accuracy graded by word frequency but the length of the successful cue was also directly related to this factor: phonological activation was weakest for words of low frequency and so greater amounts of additional phonological activation (as gauged by the length of the successful phonemic cue) were required to elicit the word form.

Although phonemic cueing proved to be a successful way to improve FR's naming, the underlying mechanisms are complex and may not simply reflect automatic activation of target phonology. In the present study, therefore, we investigated a more "online" technique. Results from the priming study demonstrated that covert presentation of the written target name yielded a significant and beneficial effect on naming performance. As far as we know, this is the first study to show an improvement in naming performance due to automatic and implicit activation.

What are the possible mechanisms underlying this technique? There are two possibilities, which we will discuss briefly in turn. One possibility is that the written prime word activates and reinforces the semantic representation of the pictured concept. Enriched semantic activation (e.g., higher, less noisy, more accurate activation) should automatically improve input to phonology and thus facilitate naming accuracy. While we acknowledge that this is a viable explanation for the improvement in FR's naming, a more obvious explanation lies in the additional activation derived directly from print to sound.²

Given the quasi-regular relationship between orthography and phonology, it is likely that phonology should be activated relatively quickly and robustly from ortho-

² Even if the prime word does activate its corresponding semantic representation and thus enrich the conceptual input to speech production, it could be argued that this should have had no beneficial effect for FR because his conceptual knowledge was apparently intact. We note two additional points here, however. First, it is always possible that our assessments of comprehension were too insensitive to highlight subtle impairments to the system supporting semantic representations. If so, additional semantic activation from the written word could summate with that derived from the picture leading to improved semantic input to phonology. The second possibility is not so immediately obvious. It is possible that the normal, intact naming system has an in-built tolerance for mild degrees of noisy semantic input—the precise semantic representation for a concept is likely to vary across occasions and contexts but we still require the same target name in all cases (e.g., the semantic representation for the concept *olive* will vary across contexts—for example, in the context of growing olives, eating olives, or pressing olives—but the correct name for the concept is always "olive"). The pathological naming system may lose this tolerance following a postsemantic impairment and, consequently, ultraprecise semantic input (derived from word plus picture inputs) may improve accuracy.

graphic input (Lambon Ralph et al., 1999). As noted in the Introduction, Ferrand et al.'s (1998) study of intact subjects using this paradigm suggested that the primes were acting primarily at a phonological level. Also, FR's pattern of errors in primed and unprimed trials was quite different (see Fig. 2). When compared with unprimed trials, primed trials reduced the number of semantic errors and increased the number of phonological and phonological-semantic errors. Weakened semantic input may lead to an unresolved/inaccurate competition between semantically related phonological forms and in turn to overt production of semantic paraphasias. With additional target phonological activation, however, most semantic competitors should be filtered out—which should be especially efficient given that semantically related words typically have little or no phonological overlap. If thought of in terms of a process of cross-referencing, the intersection between partial phonological activation from the prime or a phonemic cue and the range of semantically related candidates from weakened semantic input typically leaves only one or two possible forms (Lambon Ralph et al., 2000). Partial phonological activation from the prime, however, may exacerbate any underlying phonological deficit, leading to an increase in phonologically related paraphasia.

In summary, we conclude that the implicit written primes acted in a similar manner to phonemic cueing. Both methods provide partial but correct activation of the target word form. This additional phonological information interacts or summates with the impoverished activation that remains in the impaired naming system leading to a significant amelioration of FR's anomia.

APPENDIX 1: SEMANTIC AND PHONOLOGICAL ERRORS IN THE PRIMING TASK

	Unprimed	Primed
BARRIL (barrel)	BAUL (trunk) (PS)	BAUL (trunk) (PS)
TARTA (cake)	PASTEL (cake) (S) ^a	TARTA
LAZO (bow)	NUDO (knot) (S)	(O)
MARIPOSA (butterfly)	(O)	MARIONETA (puppet) (P)
CAMELLO (camel)	CAMEL (N) (P)	CAMELLO
VELA (candle)	(O)	CIRIO (candle) (S)
CADENA (chain)	CUERDA METALICA (metal rope) (S)	(O)
PINZA (clothespin)	(O)	PINCHA (prick) (P)
TAMBOR (drum)	TAMBOR	BOMBO (bass drum) (PS)
PEINE (comb)	CEPILLO (brush) (S)	(O)
SOFA (sofa)	SOFA	SILLON (armchair) (S)
SOBRE (envelope)	CARTA (letter) (S)	SOBRE
PATO (duck)	PATO	PAVO (turkey) (PS)
SARTEN (frying pan)	PAELLA (paella) (S)	(O)
PERCHA (hanger)	COLGANTE (hanging) (S)	COLGANTE (hanging) (S)
ARPA (harp)	ASPA (cross) (P)	ARCO (arch) (PS)
COMETA (kite)	FLOTANTE (floating) (S)	(O)
BOMBILLA (light bulb)	BOMBILLA	LLUMENETA (small light) (S) ^b
CANDADO (lock)	CERRADURA (closing) (S)	CERRADOR (close) (S) ^c
AGUJA (needle)	PUNXA (prick) (S) ^b	(O)
PINGÜINO (penguin)	PINOCHO (Pinocchio) (P)	PINOCHO (Pinocchio) (P)
PIMIENTO (pepper)	BERENJENA (eggplant) (S)	PIMIENTO
CAZO (pot)	(O)	CUENCO (bowl) (PS)
TOCADISCOS (record player)	PINCHA DISCOS (disc jockey) (S)	PORTADISCOS (S) ^c
TRINEO (sled)	TRIENIO (period of 3 years) (P)	(O)

APPENDIX 1—Continued

	Unprimed	Primed
RODILLO (rolling pin)	MOLEDOR (grinding) (S)	BATE DE HARINA (flour bat) (S)
REGLA (ruler)	METRO (meter) (S) ^a	METRO (meter) (S) ^a
MOFETA (skunk)	(O)	MAZCOTA (mascot) (S) ^c
ARDILLA (squirrel)	ARCILLA (clay) (P)	ARCILLA (clay) (P)
TABURETE (stool)	(O)	BATE (bat) (P)
MECEDORA (rocking chair)	SILLON (armchair) (S)	MESILLON (me-armchair) (PS) ^c
COLUMPIO (swing)	TRAMPOLIN (trampoline) (S)	COLGANTE (hanging) (P)
DEDAL (thimble)	DEDO (finger) (PS)	(O)
PEONZA (top)	(O)	PEONCIO (P) ^c
SILBATO (whistle)	XIFLADOR (PS) ^c	XIFLAR (whistle verb) (PS) ^b
REGADERA (watering can)	REGADOR (watering can) (P) ^a	REGADOR (watering can) (P) ^a
SANDIA (watermelon)	SANGRIA (sweetened drink of red wine with fruit) (P)	SANDIA
JARRON (vase)	(O)	JACO (P) ^c
NUBE (cloud)	BOIRA (fog) (S) ^b	(O)
CORONA (crown)	CASCO DE REY (king’s helmet) (S)	CORONA
TABLA PLANCHAR (ironing board)	(O)	PLATA DE PLANCHAR (ironing silver) (P)
LECHUGA (lettuce)	CLOCHA (P) ^c	COLIFLOR (cauliflower) (S)
RINOCERONTE (rhinoceros)	(O)	BISONTE (bison) (PS)
SALERO (saltshaker)	SALERO	PORTASAL (S) ^c
TROMPETA (trumpet)	TRO (P) ^d	TROMPETA
TORTUGA (turtle)	CANGURO (kangaroo) (S)	TORTUGA

Note: O, omission; S, semantic error; P, phonological error; PS, phonological and semantic error.
^a Correct word different of the primed word.
^b Responses in Catalan language.
^c Nonwords.
^d Fragments.

APPENDIX 2: ERRORS IN PHONEMIC CUEING

Picture	Cue	Response
CAZO (pot)	CAZ	CAZA (hunt)
CAZO (pot)	CAZ	CAZUELA (pan)
CALABAZA (pumpkin)	CALA	CALAVERA (skull)
CALABAZA (pumpkin)	CALAB	CALAMOCHE (N)
TORNILLO (screw)	TO	TORTILLA (omelette)
COLUMPIO (swing)	COLUM	COLUMNA (column)
SILBATO (whistle)	SILBA	SILBADOR (N)
ESCOBA (broom)	ES	ESPARRAGO (asparagus)
ESCRITORIO (desk)	ESCRI	ESCRIBANÍA (writing desk)
POMO (doorknob)	P	PUÑAL (dagger)
COMODA (dresser)	COM	COMODORA (N)

Note. N, nonword.

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