

## Phonological alexia with vowel–consonant dissociation in non-word reading<sup>☆</sup>

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### Abstract

We present a patient with alexia secondary to cerebral lesion whose errors in the reading of non-words affect vowels more than consonants. The interest of the case resides in: (1) the documentation of a vowel–consonant dissociation selectively affecting the reading of non-words; and (2) the localization of the alteration in a specific stage of the perilexical reading pathway, that is, the blending of phonetic chains. The case contributes to the discussion on the nature of representations and the processing of vowels and consonants.

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### 1. Introduction

It has long been observed that aphasic patients present a different rate of errors for consonants and vowels. Vowel–consonant dissociation was mainly studied in patients with alterations in oral production, but also in the auditory phonemic discrimination, in writing and in reading.

Early observations (Alajouanine, Ombredane, & Durand, 1939; Blumstein, 1978; Fry, 1959) and studies specially aimed to compare vowel and consonant errors showed that non-fluent aphasic patients produce more consonant than vowel errors. Such consonant–vowel dissociation has been observed in several languages (French, English, Spanish, Finnish, German, and Turkish; see references in Beland, Caplan, & Nespoulous, 1990; Ferreres, 1990a; Ryalls, 1987) and mostly attributed to the “greater articulation difficulty” for consonant production.

However, the prevalence of consonant errors has also been observed in fluent patients lacking articulation difficulties (Ferreres, 1990b). The reverse pattern, that is to say, more severe impairment of vowels in oral production, has only rarely been

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communicated, invariably in cases presenting conduction aphasia (Monoi, Fukusako, & Sasanuma, 1983; Romani, Graná, & Semenza, 1996). Recently Caramazza, Chialant, Capasso, and Miceli (2000) documented two patients with conduction aphasia, one with the habitual pattern, i.e., more consonant errors, and another with the reverse pattern, i.e., more vowel errors, configuring a double dissociation. The authors point out that selective damage to vowels or consonants contradicts the argument that vowels are easier than consonants. Besides, the errors of the patient presenting greater vowel alteration could be explained neither in terms of sonority nor of phonetic feature properties. Thus, they concluded that vowels and consonants are categorically distinct objects, at some representation level, though indistinguishable at phonetic level. The authors contend that vowel–consonant distinction may play a major functional role in syllable division, when assigning segments to nuclear and non-nuclear syllabic units.

Left cerebral lesions may also produce a consonant–vowel dissociation in input auditory processing. In the well-known context of pure verbal deafness, patients experience greater difficulty to discriminate consonants than vowels. This dysfunction has been attributed to the greater ability of the left hemisphere to process the fast sound variations that characterize consonants. As far as the present authors have been able to ascertain, the reverse pattern, that is to say greater difficulty to discriminate vowels, has not been communicated in patients sustaining brain lesions.

The consonant–vowel pattern in reading and writing errors of brain-damaged patients has been less studied. Cubelli (1991) reported two patients with acquired dysgraphia who showed a selective deficit in writing vowels, but this vowel–consonant dissociation failed to manifest either in oral production or in reading.

In a case of fluent aphasia studied by Ferreres et al. (1989), the most severe vowel impairment was observed in all tasks with oral output (repetition, spontaneous speech, and reading) and in all tasks with written output (dictation, writing).

Here we present an alexic patient who displayed a VC dissociation pattern in the reading of non-words, without a similar manifestation in other tasks of oral production. The goals of the work were to document the error pattern and attempt to determine the processing level at which it originated.

## **2. Materials and methods**

### *2.1. Case*

AP is a 24-year-old man, right-handed, with 10 years' schooling, who in September 1995 sustained an encephalic skull trauma that led to right hemiplegia and aphasia. CT scanning demonstrated an extensive left frontal, cortico-subcortical traumatic hemorrhagic lesion. He had a good evolution and responded to rehabilitative treatment. At the time of carrying out the present work (three years post trauma and after two years of treatment) the patient presented: controlled secondary epilepsy, good motor recovery, and good verbal performance in daily life activities. In particular, improvement in language processing was recorded mainly during the first two later years post trauma (1996 and 1997). In the course of the last year of treatment (1998), a marked improvement was observed in communication, due more to the development of adaptation mechanisms and control of pragmatic aspects than to an improvement in verbal processing itself. Because of this, in spite of communicational improvement, the last two language evaluations showed a similar result.

### 3. Language evaluation

Language evaluation was carried out by means of the Spanish version of the Battery for the Analysis of Aphasia Deficits (Miceli, Laudanna, Burani, & Capasso, 1994; Ferreres et al., 1999).

AP had a stable language alteration and in his last two evaluations (July 1997 and June 1998) showed very similar results (Appendix A): (1) he presented fluent aphasia ranging from mild to moderate, he was slightly anomie, without articulation deficits, and accompanied by moderate alexia; (2) a lexical advantage was observed in transcoding tasks since repetition, reading, dictation, and delayed copying of words, it was better than that of non-words; (3) a poorer yield was recorded in visual input tasks (reading poorer than repetition; visual lexical decision poorer than auditory lexical decision; visual grammatical judgment poorer than auditory ones, sentence reading poorer than repetition); (4) in general he showed poorer yield in output tasks (denomination) than in input tasks (comprehension); and (5) he presented alterations in syntactic processing and in audioverbal memory (for details see Appendix A).

### 4. Experimental investigation

The aims of the experimental investigation were to document the pattern of vowel-consonant dissociation in reading, to attempt to determine the related processing level and to analyze qualitatively the pattern of errors. It comprised four parts: (1) performance in different tasks to identify which components of the reading system were altered; (2) evaluation of the non-lexical reading route; (3) analysis of consonant/vowel error pattern in different tasks with non-words; and (4) qualitative analysis of the errors produced in reading non-words.

#### 4.1. Performance in tasks with words and non-words

A test designed by China and Ferreres (1998) consisting of 45 words and 45 non-words was used. The 45 words are concrete picturable nouns and controlled as regards length (15 of two, 15 of three, and 15 of four syllables) and frequency (18 frequent and 27 infrequent words, with 6 and 9, respectively, for each length group). In turn, the syllabic complexity was also controlled (30 words containing a non-CV syllable and 30 only containing CV syllables, with 5 and 10, respectively, for each length group). Thus, each length group (words of 2, 3, and 4 syllables) contained the following stimuli: 5 frequent words with CV syllables, 5 infrequent words with CV syllables, 1 frequent word with a non-CV syllable, and 4 infrequent words with a non-CV syllable.

Word frequency was obtained from the “Diccionario de Frecuencias de las Unidades Lingüísticas del Castellano” by Alameda and Cuetos (1995). Words whose occurrence exceeded 95/2.000.000 were considered frequent and those whose occurrence fell below 15/2.000.000 were regarded as infrequent. The list of non-words was built up by means of word syllable recombination, seeking non-words distant from actual words. They were also matched with words in length and syllabic complexity of each stimulus.

The same list of 45 words was used in repetition, reading, dictation, delayed copying, and denomination tasks. Drawings for the denomination task were taken from Snoodgras (1984) or from the Oxford–Duden dictionary (1985). The list of non-words was used for repetition, reading, dictation, and delayed copying tasks. Because the use of the same stimuli in different tests is liable to introduce a distortion

due to the learning effect, the list was divided into four parts and in each session a quarter of the list was taken for each task (for example the first quarter in repetition, the second in reading, the third in dictation, and the last in delayed copying); at the following session (separated by at least 4 days) the list was taken in another order (for example reading, dictation, delayed copying, and repetition) and so on, until completing the 45 stimuli in each task and preventing any task in particular to be privileged in a special way by the use of the same stimuli as in the previous task.

For error pattern analysis in each task, the Miceli et al. (1994) classification was used, with slight modifications. Errors on words were classified as follows: (1) a word related by the form: when the product is a word that contains at least 50% of the target phonemes or letters (camión > cañón), (2) semantic error (camión > auto), (3) morphologic error (camión > camionero), (4) a related non-word: when the product is a non-word that contains at least 50% of the target phonemes or letters (camión > camenon), and (5) a non-related non-word: when the product is a non-word that contains less than 50% of the target phonemes or letters (camión > paranelo). Errors on non-words were classified as follows: (1) a word related by the form: when the product is a word and contains at least 50% of the target phonemes or letters (merro > perro), (2) a related non-word: when the product is a non-word that contains at least 50% of the target phonemes or letters (merro > terro), and (3) a non-related non-word: when the product is a non-word that contains less than 50% of the target phonemes or letters (merro > tiso).

#### 4.2. Evaluation of the non-lexical reading route: Several tests were used

*Allograph matching:* the patient was presented cards with three letters, of which two were allographs (capital and lower case printing of the same letter) and the third was a distracter (e.g., E–f–e). The patient was requested to point out the allograph couple. The 27 simple letters or the alphabet (5 vowels and 22 consonants) were used.

*Syllabic segmentation of non-words:* the patient was presented 16 cards with written non-words (8 with three and 8 with four syllables); and requested to mark with a pencil the limit between each pair of syllables

*Naming/reading vowel letters:* the patient was presented 10 cards, each one with a vowel; each one of the 5 vowels in Spanish was used twice in random order, the patient was requested to name the vowel that is a monophonemic word coinciding with its sound.

*Naming consonant letters:* the patient was presented 44 cards, each one with a consonant letter; each one of the 22 simple consonant letters of the alphabet was used twice in random order; the patient was requested to name the letter. To evaluate the rules of grapheme–phoneme conversion, the following three tasks were used:

*Reading (to give the sound) of isolated consonants:* the patient was presented 36 cards with letters, twice the simple consonant letters of the alphabet except the letters Q, W, H, and X; the patient was requested to give its sound; (2) production of the sound of consonant letters with a support vowel: the patient was presented 36 cards (twice the simple consonant letters of the alphabet except the letters Q, W, H, and X) and instructed to pronounce them by adding an /a/ as support vowel; (3) reading of context-sensitive consonants: the patient was presented 32 cards with syllables whose pronunciation depends on the context (example: GA>/ga/; GE>/xe /; GUE>/ge/).

*CV and non-CV monosyllable reading:* the patient was presented 60 cards with monosyllabic non-words, 12 for each one of the following syllabic types: CV, VC, CVC, CCV, and CCVC, and requested to read them aloud.

*Phonemic blending:* In this test the interviewer pronounces the phonemes of a word or non-words target one by one and the patient is requested to pronounce the

complete word or non-word. The targets were: 30 words of 1, 2, and 3 syllables and 30 non-words, developed on the basis of word list syllables, respecting the relationships of length and syllabic complexity.

*Syllabic blending*: the interviewer pronounces the syllables that make up the targets and the subject is requested to say the complete word or non-word. The same 30 words and 30 non-words as for phonemic blending were used.

*Vowel/consonant pattern analysis of errors in tasks with non-words*: to study the vowel/consonant pattern of the errors in reading, delayed copying, repetition, and dictation of non-words, a test was designed with 80 non-words from one to four syllables. Only simple CV syllables with a frequency range from 5000 to 50,000 per 2 million were used (Alameda & Cuetos, 1995). The incidence of vowel and consonant errors was calculated by dividing the number of errors by the quantity of vowels and consonants elicited in each test.

*Qualitative analysis of the errors in reading non-words*: to obtain a sufficiently large corpus of errors for statistical analysis of the error pattern and of the influence of sublexical variables, a test of reading 132 non-words designed by China and Ferreres (1999) was applied. The test consists of two groups of 66 stimuli that differ in syllable frequency and are matched in length and syllabic complexity (see further details in Appendix B).

## 5. Results

### 5.1. Performance in different tasks

*Words vs. non-words in different tasks*: AP had a better performance with words than with non-words. This difference was significant in reading, dictation, and delayed copying. The repetition of both words and non-words was very good (Table 1). Length effect was only observed in the reading of non-words ( $\chi = 9.600$ ;  $p = .008$ ), with a trend to length effect in delayed copying ( $\chi = 8.514$ ;  $p = .014$ ). Syllabic complexity effect was not observed in any task, although in reading non-words a slight advantage was recorded for stimuli of lower syllabic complexity.

*Comparison among tasks with words*: the best yield was in word repetition (100%) followed by reading (95.6%), dictation (91.1%), and delayed copying (82.2%). The yield in delayed copying was significantly lower than in repetition and reading (Table 2).

*Comparison among tasks with non-words*: the repetition of non-words by AP was almost normal and significantly better than reading, dictation, and delayed copying of non-words (Table 2).

*Error pattern in different tasks with words and non-words*: in tasks with words, AP produced few errors, which were lexical in nature. Errors in reading and delayed copying were orthographically related words (libro [book] > labro). In dictation and delayed copying of words a few errors were related non-words (Table 3). In all tasks

Table 1  
Words vs. non-words performance

Task	Words		Non-words		Difference
Reading aloud	43/45	95.6%	30/45	66.7%	S ( $\chi = 12.256$ ; $p = .000$ )
Repetition	45/45	100%	44/45	97.8%	NS ( $\chi = 1.011$ ; $p = .315$ )
Dictation	41/45	91.1%	32/45	71.1%	S ( $\chi = 5.874$ ; $p = .015$ )
Delayed copy	37/45	82.2%	27/45	60.0%	S ( $\chi = 5.409$ ; $p = .020$ )
Naming	38/45	85.3%	—	—	—

Table 2  
Performance on different tasks

Compare tasks	Correct responses (%)	Difference
<i>Non-words</i>		
Repetition/reading aloud	97.8–66.7	S ( $\chi = 14.899$ ; $p = .000$ )
Repetition/dictation	97.8–71.1	S ( $\chi = 12.180$ ; $p = .000$ )
Repetition/delayed copy	97.8–60.0	S ( $\chi = 19.281$ ; $p = .000$ )
Reading aloud/delayed copy	66.7–60.0	NS ( $\chi = 0.431$ ; $p = .512$ )
Reading aloud/dictation	66.7–71.1	NS ( $\chi = 0.207$ ; $p = .649$ )
Dictation/delayed copy	71.1–60.0	NS ( $\chi = 1.230$ ; $p = .267$ )
<i>Words</i>		
Repetition/reading aloud	100.0–95.6	NS ( $\chi = 2.045$ ; $p = .153$ )
Repetition/dictation	100.0–91.1	NS ( $\chi = 4.186$ ; $p = .410$ )
Repetition/delayed copy	100.0–82.2	S ( $\chi = 8.780$ ; $p = .003$ )
Reading aloud/delayed copy	95.6–82.2	S ( $\chi = 4.050$ ; $p = .044$ )
Reading aloud/dictation	95.6–91.1	NS ( $\chi = 0.714$ ; $p = .398$ )
Dictation/delayed copy	91.1–82.2	NS ( $\chi = 1.583$ ; $p = .215$ )

Table 3  
Error pattern on different tasks

Tasks	A	P	SRW	FRW	NRW	RNW	NRNW
<i>Non-words</i>							
Reading aloud	—	—	—	1	—	14	—
Delayed copy	—	—	—	2	—	15	1
Repetition	—	—	—	—	—	1	—
Dictation	—	—	—	—	—	13	—
<i>Words</i>							
Reading aloud	—	—	—	2	—	—	—
Delayed copy	—	1	—	3	1	3	—
Repetition	—	—	—	—	—	—	—
Dictation	—	—	—	—	—	4	—
Naming	5	—	—	—	—	—	—

Note. A, P, SRW, FRW, NRW, RNW, and NNRW means anomia, perseveration, semantic related word, formal related word, non-related word, related non-word, and non-related non-word.

with non-words the errors were almost entirely related non-words (tilefa > tilafo). Only one of the reading errors and two of delayed copying were related words (pebro > Pedro [Peter]) (Table 3, Appendix C).

## 6. Evaluation of the perilexical route

AP had a perfect yield (100%) in the tasks of allograph matching, syllabic segmentation, and naming/reading of vowels. Consonant letter naming was almost perfect (95.4%). AP produced some errors in the task of reading isolated consonant letters (80.5%), most consisting in the addition of a support vowel without substitution of the consonant sound (T: /t/ > /te/; F: /f/ > /ef/). The yield in reading consonant letters with a support vowel was perfect and the reading of context-sensitive consonants was quite good (90.6%). In the test of syllabic complexity, AP showed perfect reading of CV monosyllables and certain difficulty (87.5%) with monosyllabic non-CV monosyllables (Table 4).

Table 4  
Perilexical route of reading evaluation

Allograph matching	27/27	100%
Non-word syllabic segmentation	16/16	100%
Consonant letter naming	42/44	95.4%
Vocal letter naming/reading	10/10	100%
Consonant letter reading:		
(a) isolated consonant	29/36	80.5%
(b) consonants with support vowel	36/36	100%
(c) consonants in context	29/32	90.6%
Syllable reading:		
(a) CV	12/12	100%
(b) Non-CV	42/48	87.5%
Word phonemic assembly	19/33	57.7%
Non-word phonemic assembly	13/33	39.3%
Word syllabic assembly	33/33	100%
Non-word syllabic assembly	33/33	100%

Phonemic blending tasks were very difficult for AP, mainly the phonemic blending of non-words which only reached 39.3% success. On the other hand, he achieved 100% success in the syllabic blending of words and non-words (Table 4).

## 7. Consonant/vowel error pattern in tasks with non-words

AP produced a greater incidence of errors on vowels than on consonants in the reading of non-words. In repetition and dictation of non-words a greater incidence of errors was observed on consonants. In delayed copying AP produced more errors than in the other tasks and the incidence of errors on consonants and vowels was very similar (Table 5). The predominant error type was substitution, both for vowels and for consonants (Table 6).

## 8. Qualitative analysis of the error pattern in the reading of non-words

In the reading of the list of 132 non-words AP only read correctly 34 (25.8%) of the stimuli. Out of the 98 errors, most (85) were related non-words, a few were non-related non-words (12) and only one was a related word.

As expected, AP produced more errors on vowels than on consonants. The 132 non-words contained 396 vowels and 566 consonants; AP read 68.9% of the vowels and 82.9% of the consonants correctly. This difference between vowels and consonants proved statistically significant ( $\chi = 25.604$ ;  $p = .000$ ) (Table 7).

Table 5  
Consonant and vowel errors incidence on non-word tasks

	Targets errors/80		Vowels errors/200		Consonants errors/200	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Reading aloud	21	26.2	18	9.0	8	4.0
Delayed copy	20	25.2	15	7.5	17	8.5
Repetition	5	6.2	4	2.0	7	3.5
Dictation	6	7.5	2	1.0	5	2.5

*Note.* A target produced erroneously can contain more than one vowel and/or consonant error. Because of this, the vowel and consonant error summation exceed the error number on targets.

Table 6  
Error types on non-word tasks

	Vowels				Consonants			
	S	A	D	T	S	A	D	T
Reading aloud	16	—	—	2	8	—	—	—
Delayed copy	14	—	1	—	13	—	1	3
Repetition	4	—	—	—	5	—	—	2
Dictation	2	—	—	—	4	—	—	1

Note. S, A, D, T, and DI means substitution, addition, delete, transposition, and displace.

Table 7  
Vowel and consonant error incidence in non-word reading

Letters	Correct response	
	<i>n</i>	%
Vowels	273/396	68.9
Consonants	469/566	82.9
$\chi = 25.604$	$p = .000$	

Most of the errors were simple or double, but he also produced more complex errors (Table 8). VC dissociation of the errors was more marked in the simple and double errors.

AP read long non-words worse and this length effect proved significant ( $\chi = 24.324$ ;  $p = .000$ ). Vowel–consonant dissociation of the error was more marked in non-words of three syllables. A statistically significant effect of syllabic frequency was also observed ( $\chi = 10.142$ ;  $p = .000$ ), since AP read worse the non-words made up with syllables of lower frequency. However, the influence of syllabic frequency was greater for consonants. Indeed, most of the consonant errors (77.3%) occurred on non-words with syllables; of lower frequency. On the other hand, the vowel errors were distributed between both types of non-words (56.1% in those of lower and 43.9% in those of greater frequency).

Both in consonants and in vowels the error type ranking was similar: substitution > omission > addition > exchange. Comparing vowels and consonants, a greater percentage of substitutions was observed in vowels than in consonants and a greater percentage of omissions in consonants than in vowels (Table 9). In this test the effect of syllabic complexity could not be routinely evaluated since all the stimuli contained at least one non-CV syllable. The analysis of the syllable type on which the error occurred showed that vowel errors display a greater incidence than consonant errors in all syllabic types (Table 10).

Table 8  
Vowel and consonant errors by number of errors per stimuli

Errors	No.	Vowels <sup>a</sup>	Consonants <sup>b</sup>	Ratio <sup>a/b</sup>
Simple	40	27	13	2.1
Double	22	28	16	1.7
Triples	22	35	31	1.1
Quadruples	6	12	12	1.0
Quintuples	4	8	12	0.7
Sextuples	2	5	7	0.7
Septuplets	2	8	6	1.3
	98	123	97	

Table 9  
Error types distribution

	S		D		A		T	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Vowels	111	90.2	8	6.5	3	2.4	1	0.8
Consonants	56	57.7	33	34.	6	6.2	2	2.1

Note. S, A, D, and T means substitution, addition, delete, and transposition.

Table 10  
Vowel and consonant errors by syllabic types

Syllable	Vowels		Consonants		Ratio <sup>a/b</sup>
	Errors/elicit	% <sup>a</sup>	Errors/elicit	% <sup>b</sup>	
CV	59/185	31.9	28/185	15.1	2.1
VC	18/41	43.0	10/41	23.4	1.9
CVC	39/144	27.1	51/288	17.7	1.5
CCV	6/26	23.1	6/52	11.5	2.0
Others	1		2		
	123		97		

The vowel substitution matrix shows that four out of the five vowels in Spanish were affected to a very similar degree, almost 30% of the times they had to be read; the exception corresponded to the vowel U that was substituted a single time. Vowels O and U were the most frequent substituents. There is no relationship between these findings and the occurrence of the vowels in Spanish (Table 11); on the contrary, the less frequent vowel U was the least affected and the one more used as a substituent.

The consonant substitution matrix failed to show a strict relationship with frequency. A high incidence of substitutions was observed in the reading of letters such as Y, G, and Ñ that are of low occurrence in Spanish, but other letters of low frequency J, Q failed to show a similar level of involvement, and letters of high frequency as R even showed a marked incidence of substitutions (Table 11). Consonant substitutions seem to be due to mixed mechanisms. In the substitutions Y > /x/, Ñ > /n/ there is visual and phonological resemblance; the substitutions of G seem to be due in half of the cases to problems of grapheme–phoneme conversion, since the letter was substituted by /x/ in contexts where it should be pronounced as /g/; the substitution of the letter R seems restricted by the syllabic structure, since it was pronounced as /l/ /r/ /s/, or /n/ when it occupied the coda place and as /l/ when it occupied the C2 place in CCV syllables (in Spanish the phonemes that occupy the coda position are almost exclusively /l,n,r,s/ and only /r,l/ occupy C2 position).

Word part effect was studied in single errors. Vowel errors showed a trend to occur on the final part of the word (Table 12).

The same list of 132 non-words was taken in a repetition task in order to make a comparison. The patient repeated 117/132 stimuli correctly (88.6%). All the 15 errors were substitutions of a segment, 3 vowels and 12 consonants.

## 9. Discussion

The experimental investigation showed that AP consistently produced more vowel than consonant errors in the reading of non-words.

Table 11

	/a/	/e/	/i/	/o/	/u/	Err./elicit	Incid.	Occurence										
Vowel substitution matrix																		
A	X	10	—	17	6	33/112	0.29	1.191.344										
E	4	X	4	13	16	37/130	0.28	1.222.720										
I	—	2	X	—	3	5/17	0.29	620.719										
O	3	5	1	X	26	35/122	0.29	877.945										
U	—	1	—	—	X	1/15	0.01	401.935										
Total	7	18	5	30	51	111/396	0.28											
	/ch/	/d/	/g/	/k/	/l/	/m/	/n/	/ñ/	/r/	/s/	/x/	/y/	Total/elicit	Incid.	Occur			
Consonant substitution matrix																		
D	—	X	—	—	—	—	—	—	1	—	—	—	1/31	0.03	453.793			
G	—	—	X	—	—	—	—	—	—	—	6	2	8/22	0.36	100.010			
J	—	—	—	—	—	—	—	—	—	1	X	1	2/16	0.12	40.064			
L	—	—	—	—	X	1	3	—	1	1	—	—	6/90	0.06	458.008			
N	—	—	—	—	3	—	X	3	—	1	—	—	7/63	0.11	646.113			
Ñ	—	1	—	—	—	—	5	X	—	—	—	—	6/23	0.26	17.455			
Q	3	—	—	—	—	—	—	—	—	—	—	—	3/23	0.13	99.190			
R	—	—	—	—	7	—	2	—	1	1	—	—	11/65	0.17	601.379			
S	—	—	—	—	—	—	1	—	—	X	—	1	2/62	0.03	700.931			
Y	1	—	1	1	—	—	—	—	—	—	7	X	10/17	0.59	83.080			
Total	4	1	1	1	10	1	11	3	3	4	13	4	56/412	0.13				

Table 12  
Word segment effect

	Vowels				Consonants			
	S	A	O	I	S	A	O	I
Initial	7	—	—	—	3	—	2	—
Medial	4	—	—	1	2	—	—	—
Final	14	1	—	—	5	—	1	—

Difficulties for the reading of non-words cannot be attributed to the processing components of oral output since the capacity of AP to repeat words and non-words was preserved.

Neither can they be attributed to the components of the lexical reading route because AP read isolated words correctly. His errors and the VC dissociation pattern took place when he read non-words, that is to say, when he used the non-lexical reading route. Specific evaluation of this route showed that several of its components were preserved. The patient had no problems in initial processing of the written stimulus since he could match allographs, name letters and segment non-words into syllables in a correct way. Neither had he any problems with the knowledge and application of grapheme–phoneme conversion rules since he could give the sound and the name of all the vowels, the sound of isolated consonant letters or with vowel support; he only produced a few errors when reading some context-dependent consonants and some non-CV monosyllables.

The most severe difficulties in AP appeared in those two tasks that require joining phonemes into syllabic sequences capable of being pronounced. One is the reading of non-words and the other one the combination of phonemes presented by ear in words and non-words (blending aurally presented phonemes into words and non-words). On the other hand, those tasks with oral output, in which syllabic information can be obtained from the stimulus (combination of syllables presented by ear in words and non-words, repetition of words and non-words) or from the lexicon (reading of words, repetition of words, and naming) failed to show the same difficulty.

The issue is therefore to elucidate why such vowel consonant dissociation should appear in the reading of non-words.

The differences in articulatory difficulty between consonants and vowels, advanced to explain speech errors in patients with non-fluent aphasia, are obviously not pertinent in this case. Not only because AP repeated words and non-words perfectly but because in the reading of non-words he presented a greater error rate in vowels, the group of phonemes whose articulation is considered simpler.

In oral production errors of patients with fluent and non-fluent aphasia, consonant substitutions showed correlation with the frequency of use (Ferreres, 1990a, 1990b). In AP, neither vowel nor consonant errors correlated with frequency. Furthermore, the error rate in reading non-words was greater for vowels (globally more frequent) than for consonants. In contrast, a correlation was observed between low syllabic frequency and a greater error rate in reading non-words.

The sonority principle, used to explain consonant and vowel errors by Romani and Calabrese (1998), is not applicable to our patient's vowel errors. In vowel substitutions AP failed to show any tendency to respect the more sonorous vowels (vowel /a/), or to increase the sonority of the syllabic nucleus. On the contrary, the vowel least affected by substitution and the more used as substituent was the vowel /u/ that in Spanish presents the least sonority.

In agreement with Caramazza et al. (2000), it could be argued that vowels and consonants are categorically different objects, that vowel–consonant distinction plays a role in syllabic organization and that the errors committed by AP could be due to selective damage to vowel representations. In this sense, it is strongly suggestive that our patient's errors appear in tasks that require syllabification of phonemic chains and that they are influenced by syllabic frequency.

However, we could not obtain evidence in AP that vowel representations, in any of their modalities, were affected. The good results he showed in vowel allograph matching, in vowel grapheme–phoneme rules of conversion, and in the correct repetition of vowels (including those in non-words), show that input orthographic and input/output phonemic vowel representations were preserved.

The difficulty of AP with vowels cannot therefore be attributed to damage to the representations per se but to difficulties with their processing during the syllabic blending of the chain of phonemes obtained from grapheme–phoneme conversion.

To attribute the greater involvement of vowels to a defect in blending rather than to damage to the representations fails to invalidate the argument that vowels and consonants are categorically distinct objects. A faulty process will only be able to produce a differential error pattern provided the representations with which it operates are somehow different for the process in question. However, the finding compels us not only to consider the structural differences between vowels and consonants but also the differences in processing.

The two-cycle blending model (Berent & Perfetti, 1995, Berent, 1997) assumes that vowels and consonants differ not only structurally but also in processing. Starting from their findings in experimental studies with normal subjects, the authors contend that vowels and consonants are structurally different constituents in blended representations and also that they are derived through processes that differ in speed and automaticity since consonants are processed faster and more automatically than vowels.

The confirmation of VC dissociations in oral production (Caramazza et al., 2000) that selectively affect writing (Cubelli, 1991) or the perilexical reading route (as in the case of AP), stress that the structural consonant–vowel distinction should also be analyzed in connection with the processes in which this type of information is used.

#### Appendix A. AP language evaluation by Miceli y col. Battery (1994)

	July 1997		June 1998	
<i>Tasks exploring sublexical orthography and phonology</i>				
Phoneme discrimination	59/60	98%	56/60	93.3%
Auditory–visual matching	59/60	98%	60/60	100%
Non-word repetition	36/36	100%	36/36	100%
Non-word reading	28/45	62.2%	30/45	66.6%
Non-word dictation	23/25	92%	19/25	76%
<i>Tasks exploring lexical-semantic level</i>				
Auditory lexical decision	75/80	93.7%	80/80	100%
Visual lexical decision	67/80	83.7%	64/80	80%
Word repetition	45/45	100%	45/45	100%
Word reading	73/92	79.3%	76/92	82.6%
Word dictation	44/46	95.6%	44/46	95.6%

**Appendix A** (*continued*)

	July 1997		June 1998	
Object oral picture naming	22/30	73.3%	23/30	76.6%
Action oral picture naming	26/28	92.8%	19/22	86.3%
Object written picture naming	20/22	90.9%	27/28	96.4%
Action written picture naming	19/22	86.3%	19/22	86.3%
Object naming described by the examiner	14/16	87.5%	14/16	87.5%
Object auditory comprehension	39/40	97.5%	37/40	92.5%
Action auditory comprehension	20/20	100%	20/20	100%
Object visual comprehension	39/40	97.5%	39/40	97.5%
Action visual comprehension	19/20	95%	18/20	90%
<i>Tasks exploring sentence processing</i>				
Auditory grammaticality judgement	46/48	95.8%	39/48	81.2%
Visual grammaticality judgement	18/24	75%	15/24	62.5%
Sentence repetition	6/6	100%	6/6	100%
Phrase repetition	14/14	100%	14/14	100%
Phrase reading	4/6	66.6%	3/6	50%
<i>Tasks exploring memory</i>				
Word recognition				
4 stimulus	24/24	100%	21/24	87.5%
6 stimulus	20/24	83.3%	24/24	100%
8 stimulus	23/24	95.8%	22/24	91.6%
<i>Non-word recognition</i>				
4 stimulus	21/24	87.5%	21/24	87.5%
6 stimulus	21/24	87.5%	22/24	91.6%
Word reproduction	List		List	
2 stimulus	10/10	100%	20/20	100%
3 stimulus	10/10	100%	30/30	100%
4 stimulus	2/5	40%	3/5	60%
6 stimulus	0/5	0%	0/5	0%
Non-word reproduction	List		List	
2 stimulus	10/10	100%	10/10	100%
3 stimulus	1/10	10%		
4 stimulus	0/5	0%		

**Appendix B**

The test of reading 132 non-words consists of two groups of 66 stimuli that differ in the frequency of the syllables with which they were built. Both groups are balanced for length (both groups include non-words of 2, 3, and 4 syllables, 22 of each length) and syllabic complexity (both include 21 CV, 15 CVC, 5 VC, and 3 CCV syllables). What differs in both groups is the frequency of the syllables with which the non-words were built. Because the distribution of the syllabic frequency varies widely according to the syllabic type, frequent/infrequent differences were determined for each syllabic type in the following way:

	Frequents	Infrequents
CV	161.561 and 32.613	16.545 and 682
CVC	42.094 and 11.201	3 and 1
VC	66.912 and 14.642	2.477 and 748
CCV	16.020 and 12.866	209 and 3

### Appendix C. Error in non-word tasks

Related non-word	Related word	Non-related non-word
<i>Non-word reading</i>		
carijelo → /kanixelo/	pebro → /pedro/ [Peter]	
tilefa → /tilafo/		
biramizón → /marimisón/		
cirretello → /si□etalio/		
caleza → /kalasa/		
pecrócano → /prekikano/		
verrello → /ba□elio/		
telífode → /telifade/		
cajello → /kafelia/		
cogadella → /kabadelia/		
becarrilla → /mekarilia/		
cameta → /kamata/		
milérano → /milarano/		
cacodrina → /kokodrina/		
<i>Non-word repetition</i>		
Related non-word		
becarrilla → /bekarilio/		
<i>Non-word delayed copy</i>		
malleralo → /maierafb/	bopa → /boka/ [mouth]	fola → /toše/
empózon → /'empofón/	liya → /lisa/ [ plain]	
trijullo → /trixulo/	camira → /kamila/	
	[Camile]	
cirretello → /sifarošo/		
zagatira → /sagatiša/		
verrello → /ve□ošo/		
telífode → /tešikoše/		
jibana → /xibala/		
becarrilla → /boka□iša/		
espamera → /espariša/		
milerano → /milerafo/		
perma → /perka/		
carentisa → /karentisa/		
repalera → /□opalera/		
<i>Non-word dictation</i>		
malleralo → /marielalo/	merro → /mero/	
empozón → /emposom/		
trijullo → /trixulio/		

**Appendix C (continued)**

Related non-word	Related word	Non-related non-word
biramizón → /biramison/		
cirretello → /siretelio/		
verrello → /be□elio/		
telifode → /telifole/		
cogadella → /kogadelia/		
cache → /kake/		
becarrilla → /bekariša/		
milérano → /mineralo/		
murata → /murapo/		

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