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Re-education of a Surface Dysgraphia with a Visual Imagery Strategy

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We report the re-education of a brain-damaged patient, LP, who presented a surface dysgraphia. This dysgraphia resulted from impairments of the lexical procedure of writing arising from a deficit located in the orthographic output lexicon. Our hypothesis was that LP had lost the relevant orthographic representations of some words. A two-stage therapeutic programme was carried out. In the first stage, we tried to optimise the relatively spared phonological procedure in writing by re-teaching some graphemic contextual rules. Because of residual surface dyslexia and verbal memory deficits associated with this surface dysgraphia, and because of the structure of the French language, we retaught, in the second stage, the spelling of some irregular and ambiguous words by means of a visual imagery technique. In post-therapy, we observed a selective effect of this imagery strategy by comparison with a classic methodology of repetitive presentation of ambiguous and irregular spellings. The results of our therapy support cognitive-oriented therapeutic approaches and are discussed with regard to recent debates on the subject in neuropsychology.

INTRODUCTION

For some years now, advances in cognitive neuropsychology have begun to influence the way the logic of the therapeutic intervention is conceived. Despite a marked paucity of literature on therapy, some recent studies

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have demonstrated the effectiveness of single-case studies and well-controlled re-education that share methods and concepts proposed by cognitive neuropsychologists. Some aspects of these therapeutic approaches are elaborated according to some hypotheses about the selective processing breakdown a patient experiences after a brain lesion (Bachy & de Partz, 1989; Beauvois & Derouesné, 1982; Behrmann, 1987; Byng, 1988; Carlomagno & Parlato, 1989; Coltheart & Byng, 1989; Deloche, Seron, & Ferrand, 1989; de Partz, 1986; Hatfield, 1982; Jones, 1986).

Such cognitively oriented re-education approaches require the understanding of the impaired process as well as of the spared processes in order to devise a re-education strategy suited to the specific problem of the patient (Coltheart, 1983; Howard & Patterson, 1989; Seron & Laterre, 1982). But to be useful in the clinical domain, these cognitive models have to be sufficiently detailed on the computational level. At present, this is only the case for areas of cognitive processing such as reading, writing, naming, and some aspects of number processing and memory (Seron & Deloche, 1989). The present paper is devoted to the re-education of a selective writing disorder of a surface dysgraphic patient.

Most models of normal writing assume that there are two or perhaps three major procedures for producing written language (Ellis, 1982; 1984; Frith, 1980; Margolin, 1984; Patterson, 1985; 1986; Young & Ellis, 1988). Firstly, there is the lexical procedure that entails the direct retrieval of word spellings stored in the orthographic output lexicon. This direct, or so-called semantic route, can be used for writing all words (regular as well as ambiguous or irregular). Secondly, there is the phonological procedure, which deals with segmental translation from phonology to orthography and allows the writing of regular words and nonwords. The third procedure, although its existence is disputed, links the auditory-input lexicon to the orthographic output lexicon via the phonological output lexicon (Kohn & Friedman, 1986; Patterson, 1986).

Several neuropsychological studies have provided evidence for selective impairment of various components of each of these procedures (Beauvois & Derouesné, 1981; Bub & Kertesz, 1982; Caramazza, Miceli, Villa, & Romani, 1987; Goodman & Caramazza, 1986; Hatfield, 1982; 1983; Miceli, Silveri, & Caramazza, 1985; Shallice, 1981). Beauvois and Derouesné (1981) were the first to report a case of a patient who presented a severe impairment of the lexical procedure but a well-preserved phonological procedure. This patient's performances were directly influenced by regularity of spelling: Nonwords and regular words were written correctly whereas ambiguous and irregular words gave rise to numerous spelling regularisations.

Although several cases of surface dysgraphia have been identified since this seminal report, few remediation studies have been described. Hatfield (1982) proposed a two-stage retraining programme, which she applied to a surface dysgraphic patient (TP). Firstly, the better-preserved phonological procedure was optimised. TP was trained to use some complex conversion rules (e.g. the rule of consonant doubling). Secondly, the vowels and diphthongs /i/, /ei/, /ou/ represented by different graphemes (e.g. /i/ was written EE–EA; /ei/, AI–A, . . .) were trained by associating key words, correctly written, with each ambiguous spelling (e.g. correct spelling of SPAIN was associated with RAIN, correctly written by TP). After 5 training sessions and homework exercises, the patient correctly wrote 16 items out of a list of 20 items that supposed the application of the rule of consonant doubling (12 correct responses for items in pre-therapy) and 17 items out of a list of 20 ambiguous words containing spelling of phonemes /ou/, /ei/, and /i/ (11 correct responses were obtained in pre-therapy).

Behrmann (1987) described an item-specific treatment procedure that enhanced direct lexical access of 50 incorrect written homophones. Homophones were always taught in pairs (e.g. sail/sale, but/butt, . . .). The retraining programme consisted of associating each homophone of a pair with its pictorial representation in order to provide its correct meaning and to link orthography with the corresponding meaning. At each session, each homophone was written on a card and paired with its pictorial representation. The second member of the pair was then introduced together with its corresponding picture. The 2 written forms were contrasted explicitly and the difference in meaning was pointed out. The patient was encouraged to distinguish between the 2 written forms and to memorise the orthographic differences. At the post-therapy testing, the patient correctly wrote 93 homophones out of a list of 138 items compared with her pre-therapy score of 68/138. The lack of generalisation from the treatment procedure to non-relearned items is coherent with such a specific therapeutic approach.

We will present here a specific and original re-educational strategy for a surface dysgraphic patient, LP; it was developed on the basis of a cognitive analysis of his deficit in writing and in reading. According to our interpretation of the deficit, we proposed a two-stage therapeutic programme. In the first stage, LP was retaught some complex graphemic contextual conversion rules in order to optimise the relatively spared phonological writing procedure (Hatfield, 1982). In the second stage, we created an original imagery strategy to reteach LP the writing of ambiguous and irregular words. We will describe the logic, the design, and the procedure we adopted for these two therapeutic stages and we will evaluate their results. Finally, we will discuss our results and consider the possible relationship between theoretical advances in cognitive neuropsychology and therapeutic intervention.

CASE SUMMARY

Medical History

LP was a right-handed, 24-year-old man with familial antecedents of left-handedness (his father and brother were left-handers or ambidextrous). He was a nursing student when he contracted encephalitis in October 1984, which required a lobectomy of the left temporal point (3 × 2 × 0.5cm.) and suction of the lower area of the left frontal lobe. At the time of his admission to hospital, LP presented a gross alteration of consciousness. Neurological examination of his sensory-motor status revealed a right hemiparesis and a very mild right hemispatial neglect without hemianopia.

Neuropsychological Evaluation

Two months post-onset, the language clinical profile was that of transcortical sensory aphasia (Goodglass & Kaplan, 1972). Speech output was fluent with semantic paraphasias, prominent word-finding difficulties, paragrammatism, and numerous perseverations. Repetition was normal except for long sentences. Single-word comprehension was impaired both in the auditory and the visual modality. Only simple and short commands were correctly executed. In written language, the deficits were also severe: Jargonagraphia was present in tasks requiring spontaneous writing or writing from dictation. Copying was better, though laborious, and perseverations were numerous. Jargonalexia was observed in the oral reading of letters, words, nonwords, and sentences. Attentional and mnesic functions were disturbed. LP presented moderate frontal cognitive disorders as well as some behavioural problems, such as mood lability and social inadequacies. Given the initial severe aphasia and the partial anosognosia, the first attempts concentrated on conversational and communication skills.

In August 1985 (10 months post-onset), the patient came to our rehabilitation unit for language, memory, and attentional therapy. At this time, significant improvements were observed in language: The patient obtained a rating score of 3 on the severity B.D.A.E. aphasia scale (Goodglass & Kaplan, 1972), which indicated an ability to discuss almost all everyday topics but with a reduction of oral comprehension and speech output. Verbal speech output had become more informative but word-finding difficulties were still present. We noted many pauses, circumlocutions, and semantic paraphasias. Automatic speech was now good and repetition flawless. On oral naming tests of pictured objects that controlled frequency of use and syllable length (Bachy, Note 1), LP made 24 errors on a 90-item set.

At this time, oral comprehension had also improved. In a picture-word matching task with 5 phonological distractors, the patient pointed correctly

to the picture corresponding to the orally presented word (10/10). However, some difficulties remained when the 5 distractors were semantic (9 responses correct out of 12 items). His comprehension of complex syntactical-semantic sentences expressing spatial and temporal relations and passive and relative structures was generally correct. LP produced 7 correct responses out of 8 sentences matched with pictures (e.g. the sentence "il pose le verre à côté du meuble" [he places the glass *next* to the cupboard] was matched with a picture of a man putting a glass *in* a cupboard). Unusual pauses were still observed in a French version of the Goodglass subtest of complex ideational material (Goodglass & Kaplan, 1972). The complex commands, including the test of "three pieces of paper of Pierre Marie," were correctly executed.

Progress was also significant in other cognitive domains. The spatial and temporal disorientation had disappeared. On Raven's Progressive Matrices Test, LP scored 42, which indicated an I.Q. of 95, lower than his presumed previous level. A test battery sensitive to frontal disorders, consisting of Luria's graphic series, criticism of nonsense stories, and execution of contradictory gestures, was administered. LP made errors that suggested the presence of frontal disorders on a cognitive as well as a behavioural level (mood lability and social inadequacies). Some difficulties also appeared in different attentional tests. Simple reaction times were 212msec. in the visual modality (mean rate: approximately 200msec.) and 270msec. in the auditory modality (mean rate: approximately 250msec.). In the memory tasks, the Rey figure was performed at percentile 25. LP obtained a score of 4 on the Benton visual retention test but this poor result was largely due to a right visual neglect since 5 of the 6 errors were omissions of the right elements of the figures. For verbal memory tasks, the patient recalled a low average of 6.2 words per trial of the 15-Word Rey test, and the learning curve was very poor (6-7-8-5-5) on the successive trials; the score, at the delayed multiple-choice recognition (12, expected mean: 15), was also below average. At this stage, his visual and verbal memory performances were disturbed, but the poor performance on the visual tasks could have been mostly due to the residual neglect phenomenon. In the subsequent months, his performance in visuo-spatial memory tasks tended to become better: scores on the Rey figure memory test were at percentile 25 in June '86, percentile 80 in January '87, and percentile 65 in June '87. LP's short-term auditory verbal memory span remained normal, as shown by his excellent digit span (8 forward). However, impairments of episodic long-term memory were observed. In a 15-word list learning task (Selective Reminding Test, Buschke & Fuld, 1974), the patient recalled a low average of 6.1 words in June '86, 8.7 in January '87, and 9.2 in June '87 (expected mean: 11) and his C.L.T.R./L.T.R. (constant long-term retrieval/long-term retrieval) score was under the mean score (70%): 11.5% in June '86, 27.5% in January '87, and 41.3% in June '87.

Although the main topic of this paper deals with the re-education of spelling, it is necessary for a complete interpretation of LP's deficits as well as for the justification of the re-educational strategy to present the information we collected about his reading abilities. Our investigation of LP's reading and spelling was based on the three-route model mentioned earlier. Firstly, we present a cognitive analysis of LP's spelling and, secondly, of his reading.

Spelling Evaluation: Nonlexical Procedure

This procedure is generally assessed by writing isolated letters and nonwords.

Task 1: Writing of Isolated Letters

Material and Procedure. The patient was asked to write the 26 letters of the alphabet in response either to their names or to their sounds.

Results. LP was able to write single letters perfectly both in response to their names (26/26) and to their sounds (26/26).

Task 2: Writing of Nonwords

Material and Procedure. LP was presented a set of 50 nonwords varying in length (1, 2, and 3 syllables) and in syllabic complexity (CV-CVC-CCV).

Results. LP wrote 44/50 (88%) nonwords correctly. The errors consisted mainly of letter substitutions, which indicated that some graphemic conversion rules sensitive to the context were not preserved (e.g. /vlys,/ correctly written *vlusse* or *vluce*, was written by LP *vluse* (/vlyz/)—according to a French graphemic conversion rule, the phoneme "s" cannot be converted to the grapheme *s* when it appears between two vowels. In this case, LP assigned to the phoneme "s" its most frequent graphemic counterpart.) A deficit located at the auditory processing stage was eliminated, given that the patient was able to repeat perfectly all the nonwords presented in writing from dictation.

Thus, the non-lexical strategy was well-preserved, though not perfect. Indeed, the errors were due to partial deficit of phoneme-grapheme skills and, particularly, to the misapplication of graphemic conversion rules sensitive to the context.

Spelling Evaluation: Lexical Procedure

A patient who can use the lexical procedure in writing is expected to be able to spell ambiguous and irregular words.

Task 3: Writing Ambiguous and Irregular Words

Material and Procedure. LP had to write from dictation a list of 56 words (drawn from the Beauvois and Derouesné battery, 1981), which were subdivided into: 12 regular words, 32 ambiguous words, and 12 irregular words. Among the 32 ambiguous words, there were different degrees of orthographic ambiguity (D.O.A.): 12 words containing 1 ambiguous grapheme (D.O.A. = 1), 12 words with 2 ambiguous graphemes (D.O.A. = 2) and 8 words with 3 ambiguous graphemes (D.O.A. = 3).

Results. As illustrated in Table 1, LP's performance tended to be influenced by spelling regularity but, in fact, this difference was not statistically significant (Jonckheere trend test $z = 1.29$)[1]: 58% correct responses for regular words, 58% for D.O.A.1 words, 33% for D.O.A.2 words, 38% for D.O.A.3 words, and 33% for irregular words.

If we consider the regular word set, it is surprising to observe so many errors. As indicated in Table 2, most of these errors were due to a tendency to add silent letters in words that were otherwise correctly written. Indeed, 4 words were misspelled because of additions of silent consonants (*défit*, *détourt*, *aviont*, and *hoursin* instead of *défi* [challenge], *détour* [deviation], *avion* [plane], and *oursin* [sea-urchin]), the fifth word had 2 errors (an addition of a silent consonant and a phonological error—*pouissont* instead of *poisson* [fish]). Thus, we have reconsidered our data of the whole set of the Beauvois and Derouesné battery and have ignored the errors that were due to the addition of silent letters. With such a criterion, LP's performances were significantly influenced by regularity of spelling

TABLE 1
Percentages of Correct Responses According to Different Degrees of Orthographic Ambiguity in Writing from Dictation

	Number of Items	*Percentages of Correct Responses*
Nonwords	50	88%
Regular Words	12	58%
Ambiguous Words		
D.O.A. = 1	12	58%
D.O.A. = 2	12	33%
D.O.A. = 3	8	38%
Irregular Words	12	33%

Note: D.O.A. = degree of orthographic ambiguity (Beauvois & Derouesné, 1981).

[1]This difference would have appeared if the number of observations had been higher.

TABLE 2
Responses to the Beauvois and Derouesné (1981) Word Set

Frequency	*Regular*	*D.O.A. = 1*	*D.O.A. = 2*	*D.O.A. = 3*	*Irregular*
F < 1	"défi" *défit** (challenge)	"forain" *forin* (itinerant)	"anchois" + (anchovy)	"agent" *ajean* (agency/policeman	"baptême" + (baptism)
	"oursin" *hoursin** (sea urchin)	"béret" *bérait* (beret)	"tank" *tanque* (tank)	"monaie" *monée* (money)	"agenda" *agendat** (diary)
	"cavité" + (cavity)	"bretelle" + (braces)	"bicyclette" *biciclète* (bicycle)	"gencive" *jancive* (gum)	"toast" *taust* (toast)
	"abusif" + (excessive)	"potion" *possiont* (draught)	"meunier" *meugnié* (miller)	"patient" *passiant* (patient)	"oignon" *hogniont* (onion)
1 < F < 30	"menu" + (menu)	"pigeon" + (pigeon)	"hochet" + (rattle)		"estomac" *estomact** (stomach)
	"bonté" + (goodness)	"herbe" + (herb)	"vallée" *valée* (valley)		"dixième" + (tenth)
	"poisson" *pouissont* (fish)	"bouteille" + (bottle)	"diamant" *diament* (diamond)		"solennel" *solagnele* (solemn)
	"détour" *détourt** (deviation)	"ressort" + (spring)	"s'habiller" *s'abiller* (to dress)		"tabac" + (tobacco)
F > 31	"peur" + (fright)	"photo" + (photography)	"accord" + (agreement)	"gentil" *jantil* (kind)	"femme" *fame* (woman)
	"avion" *aviont** (plane)	"soeur" *seure* (sister)	"style" *stile* (style)	"enfant" + (child)	"second" *segont* (second)
	"montagne" + (mountain)	"théâtre" *téatre* (theatre)	"village" *vilage* (village)	"jeunesse" + (youth)	"examen" *examin* (examination)
	"prison" + (gaol)	"tableau" + (board/painting)	"énergie" + (energy)	"développement" + (development)	"monsieur" + (mister)

+ correct responses; *italic print* for errors; * particularly due to LP's tendency to generalise the use of mute letters.

(Jonckheere trend test $z = 1.95$, $P < 0.05$): 92% of correct responses for regular words, 58% for D.O.A.1 words, 33% for D.O.A.2 words, 37.5% for D.O.A.3 words, and 50% for irregular words. The score obtained for regular words (92%) appeared to be equivalent to that of the nonwords set (88%) (see Task 2).

Since, with such a criterion, the regularity of word spelling exhibited an influence on the writing performance of LP, we checked for the influence of word length and frequency.

Task 4: Length of Words

Material and Procedure. A word subtest with 12 short words (4–5 letters) and 12 long words (7–10 letters) was administered.

Results. As indicated in Table 3, the length of the letter string did not influence LP's writing performance: The correct response rate was 41% for short words and 50% for long words.

Task 5: Frequency of Words

Material and Procedure. Fifty-six words were distributed in 3 groups of low ($F < 1 = 20$ items), medium ($1 < F < 30 = 16$ items), and high-frequency nouns ($F > 30 = 20$ items) (from the lists of Juillan, Brodin, & Davidovitch, 1970).

Results. A clear effect of frequency of use was noted: LP wrote correctly 60% of the high-frequency words, 69% of the medium-frequency words, and 40% of the low-frequency words (Jonckheere trend test $z = 1.73$, $P < 0.05$).

TABLE 3
Writing to Dictation According to Letter-string Length and Word Frequency

	Number of Items	*Percentages of Correct Responses*
Letter-string Length		
Short Words (4/5L)	12	41%
Long Words (7/10L)	12	50%
Word Frequency		
High	20	60%
Medium	16	69%
Low	20	40%

As indicated in Table 2, all the errors on words consisted of nonword productions. Moreover, most of them (93%) sounded exactly like the target word but did not respect French orthographic conventions. The remaining 7% of these errors corresponded to letter additions or substitutions that seemed to depend on misapplication of phoneme/grapheme conversion rules rather than on a deficit in phonological input processes. As noted previously for nonwords, LP was able to repeat perfectly all the words he failed to spell correctly. It is important to note that our patient retained partial lexical knowledge of ambiguous and irregular words (e.g. "gentil" [kind] was written *jantil*; one of the ambiguous spellings [*-il*] contained in the word being retained). From a qualitative point of view, we analysed the graphemic value conferred by LP on each phoneme enclosed in the 56-word list (Table 4). Among the 48 erroneous graphemes, 63% were substitutions, 24% were additions, and 13% were omissions. As observed by Goodman and Caramazza (1986a) and Baxter and Warrington (1987), we noted that LP substituted the most frequent graphemes for target graphemes (74%) (e.g. *ain* in *forain* [attraction-holder] was changed to *in*, which, according to Veronis's quantitative inventory of French graphemes [1988] is the most frequent graphemic value of the phoneme /ɛ̃/). Omissions also consisted in silent-letter omissions or in omissions of one of the double consonants included in the words (e.g. "vallée" [valley] was written *valée*; "monnaie" [money], *monée*). All the additions were additions of a mute consonant at the end of the word (particularly the letter t).

Another aspect of his performance that warrants mention is the variability of spellings produced for the same word (e.g. "émotion" [emotion] was written *aimaussion* or *émaucion*). Thus, the same phonological segment did not necessarily produce the same orthographic representation.

TABLE 4
Error Types in Writing from Dictation

Error Types		*Percentages*
Substitutions		63%
Phonologically Identical	93%	
More frequent graphemes (74%)		
Less frequent graphemes (26%)		
Phonologically Different	7%	
Additions		24%
Omissions		13%

Note: number of phoneme/grapheme pairs = 296; number of errors = 48.

Task 6: Writing Homophones

Material and Procedure. As for the ambiguous and irregular words, we noted errors in a list of 30 frequent homophones (15 pairs). The target homophone was presented in a sentence to disambiguate the context (e.g. LP had to write "mord" [bite], which could be confused with "mort" [death], after he had heard the sentence "le chien mord" [the dog bites]).

Results. Overall, LP wrote 16 of these 30 homophones correctly. The errors consisted of 10 nonwords (all phonologically plausible, except one), and 4 by the correct writing of the more frequent homophone counterparts. These results suggest that the patient was able to encode phonological information into graphemic segments correctly, without being able to retrieve the semantic information for disambiguation or to access the correct written form. These errors could be relevant to the general semantic impairments presented by the patient. Indeed, in some semantic exercises (definition tasks), we noted difficulties in evoking the different meanings of frequent polysemic words.

Reading Evaluation: Nonlexical Procedure

As in spelling, we distinguish the non lexical procedure and the lexical procedure of reading. The nonlexical procedure of reading was assessed by reading isolated letters and nonwords.

Task 7: Reading of Isolated Letters

Material and Procedure. The patient was asked to read the 26 upper- and lower-case letters of the alphabet.

Results. LP named quite correctly upper-case and lower-case letters presented visually (24/26 and 22/26, respectively). In the errors, the patient often uttered letter names having a physical similarity with the target letter (e.g. letters were confused: W with V, p with j, a with q, b with l, h with k); in only one case he confused the names of letters having the same phonological value (Q was read /ka/, the name of the letter K, but such an error is not unusual in normal subjects).

Task 8: Letter-matching Test

Material and Procedure. In a same-different matching test, the patient was asked to match 26 upper-case letters to the corresponding lower-case letters.

Results. LP occasionally made visual errors (24 correct responses out of 26 items) (e.g. b was paired with L and h with K). Because of the physical nature of these few confusions, we assumed a residual deficit in the perceptual processing stage as described in agnosic alexia (Lecours & Lhermitte, 1979).

Task 9: Reading of Nonwords

Material and Procedure. Nonword processing was assessed by the reading of a set of 30 nonwords and 30 regular words, paired for length and syllabic structure, randomly mixed together (de Partz, 1986).

Results. LP read nonwords (26/30) as well as words (26/30). The errors were generally similar in the 2 categories of stimuli and consisted mainly of substitutions of 5 of the 8 physically similar letters (e.g. *hatupore*: /atypɔr/ was read "katupore" and written *katupore*). Phonological substitutions were rare (2 of the 8 errors) (e.g. *idole* [idol] was read "itole").

Reading Evaluation: Lexical Procedure

Task 10: Reading Ambiguous and Irregular Words

Material and Procedure. To test LP's ability to read ambiguous and irregular words, a list of 40 words was constructed following the criteria of Beauvois and Derouesné (1981). Twenty irregular words, which contained exceptional conversions of subword orthographic segments into phonological segments, and ambiguous words, which contained orthographic segments with alternative phonological counterparts (e.g. *-ille* in French can be pronounced /ij/ in "fille" [girl] and /il/ in "ville" [town]). These words were paired in length and frequency of use with 20 regular words.

Results. The patient's performance was not significantly influenced by regularity of spelling-to-sound correspondence (regular words 19/20, 95%; irregular and ambiguous words 15/20, 75%; Fisher exact, $z = 1.31$). Nevertheless, all the errors consisted of regularisation of reading (Table 5).

Task 11: Length of Words

Material and Procedure. The possible influence of length as a variable was tested in a set of 40 words: 20 short words (3–6 letters) and 20 long words (7–12 letters).

Results. LP's performance was not influenced by the number of letters of the target: the error rate was 10% on short words and 0% on long words.

Task 12: Frequency of Words

Material and Procedure. LP was asked to read a 22-word set: 11 were frequent ($F > 30$) and 12 were infrequent ($F < 1$) (Juillan et al., 1970).

Results. No differences between high-frequency words (11/11) and low-frequency words (10/11) were observed. Because of the production of regularisation errors in reading, we assumed that LP presented a residual impairment at the level of the lexical procedure of reading.

As suggested by Patterson, Marshall, and Coltheart in 1985, impairments located at different levels of the lexical procedure could explain such a symptomatology. Thus, we assumed that LP's reading deficit could not be due to an impairment of access to the ouput phonological lexicon but rather to an impairment located on the pre-semantic level and particularly on the level of the visual input lexicon. Some arguments from a lexical decision task (Task 13) and from a detection of orthographic errors task (Task 14) tended to support this hypothesis.

Task 13: Lexical Decision Task

Material and Procedure. This task (de Partz, 1986) consisted of 80 items: 40 words and 40 nonwords. The nonwords were of 4 types (10 nonwords of each type): nonwords having an illegal phonotactic and graphotactic structure in French (e.g. *pchalt*, /pʃalt/); nonwords having an acceptable structure (e.g. *puko*, /pykɔ/); nonwords visually similar to words (e.g. *bune*, /byn/—*dune* [sand-hill]); and nonwords that were homophones

TABLE 5
Errors Produced in Reading Aloud According to Regularity of Spelling

Items	*Usual Reading*	*Erroneous Reading*	*Written Word Definitions*
VOIX (voice)	/vwa/	/vwaks/	"voie de train . . ."
CAMP (camp)	/kã/	/kami/ . . . /kã/ . . . /kãp/	"c'est un endroit où on va en vacances . . ."
SCULPTEUR (sculptor)	/skyltœr/	/skylptœr/	"c'est le type qui sculpte"
GARS (young fellow)	/ga/	/gar/	"c'est ce qui concerne les trains . . . mais je mettrais E ça pourrait être /ga/ mais ça s'écrit autrement G.A.T."
SECOND (second)	/səgɔ̃/	/səgɔ̃d/	"c'est un instant précis, c'est une seconde . . ."
COLLINE (mill)	/kɔlin/	/kɔlimœ/ . . . /kɔjim/	"?"

of real words (e.g. *kok* homophone with word *coq* [cock]). The 40 words were paired in letter length with the 40 nonwords.

Results. LP made 11 errors in this test (14%). He was not able to recognise 6 out of the 40 words. On nonwords, he made 5 errors: all of them were produced with the 10 nonword homophone set of real words. This last type of error arises because the decision was made from the phonological transcoding and not from visual word recognition.

Task 14: Detection of Orthographic Errors

Material and Procedure. In this task, the patient was invited to detect and correct 80 regularisations of spelling errors in a text. All these errors were issued from the errors LP produced in tests or exercises.

Results. LP failed to find 30% of them and made 7.5% false recognitions. In the 56 errors detected, the patient was able to correct 39% with confidence, 28% with doubt, and he produced 33% erroneous spellings. Thus, LP seemed to be unable to decide from some orthographic cues if a written sequence did or did not belong to French written language.

Task 15: Comprehension of Homophones

Material and Procedure. LP had to read, then to match, 30 target written words, either ambiguous or irregular, to a semantically related written word included in a list of 3 words. Distractors consisted of one neutral word and one word semantically related to the incorrect reading of the target word if a regularisation did occur (e.g. the written word *gars* [boy], pronounced "ga" had to be read aloud then matched to the semantically related word included in the set of three: (1) *fille* [girl] [correct response]; (2) *pomme* [apple] [neutral distractor]; (3) *train* [train]—i.e., a related word to the word *gars* if it was read "gare"—[station]).

Results. LP made 18 errors (see Table 6): 16 of them consisted of words related to the homophone. For example, when LP read the irregular word *gars* (boy) as "gare" instead of "gars," we noted that he also failed

TABLE 6
Distribution of Responses in Comprehension of Homophones

Correct Choice	*Word Related to Homophone*	*Neutral Distractor*
12	16	2

to match this written word to the correct semantic written associate. Indeed, he matched *gars* with *train* (train) instead of *fille* (girl). This written comprehension of homophones and ambiguous or irregular words demonstrated that he generally could not understand words he was not able to read aloud correctly.

From these arguments, we assumed that the errors in reading were due to a deficit located at the pre-semantic level and particularly at the visual input lexicon. Because of a failure at this level, the patient used the nonlexical procedure as an alternative strategy, and activated a semantic representation via the auditory input lexicon. However, this interpretation was insufficient to account for all the written comprehension errors. Indeed, in the matching task (Task 15), 6 irregular or ambiguous homophones out of a list of 13 were successfully pronounced, but nevertheless incorrectly matched (e.g. *choeur* [chorus], pronounced /koer/, was matched to *estomac* [stomach] in the set *estomac—frère* [brother]—*chanter* [to sing], the patient confusing *choeur* with its homophone *coeur* [heart]). As suggested by Coltheart, Masterson, Byng, Prior, and Riddoch (1983), the correct lexical orthographic specification had provided access to a lexical phonological representation but had been unable to provide access to meaning. The semantic difficulties appeared in tasks other than reading: When the patient was asked to define the different meanings of 20 frequent polysemic words presented in auditive modality, he was unable to evoke all the meanings of 40% of them (e.g. among the different meanings of "livre" [book, he or she delivers, pound], the patient evoked only the meaning of book).

From this pre-therapeutic investigation, we concluded that LP presented an important dissociation between the phonological and the lexical writing procedures. The effects of regularity of spelling and frequency of use and the production of spelling regularisations suggested that he was forced to rely on the conversion of sub-word phonological segments into orthographic segments when he failed to access spellings stored in the orthographic output lexicon. Residual reading impairments were located at two levels: in the access to the visual input lexicon, often preventing the patient from judging as true or false his own written productions, and in the access to the semantic level because of homophone confusions and a semantic deficit not limited to reading.[2]

[2]Given that the patient had presented some signs of neglect in the right hemifield, one may question our analyses by suggesting that some reading errors would have been due to after-effects of neglect. However, some arguments tend to eliminate this hypothesis.

1. In case of neglect, no effect of lexical variables (such as regularity of spelling, frequency of use, length, . . .) are predicted (Ellis, Flude, & Young, 1987), whereas LP's errors were influenced by regularity of spelling and frequency of use. In case of neglect, one may have

Writing Therapy

The therapy was conceived in two stages: firstly, the relatively spared phonological procedure in writing was reinforced by reteaching LP some conversion rules sensitive to the context. Secondly, the correct writing of ambiguous and irregular words was specifically trained with a visual imagery strategy. Indeed, the residual lexical process impairment in reading prevented the patient from using reading as a backup procedure to identify his spelling errors in written productions. Moreover, we had to take his verbal memory deficit into account by using a treatment procedure that did not require too much of a verbal memory load.

At the different stages of the therapy, the previously described list of 56 words issued from the Beauvois and Derouesné battery (see Task 3) was administered as a baseline to control the effectiveness of the different learned strategies.

First Stage: Reteaching Defective Conversion Rules

Material. Like Hatfield (1982), we tried to reinforce the relatively spared phonological procedure in writing by reteaching LP some spelling rules. This relearning was conventionally didactic and verbal. To select these rules, we analysed the 48 spelling errors scored in the 30 erroneously written words out of the Beauvois and Derouesné 56-word set and the 318 spelling errors observed in the 250 erroneous words produced by LP in response to the 1000 high-frequency written words taken from Juillan et al.'s dictionary (1970). Within these 2 error sets, 12 (25.5%) and 42 (13%) errors respectively would have been avoided if some rules had been applied correctly. Five frequent rules requiring no technical knowledge of the French language (e.g., etymology) were selected and retaught to LP: He was trained as follows:

1. to use derivation of lexical morphology as a backup procedure to find the mute consonant at the end of the word (e.g. *rond* [round]—*ronde*; *plomb* [lead]—*plombier* [plumber], . . .);
2. to suppress the letter E that LP habitually added to verbs ending with *-ir* (e.g. *finir* [to end] instead of *finire*);
3. to convert the phonemes /s/ and /z/ in an intervocalic position (e.g. *boisson* [drink] instead of *boison* /bwazɔ̃/);
4. to observe the relative frequency of translation of phoneme /ʒ/ into graphemes G or GE instead of J inside the word (e.g. *pigeon* [pigeon] instead of *pijon*);
5. to use the conversion rule of phoneme /o/ to grapheme EAU instead of AU at the end of the word (e.g. *bateau* [boat] instead of *batau*).

Procedure. This reteaching was direct and the methodology could be described as follows:

1. each rule was presented and explained to LP;
2. each rule was trained separately in different written tasks (writing from dictation, sentence and text completion);
3. all 5 rules were then practised in the same kind of written exercises;
4. in case of errors, the rule was explained again to the patient and the correct written form was presented to be read and to be copied.

The therapy was administered 3 times a week for 6 months. None of the words chosen from the Beauvois and Derouesné 56-word set nor words chosen from the 250 errors produced in response to the 1000 high-frequency written words were used in this stage of the therapy.

To demonstrate the specific effect of this therapeutic programme, we expected to record a significant diminution of errors explained by misapplication of rules and no effect on errors resulting from other deficits observed on ambiguous and irregular words. If diminution was equally reported on these different classes of errors, we would have to conclude a nonspecific effect of the programme (product of spontaneous recovery, increased attention, or motivation, . . .).

Results. After 6 months (18 months post-onset), 1 of the 2 sets (the 56-word list from the Beauvois and Derouesné (1981) battery) was re-administered to the patient. As indicated by Table 7, a general diminution of errors resulting from misapplication of learnt rules was evident

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noted an effect of lexicality in the sense that more errors have been observed on nonwords than on words (Sieroff & Posner, 1988). On the contrary, LP produced more writing errors on words than on nonwords.

2. Reading errors of neglect patients have been described as visual errors including initial letter (in left hemineglect) or final letter (in right hemineglect) and the majority of these errors consisted of substitution or omission of letters to the left (or to the right) neglect point. As noted by Ellis et al. (1987, p. 446) "none of the errors made by [his patient] VB, can be interpreted as initial phoneme substitutions not supported by the orthography of the target (i.e. there are no errors of the form * BOOT→flute)." In LP, the majority of errors consisted of regularisation and depended consequently on the orthography of the target.

3. Nevertheless, to eliminate the neglect hypothesis definitively, we have calculated a Laterality Index (adapted from Sieroff, Pollatsek, & Posner, 1988): All the words (N = 30) composed of 4, 5, 6, 7, 8, 9, or 12 letters from the Beauvois and Derouesné battery were divided into 2 segments: the left and the right segments composed of the 2 extreme letters of the word. LP made 14 errors on the left segments and 20 errors on the right. Such a difference is not significant (chi quare [1] = 2.42) and suggests that errors could not be due to the right hemineglect phenomenon. The small difference between left and right end in favour of the right is in fact due to LP's tendency to add some mute consonant at the end of the word.

TABLE 7
Results After Reteaching Defective Conversion Rules (Percentage Correct)

	Pre-therapy	Post-therapy
Nonwords (N = 50)	88%	96%
Regular Words (N = 12)	58%	100%
Ambiguous Words		
D.O.A. = 1 (N = 12)	58%	67%
D.O.A. = 2 (N = 12)	33%	42%
D.O.A. = 3 (N = 8)	38%	50%
Irregular Words (N = 12)	33%	42%

(McNemar's Test [1] = 5, $P < 0.05$), whereas the score of errors with ambiguous and irregular words (McNemar's Test [1] = 0) observed in post-therapy was similar to that of pre-therapy.

We assume that this improvement was due to the therapy and particularly to the application of the five rules. Moreover, some new errors appeared that corresponded at this time to the inadequate application of learnt rules. For example, "bicyclette" (bicycle), which was written *bicyclète* in pre-therapy (September '85) but *bissiclaitte* (April '86), post-therapy. This error corresponded clearly to the erroneous application of a taught rule requiring the doubling of grapheme S in an intervocalic position.

Moreover, the second application of the Beauvois and Derouesné word list gave us the opportunity to evaluate the consistency of LP's errors. This criterion is one Shallice (1987) proposed to diagnose two varieties of deficit: a loss of representations and a problem of access to spared representations. The error consistency would support the hypothesis of a loss of representation and, conversely, the error inconsistency would support a problem of access to spared orthographic representations. So, we compared all the responses produced by LP with the Beauvois and Derouesné battery in pre- and post-therapy. This analysis has to be restricted to the irregular and ambiguous words[3], since the regular words were the focus of the therapy and were now correctly written. The results demonstrated consistency of responses for the ambiguous word set (words were correct on both occasions) (Goodman & Kruskal's Gamma, Gamma = 0.76, $P = 0.0057$) and for irregular words (Gamma = 0.8, $P = 0.0427$) (see Table 8). Thus, we could interpret LP's spelling errors as a loss of orthographic representations more than an access deficit to unimpaired orthographic representations.

Re-education was orientated with an imagery strategy that intended to re-establish lost irregular and ambiguous words and, at the same time, to take into account the poor performance in verbal memory.

[3]Words in which errors were only due to misapplication of learnt rules were excluded from this analysis.

TABLE 8
Distribution of Correct and Wrong Responses for Ambiguous and Irregular Words on Pre- and Post-test

	Number of Correct Words in Pre-therapy	Number of Wrong Words in Pre-therapy
Number of Correct Words in Post-therapy	11 ambiguous w. 3 irregular w.	6 ambiguous w. 2 irregular w.
Number of Wrong Words in Post-therapy	3 ambiguous w. 1 irregular w.	12 ambiguous w. 6 irregular w.

Second Stage: Relearning Ambiguous and Irregular Words with an Imagery Strategy

Where Hatfield (1982) proposed a conventionally didactic verbal relearning of some ambiguous and irregular words, we proposed to reteach a set of ambiguous and irregular words with cues based on imagery.

Logic of the Re-education. Data have been reported in the literature indicating that imagery could constitute an effective mnemonic aid for the learning of verbal material by amnesic patients and particularly by patients who had sustained left temporal damage (Ehrlichman & Barrett, 1983; Jones, 1974; Patten, 1972; Van der Linden & Van der Kaa, 1989). So we decided to use an imagery technique to support the access to the correct writing of some words with ambiguous and irregular spellings.[4] The general strategy we applied can be summarised as follows: For each word incorrectly spelt by LP, we associated a semantically related image with the misspelt part of the written word. Thus, we made drawings (as those illustrated in Fig. 1) according to two criteria: firstly, the drawings selectively combined with the defective grapheme shape; secondly, they were semantically associated with the written word meaning.

Our procedure thus had three main characteristics: firstly, it used imagery; secondly, the imagery cues were semantically related to the "entire word meaning;" and thirdly, these cues were selectively linked to the specific defective letters of the word in order to enhance their recovery. By using imagery in spelling, our therapy appeared similar to that of Behrmann (1987). But in fact, the two strategies were somewhat different. Indeed, in Behrmann's programme, imagery (pictorial representation of written words) was used to differentiate the meaning of the homophones in a pair, whereas in our programme, imagery (drawings embedded in the shape of the defective graphemes and linked to meaning of the word)

[4]Coltheart and Byng (1989) report the improvement of visual word recognition by the use of visual mnemonic aid in a surface dyslexic patient.

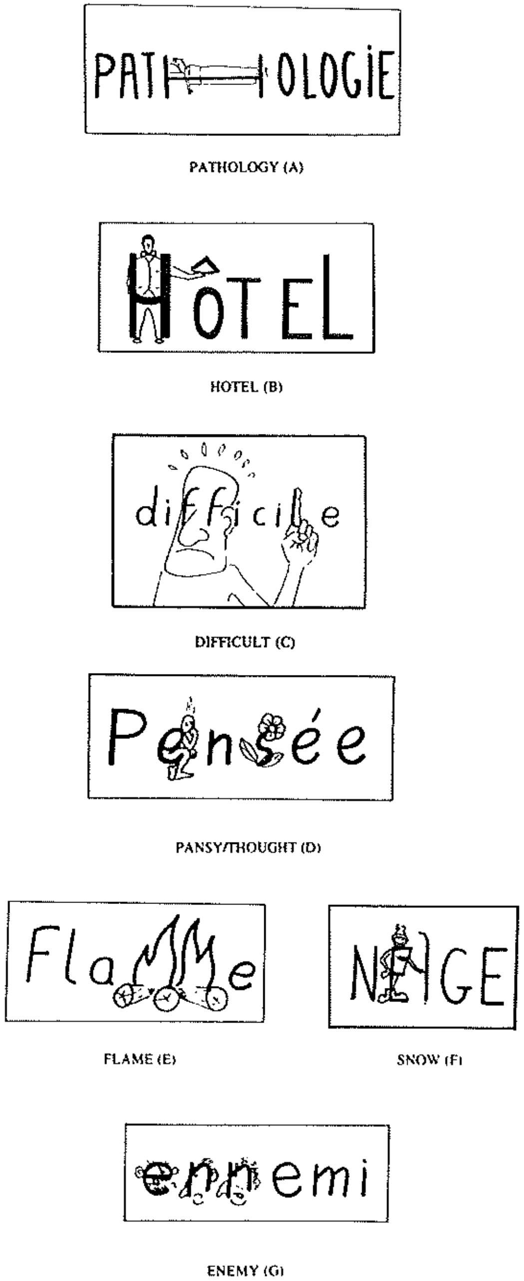

FIG. 1. Examples of drawings conceived for the imagery strategy in re-education.

consisted of cues that directly support the memorisation of the ambiguous or irregular spellings of words.

For each word introduced in the training programme, we used the following procedure:

1. The target word was dictated to the subject in order to identify the letters he could not produce correctly (e.g. *pathologie* [pathology] was written *patologie*).

2. We then tried to discover a drawing with a semantic relationship to the whole-word meaning (pathology) and capable of integrating the shape of the defective grapheme (here H). In this case, the letter H was lengthened and transformed into a "hospital bed" (see Fig. 1(A)), which has a semantic relationship to pathology. For polysemic words and when the patient made more than one error, image cues could refer to the different word meanings. For example, the word *pensée* (pansy or thought), which LP wrote *pancée* or *panssée*, was illustrated by the "Rodin thinker" in the letter E and by the flower in letter S (see Fig. 1(D)). It should be noted that, given the difficulty of imagining adequate semantic and letter-framed cues, it was necessary in some cases to change the typography.

Two points have to be emphasised: Firstly, our imagery technique was *not* concerned with teaching a letter-code system since, as indicated in Figs. 1(D) and 1(C), the same letter E could, according to the word in which it appears, be associated with different images. Secondly, the fact that for some words the patient may make different errors (e.g. *pensée* is at one time written *pancée* and in other time *panssée*) was not an obstacle for the therapy given that the same graphemes (first letter E and letter S) were concerned in the errors.

Such a procedure gives the main advantage that LP could access the correct letters when he was able to evoke the appropriate semantically related image. Of course, such a therapy is orientated to the relearning of individual words. Its effect could thus be specific to the items that were learned, and no effect is expected for untrained items.

The Methodological and Procedural Aspects of the Re-education. As pointed out by Howard and Hatfield (1987), a treatment procedure in which effects are assumed to be item-specific needs an experimental design based on a "multiple baseline," that is, we must be in a position to compare treated words with untreated words of equal difficulty. Our general baseline of the imagery strategy consisted of the Beauvois and Derouesné word set, the same as that used for the control of rules relearning. Our therapeutic 240-word set was chosen firstly from words of the 250 erroneous word set produced by LP in response to the 1000 high-frequency written words taken from Juillan et al. (1970) and which were previously used to list rules to relearn, and secondly, from a set of 20 medical terms used by the patient himself in nursing reports and generally infrequent (e.g. *pathologie* [pathology], *gynécologie* [gynaecology], . . .). Because of the lack of diminution of errors on ambiguous and irregular words in the first stage of the therapy with the Beauvois and Derouesné set and for clinical reasons (length of the examination of the whole 1000 frequently written words), the material used for this second stage of the therapy was composed of the erroneously written words out of the set of Juillan et al., except words in which we found only errors explained by the misapplication of rules (e.g. verb *finir*, erroneously written *finire*, was excluded, whereas *allemand*, written *alment*, was maintained because only the last error T could have been corrected by learned rule).

The therapy programme and its control was applied in five main stages: (1) a preliminary stage of general learning of imagery, (2) the learning of written words with embedded drawings, (3) the training of self-imagery, (4) the transfer training to spontaneous writing, and (5) the long-term duration effect of the therapy.

1. A preliminary stage: The general learning of imagery. This stage of the therapy consisted of familiarising LP with the visual imagery technique. He was trained to generate images by means of the first two steps of the procedure proposed by Branle in 1981 (Note 2) in a memory remediation programme designed to teach an imagery technique to mildly aphasic patients.

In the first *direct visualisation* step, the patient was trained to form an image based on visual support that consisted of drawings of familiar objects classified in order of increasing visual complexity. For example, LP was presented with a drawing of a banana and was invited to examine it carefully. After the drawing had been taken away, he had to form a mental image of this drawing. To check if he had actually created an accurate image of the drawing, he was asked questions about features of the object (colour, shape, detail, orientation, etc.) (e.g. Is the banana ripe? Can you describe exactly its spatial orientation?).

In the second *indirect visualisation* step, LP had to construct an image mentally from the name of an object without any visual support (e.g. Can you form a precise image of a chair?). He was then trained to draw or to describe the image he created and to answer questions about its visual characteristics (e.g. How many cross-bars does your chair have? Can you draw its precise orientation?). This preliminary stage of direct and indirect visualisation was achieved in two weeks (three times a week). Then began the spelling therapy.

2. The learning of written words with embedded drawings.

a. *Material.* At this stage, the word set comprised 120 words chosen from the therapeutic 240-word set previously described: 60 words were trained and 60 were untrained. As far as possible, these 2 word sets were paired in frequency (trained words average: 49.7; untrained words average: 48.9) and in regularity of spelling (spelling difficulty average according to Beauvois and Derouesné criteria: trained word set, D.O.A. = 1.7; untrained word set, D.O.A. = 1.9).

b. *Procedure.* Each therapy session consisted of teaching a set of approximately 5 written words with their respective letter-embedded drawings. For each word-meaning letter-shape-drawing association, the same training procedure was used and can be summarised as follows:

(i) the patient first had to copy the written word with the drawing;

(ii) secondly, he was trained to reproduce from memory the written word with the embedded drawing after a delay of ten seconds (in case of error, the copy of the word with the drawing was returned to);

(iii) thirdly, the patient was trained to produce the written word and the drawing in response to the word spoken by the therapist.

The recall of spellings and drawings was required at different intervals of retention: at the end of the therapy session and 1 day, 4 days, and 15 days later. In all these conditions, LP was invited to embed the drawing in the words.

c. *Results.* After 3 months of such training (Table 9), LP's performances showed a sharp contrast between trained words (0% of correct writing in pre-therapy and 91% in post-therapy) and untrained words (0% in pre-therapy and 30% in post-therapy) in favour of trained words. At the same time, scores at the Beauvois and Derouesné word set remained unchanged (61% in pre-therapy and 59% in post-therapy).[5] Thus, there were strong indications that the improvement was not due to a general spontaneous recovery effect.

TABLE 9

Percentages of Correct Responses After the First Step of Imagery Strategy

	Pre-therapy	*Post-therapy*
Trained Words (N = 60)	0%	91%
Untrained Words (N = 60)	0%	30%
Control List		
Beauvois & Derouesné		
(N = 51)	61%	59%

[5]Note that none of these words, except four (SOEUR, EXAMEN, DEVELOPPEMENT, MONNAIE) were trained during the therapy. These words will not be considered in the further analysis.

3. Training of self-imagery and specificity of the imagery method. In order to demonstrate more precisely the benefits of the imagery re-educative strategy, we first tried to verify that the improvements were specifically due to the imagery strategy and not simply to exercises or the stimulation effect linked to the repetitive presentation of the stimuli. Secondly, we wanted to make sure that the therapeutic effect could also be obtained when LP himself generated drawings embedded with the difficult-to-spell letters of the word, so that he could function independently of the therapist and use the imagery procedure outside of the therapeutic setting to improve his writing ability.

To demonstrate the specificity of the therapy, we compared the effect of two different re-educational strategies on LP's performance: the imagery strategy and a conventionally didactic verbal relearning like that used by Hatfield (1982) to relearn ambiguous and irregular words.

a. *Material.* At this stage, the word set[6] comprised 120 words from the therapeutic 240-word set (see Table 10): 30 words were untrained (list 1), and 90 words were trained. The trained word set was divided into 2 sub-sets: 30 words were trained with a didactic verbal relearning (list 2), and 60 words were trained with imagery strategy. In order to evaluate the capacity of the patient to generate imagery himself, these 60 words were divided into 2 separate lists: 30 words were imaged by the patient himself (list 3) and 30 words by the therapist (list 4). As far as possible, the 4 lists of 30 words were paired in frequency (frequency average; L1, 45; L2, 44; L3, 48; L4, 47.8) and in regularity of spelling (ambiguity or irregularity average: L1, D.O.A. = 1.6; L2, D.O.A. = 1.8; L3, D.O.A. = 1.5; L4, D.O.A. = 1.6).

b. *Procedure.* In each therapy session, LP was taught 6 words with visual imagery strategy (alternatively a set drawn by the patient and a set drawn by the therapist) and 3 words with the verbal didactic strategy. With this last strategy, the patient was trained to write selected words from dictation. In case of error, their correct spelling was presented by the therapist and LP was invited to copy them. The visual imagery strategy was applied according to the 3 conditions of learning considered in the previous stage: copying the written word with the embedded drawing, reproducing from memory this association after a delay of 10sec., and then producing the written word and the drawing in response to the word spoken by the therapist. As in the previous stage, the recall of spellings and drawings was also required at the end of the therapy session, 1 day, 4 days, and 15 days later. The 3 strategies of learning were, consequently, used in the same session. This learning took 3 months (3 sessions a week).

c. *Results.* As shown in Table 11, a significant training effect occurred: LP scored 72% of correct responses for trained words against 47% for untrained words. The comparison of the 2 different therapy methods indicated significant progress only for words trained with the imagery strategy (imagery strategy [patient]: chi square d.f.1 = 5.71, $P = 0.02$; imagery strategy [therapist]: chi square d.f.1 = 8.86, $P = 0.003$). Progress obtained with words trained with the classic methodology was no different from that obtained with untrained words (chi square d.f.1 = 0.60). Finally, there was no significant difference between words trained with drawings produced by the patient and those with drawings proposed by the therapist.

This result appears particularly interesting for the long-term functional use of this strategy: The patient will be able to use his own drawings with as much effectiveness as those proposed by the therapist.

TABLE 10
Description of Different Lists of Words

Lists of Words (N = 120 Words)	*Re-educative Stategy*	*Mean of Frequency*	*Mean of Regularity of Spelling (D.O.A.)*
List 1 (30 words)	untrained	45	1.6
List 2 (30 words)	trained by classic method	44	1.8
List 3 (30 words)	trained by imagery strategy (patient)	48	1.5
List 4 (30 words)	trained by imagery strategy (therapist)	47.8	1.6

[6]This word set was not used in previous therapy.

TABLE 11
Percentages of Correct Responses After the Second Stage of the Imagery Strategy

	Pre-therapy	*Post-therapy*
Untrained Words (N = 30) List 1	0%	47%
Trained Words		72%
By a classic method (N = 30) List 2	0%	57%
With drawings (patient) (N = 30) List 3	0%	77%
With drawings (therapist) (N = 30) List 4	0%	83%
Control List (N = 51) Beauvois & Derouesné	61%	63%

One must, however, point out the improvement obtained for the 30 untrained words. In pre-therapy, LP was able to write none of them, but after therapy he correctly spelled 47% of these frequent words. The interpretation of what looks like a "spontaneous" recovery requires clarification. Indeed, this improvement with the untreated words could be due at least partly— and possibly even wholly— to the patient's inconsistency across testing occasions. Thus, we considered the performance of LP in writing a subset of the Beauvois and Derouesné list, that is 32 ambiguous words corresponding to the words used in this stage of the therapy. This word set was presented twice and we showed previously that the subject was consistent (Goodman & Kruskal's Gamma = 0.76; Z = 2.53, $P = 0.0057$). However, that consistency was not absolute. From this sample, we estimated that the probability of producing errors on a second occasion when the first trial had failed was about 0.67, i.e. significantly more than the chance level but below a perfect consistency. If we consider now the word sets used in therapy (30 untrained words, 30 words trained by classic method, and 60 words trained with imagery strategy), we can expect to observe 20 errors out of 30 items and 40 errors out of 60 items in the second test by considering that all these words elicited errors on the first test. From this point of view, the comparison of observed and expected numbers of errors for trained and untrained words demonstrated that the improvements obtained with untrained words can partly be due to some inconsistency of performance (chi square d.f.1 = 3.25, $0.05 < P < 0.10$). However, that hypothesis must definitely be rejected for words trained with imagery strategy (chi square d.f.1 = 19.7, $P < 0.001$).

If inconsistency of errors can partly explain the improvements with untrained words and with words trained with a classic method, we are not sure that there is no generalisation of the visual imagery strategy to the non-trained words: When a subject has learnt to generate images in relation to words, one cannot prevent him from using such a strategy in other sets, and more especially when these words are frequent and perhaps used by LP in daily life. At the same time, we pointed out that the performances obtained on the Beauvois and Derouesné 51-word list did not reveal any significant progress: LP produced 61% correct responses in January '87 and 62.5% in January '88. According to the stability of our baseline (Beauvois & Derouesné set of words) (see Table 11), we assumed that these improvements were not due to general effects such as spontaneous recovery or increased motivation.

4. Transfer of training to spontaneous writing. At this stage of the re-education, our objective was functional. We tried to guarantee the transfer of the learning with drawings to spontaneous writing. Thus, we trained LP to detect trained words in spontaneous productions and then to produce each of them with their respective drawings. This last stage of the therapy was also intended to extend the use of the lists of trained words by teaching the patient to use them for derivational forms (for example, the drawings embedded in the word *flamme* [flame] could also be used for *inflammation* [inflamation], *inflammable* [inflammable], etc.). As noted in the first stage of the therapy and from a clinical point of view, the ability to derive words from a target word was not error free. This learning took three months (three sessions a week).

TABLE 12
Evaluation of the Long-term Validity of the Imagery Strategy
(Percentage Correct)

	End of Therapy	*6 Months Later*
First Stage		
Trained Words (N = 60)	94%	87%
Second Stage		
Trained Words (N = 90)		
Classic method (N = 30)	57%	63%
With drawings (patient) (N = 30)	77%	73%
With drawings (therapist) (N = 30)	83%	77%
Untrained Words (N = 30)	42%	50%
Control List (N = 51) Beauvois & Derouesné	61%	62.5%

5. The long-term validity of the therapy. The stability of the effects of the treatment was measured by testing the patient again six months after the end of the therapy. As indicated in Table 12, LP's performance remained relatively stable after the discontinuation of the therapy.

If we compare the performance obtained at the end of the therapy and the performance 6 months after therapy, we note no significant difference for words imaged by the patient (Haber test: Z = 1.2), for words imaged by the therapist (Haber test: Z = 0.26), for words trained by the classical method (Haber test: Z = −1.08), for untrained words (Haber test: Z = −1.58), or for Beauvois and Derouesné's list (Haber test: Z = −0.85).

CONCLUSION

On the basis of a theoretically motivated analysis, we interpreted LP's writing performance as the result of a deficit in the orthographic output lexicon caused by a loss of orthographic representations. The patient wrote mostly using the phonological route. Apart from this major deficit, however, the patient presented a residual impairment in reading that we located at two levels: Firstly, at the visual input lexicon, which prevented him from correcting his writing errors, and secondly at the semantic level itself.

Thus our therapeutic programme developed in two stages. In the first stage, we tried to reinforce the relatively spared phonological procedure in writing by teaching the patient contextual conversion rules. This strategy enabled LP to improve his written performance. In the second stage, we proposed to reteach the spelling of some irregular and ambiguous words by means of a technique that took into account his relatively spared performance in visual memory tasks. Hence, for each word incorrectly spelt by LP, we associated a semantically related image with the misspelt grapheme shape of the written words. In post-therapy, we observed a selective training effect with imagery strategy; the words trained with the visual-imagery strategy improved significantly in comparison with untrained words and with words trained with a classical methodology. Moreover, the lack of a difference between words trained with drawings produced by the patient and those produced by the therapist indicated that the patient, in a long-term functional perspective, is able to use his own drawings with as much effectiveness as those proposed by the therapist. The stability of these different effects was corroborated six months after the end of therapy, at which time the performance profile was not significantly different from that obtained at the end of the therapy.

In a critical and provocative discussion of recent works in cognitive rehabilitation in neuropsychology, Caramazza (1989) expressed scepticism about the value of using cognitive investigations as a basis for theoretically motivated approaches in rehabilitation. Some of his arguments are relevant to LP's re-education as well as to other cognitive re-educational schemes.

One point raised by Caramazza concerns the nature of the relationship that can be established between a cognitive approach to the disorders (i.e. its interpretation in terms of a specific alteration of a hypothetical model of normal cognitive functioning) and the organisation and content of the therapeutic practice. More explicitly, Caramazza (1989, p. 393) stressed that the characterisation of the patient's deficit presents no "transparent" consequences for therapeutic practice, and consequently, "A cognitive theory is not a theory of cognitive rehabilitation . . . because the content of our cognitive theories does not specify the modifications that a damaged system undergoes as a function of the different types of experiences with which a patient may be presented." One may agree with Caramazza when he asserts that the relationship between cognitive theories and therapeutic practice is not "transparent" and thus that the cognitive interpretation of a disorder is not of itself sufficient to specify the strategy that has to be selected. In the same way, when the windscreen wipers of a car are defective, one may decide to change them, to avoid driving the car when it is raining, to buy a new car, or to use a string to move the windscreen wipers manually. Nevertheless, knowing the cause of the deficit could orientate the restorative strategy: In our example, it could be instructive to learn that the battery is dead. Even if this example concerns the material cause of a deficit, the situation is not fundamentally different from the identification of a cause in a cognitive architecture. Thus, we disagree with Caramazza's point of view (1989, p. 394) that "there need not necessarily be a positive connection between just any type of detailed analysis of a patients' performance and efficacious therapeutic intervention." This is precisely what has occurred in agrammatism therapy administered by Jones (1986) and Byng (1988), in reading therapy presented by Beauvois and Derouesné (1982), and in our own present case. Indeed, *because* Byng interpreted BRB's disorder as an impairment of the procedures that map thematic relations in sentence comprehension and production, she focused her therapy *specifically* on comprehending thematic relations in written active sentences; it is on the basis of a similar hypothesis that Jones developed a therapy programme that also concentrated on the mastery of thematic relations. In the same way, it is because Beauvois and Derouesné interpreted MP's disorder as an interference between visual and verbal procedures in reading that they rejected using gestures as an input allowing identification but proposed instead gestures associated with an arbitrary verbal code as a relay between visual perception and verbalisation. Finally, it is because the spelling deficit of our patient was interpreted as a loss of orthographic representations of some words associated with a residual dyslexia and verbal memory deficits that we decided to re-establish the lost spellings by an imagery technique that took into account the well-spared performances in visual memory. Thus, even if the relationship in therapy between the cognitive analysis and the stimuli and method used is not direct and simple, the interpretation of the deficit exerts major constraints on the choice of the therapeutic strategies and thus determines some aspects of the way stimuli are presented, the nature of the stimuli, and the selection of the patient's response.

Nevertheless, one may argue, as did Caramazza, that a more phenomenological description of the patient could have resulted in essentially the same therapeutic approach. Before considering this possibility on a theoretical level, it should be noted that, in actual practice, this was not the case, since in all the experimental cognitive therapies mentioned here (except our own) the cognitively orientated approaches were used only after classical therapies failed to improve the patient's repertoire. Nevertheless, on a theoretical level, one could postulate that a therapist could try to apply by trial and error all the conceivable methods of re-education, or could test in succession all possible facilitation procedures (as well as all the combinations of these facilitations) and that, sooner or later, he will have selected the best one. The difficulties with such an approach is that it would be time consuming and that, given the diversity of cognitive disorders, the reasons for its success or failure would always remain mysterious.

Given that the interpretation of a cognitive disorder does not completely determine what the therapeutic exercises and methods will be, it is still insufficient to establish that a therapy is successful to validate the hypothesis at its origin. Many other theoretical possibilities have to be considered. For example, the success of a therapy could be interpreted in reference to another interpretation, and another therapy incompatible with the theoretical model might also prove to be equally efficient. Furthermore, any therapeutic attempt risks being influenced by the well-known Rosenthal and Hawthorne effect. The most elegant solution has been put forward by several authors (Coltheart, 1983; Howard & Patterson, 1989; Lapointe, 1978; Seron, 1979) using a crossover temporal design with a single case, that is, to try, with the same subject, different methods in succession according to different hypotheses. Whatever its intrinsic limitations (motivational variables, transfer of learning from one method to another, strategic adaptations, and so on), this is exactly the requirement that we tried to meet with LP by comparing specific imagery training to a classical corrective approach. Our results indicated a greater effect with the imagery strategy but also indicated that it is very difficult with human beings to be sure that there is no contamination from one strategy to another; when a subject has learned to generate images in relation to words, one cannot prevent him from using such a strategy. This was precisely what occurred in the delayed evaluation of the two methods of re-education.

Nevertheless, Caramazza's scepticism underlines an important point: Several critical aspects of a therapeutic methodology are not at present determined by a pre-therapy cognitive analysis. This is the case with many procedural aspects of therapy, such as the number of exercises by items and sessions, the spacing of exercises in time (distributed or massed), the rules of progression from one level of difficulty to another, and so on. At this level of therapy organisation, we think that general learning principles could fruitfully be applied. It is probably not by chance that some of the therapies that have proved to be successful in neuropsychology (such as, for example, the M.I.T. of Sparks & Holland [1976], the systematic neglect therapy programme of Diller et al. [1974], and the vanishing cue method for memory disorders of Glisky & Schacter [1987]) were organised precisely by the application of well-known principles of operant conditioning and behaviour modification (Seron, Lambert, & Van der Linden, 1977). The cognitive interpretation of a disorder is thus only a point of departure.

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