# PERIPHERAL ASPECTS OF WRITING CAN BE DIFFERENTIALLY AFFECTED BY SENSORIAL AND ATTENTIONAL DEFECT: EVIDENCE FROM A PATIENT WITH AFFERENT DYSGRAPHIA AND CASE DISSOCIATION

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### Abstract

This study reports a patient with right posterior cerebral atrophy who was affected by afferent dysgraphia, characterised by case dissociation: cursive better than upper-case print. The patient also had severe visuocostructional deficit and simultanagnosia. The hypothesis advanced to explain this dissociation is that cases are not equally dependent on visual and kinaesthetic control. Thus, if visual and kinaesthetic feedback (or the attention to them) are impaired by cerebral lesions, upper case can be expected to be more impaired than cursive.

## INTRODUCTION

All writing disorders that originate from deficits of the graphemic level and downstream are included in the so-called peripheral dysgraphia (Ellis, 1988; Margolin and Goodman-Schulman, 1992), as opposed to central dysgraphias due to lesions that affect lexical and sublexical processes up to the production of an abstract graphemic representation of the word (or non-word).

According to current cognitive models on writing processing, each component letter of a word stored at the graphemic level requires the activation of the appropriate allographic unit within an allographic level of representation. In fact, graphemes can assume different physical forms for writing in upper or lower case, in script or cursive. The graphic motor pattern (Margolin, 1984; Ellis, 1988; Margolin and Goodman-Schulman, 1992) will specify "size, position and order of strokes" (Ellis, 1988) requested to realise the allograph.

The general validity of this model, which was articulated to account for data on normal letter level slips of the pen (Ellis, 1988), receives support from pathology. Patients have been described with selective deficit at the grapheme level (Miceli, Silveri and Caramazza, 1985, 1987; Caramazza, Miceli, Villa et al., 1987; Hillis and Caramazza, 1989), at the allographic level (Rosati and De Bastiani, 1979; Rothi and Heilman, 1981; Kapur and Lawton, 1983; Goodman and Caramazza, 1986; De Bastiani and Barry, 1989; Patterson and Wing, 1989) and at the graphic motor pattern level, both in activating the adequate motor patterns (Hatfield and Patterson, 1983; Baxter and Warrington, 1986; Papagno, 1992) or in executing them (Hécaen, 1967; Hécaen and Marcie, 1974; Lebrun, 1976; Margolin and Binder, 1984; Lebrun, 1985; Ellis, Young and Flude, 1987).

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This study describes a patient, RI, with difficulties in executing graphic motor patterns. This deficit, originally called spatial (Hécaen, Penfield, Bertrand et al., 1956) or afferent (Lebrun, 1976) dysgraphia, has been repeatedly described in the past, in association with right hemisphere lesion (Hécaen, 1967; Assal and Zander, 1969; Hécaen and Marcie, 1974). At variance with dysgraphias associated with lesions in the left hemisphere, afferent dysgraphia has been interpreted as a spatial disorder that affects the "act of writing" (Lebrun, 1976) rather than as a linguistic deficit, since the right hemisphere subserves the processing of visuospatial information and proprioceptive information involved by the spatial components of writing. The main characteristics of afferent dysgraphia consist (Ellis et al., 1987) in the tendency to omit and reduplicate letters and strokes, in the difficulty to write horizontal lines and in the tendency to write on the right hand side of the page.

The patient hereby described, who suffered from a focal progressive degenerative pathology involving the posterior areas of the right hemisphere (De Renzi, 1986), presented a typical afferent dysgraphia, and, in addition, a dissociation between preserved ability to write in cursive case and difficulty to write in upper-case print.

Upper case and lower case can be differentially affected by brain lesions whit a predominant impairment of the former (Patterson and Wing, 1989) or of the latter (DeBastiani and Barry, 1986). Patterson and Wing (1989) hypothesised that the principal candidate locus for this dissociation was the allographic level (or physical letter code) and excluded downstream levels such as the graphic motor pattern.

In cognitive models of writing, afferent dysgraphia has been interpreted (Margolin, 1984; Ellis et al., 1987) as due to the inability to correctly execute graphic motor patterns, a performance which requires visual and kinaesthetic feedback in order to monitor handwriting movements. If RI's deficit is at the level of graphic motor patterns, this would demonstrate that the processes implicated in upper case and in lower case writing are separated at a lower level than the allographic level. Recently, Kartsounis (1992) reported a patient with better preservation of upper case in respect to lower case writing and attributed the dissociation to defective access to graphic motor patterns for lower case, hence suggesting the independence of the motor programs for executing upper and lower cases.

In the present patient the opposite dissociation is viewed as dependent on the greater role that the impairment of visual and/or kinaesthetic functions plays on upper case print in comparison to cursive. Thus RI's deficit would not refer to a deficit within the writing process but to the effect on writing of a more general visuospatial disorder.

### CASE REPORT

### Clinical History

RI was a 57-year old woman, teacher in the primary school, admitted at the Department of Neurology on December 1989. At the end of 1988 she begun to complain of a progressive



Fig. 1 – MRI performed on December 1993.

difficulty in object identification that obliged her to retire a few months later. She consulted an eye specialist that excluded peripheral damage and suspected a central neurological deficit. At admission, RI was well oriented in time and in place. The neurological examination was normal, except for a visual agnosic disorder, and occasional left extinction to tactile and visual double stimulation. CT scan showed a mild atrophy in the right parietal and occipital areas. The patient was discharged with the diagnosis of focal degenerative brain pathology.

She was controlled as out-patient on May 1990 and September 1990. On December 1990, she was re-admitted to the hospital and submitted to a single photon computed tomography with 99Tc-HMPAO, which showed decreased perfusion in the posterior areas of the right hemisphere. She was further examined as out-patient on October 1991 and February 1992.

Visual spatial ability progressively got worse, while other cognitive functions remained generally good. Her relatives confirmed that, with the exception due to the visual problems, RI successfully attended everyday activities. In the last control, RI seemed to be a little slower, and to have some difficulties in moving in space. However, she was still oriented in time and in place and had preserved linguistic and memory functions.

The patient was examined again on December 1993. She was markedly impaired in all visuoconstructional and visuospatial tasks. Writing and reading were virtually impossible. Severe limb apraxia, but not oral apraxia, was detected. Visual fields were normal at clinical examination, but the patient systematically extinguished the left stimulus in tactile and visual double stimulation and clearly neglected the left half of space when she performed visual tasks. Visual analysis of pictures was typical of severe simultanagnosia. Verbal memory was moderately impaired. Naming on oral description as well as spontaneous speech and episodic memory remained good. MRI confirmed the right posterior atrophy (Figure 1).

# Neuropsychological Examination

The more extensive evaluation was done on December 1990, when the patient was admitted to the hospital for the second time.

## Language

No sign of aphasia was present. Spontaneous speech was flawless and adequate to the patient's level of education. She was extremely accurate in describing her deficit, showing to be aware of her impairment. Confrontation naming was poor because of visual errors. She was able to recognise only 28 out of 70 pictures of objects and animals, and 10 out of 20 visually presented objects, whereas she immediately recognised all of them when they were presented in the tactile modality. The fact that responses were referred to part of the object suggested simultanagnosia. She produced a normal number of items in a word fluency task. Language comprehension could not be formally evaluated with visual stimuli, but her ability to comprehend and to execute complex verbal orders was normal. She was always very accurate when asked to describe the structural and functional features of verbally given stimuli. She could write correctly though slowly in cursive, only demonstrating some difficulties in maintaining horizontal lines and the regularity of the margins. Upper case writing was poor. No tendency to neglect the left-hand side of the page was observed. Reading was dominated by visual errors. Only occasional neglect errors were produced. There was no part of speech effect but only a slight effect of frequency and length. No tendency to letter-by-letter reading was detected. Reading sentences was virtually impossible.

### Memory

Verbal memory (immediate and delayed free recall of 15 words) was in the normal range: immediate recall: 37/75; delayed recall: 9/15 (cut-off: immediate recall: 35/75; delayed recall: 7/15). Digit span was 6 forwards and 4 backwards. Verbal span (words) was between 4 and 5. Spatial span was 4 forwards. In spite of her difficulty in object recognition, she demonstrated a normal ability to perform a Visual Memory task in which 10 pictures of coloured objects and animals were first presented and then had to be recognised among 40 foils.

# Visuospatial and Praxic Tasks

RI correctly performed, even though slowly, line and letter cancellation tasks without neglect for the left side. Left-right orientation was good. Copying threedimensional drawings was severely impaired. The performance was better with bidimensional drawings. Neither oral nor limb apraxia was detected. Over time, however, limb movements became progressively slower and clumsier.

## Visuoperceptual Tasks

The patient was able to name 20 out of 20 colours, and to correctly point to 20 out of 20 colours in multiple choice tasks with three foils. She was able to identify geometrical figures (15/15) only when they were of small size (up to 2-3 cm). She could not read global letters composed of smaller letters, but she was able to read the small components letters. The patient never complained of difficulty in face recognition, nor in recognising relatives or friends or the

doctors of the medical staff. She was able to identify 9 out of 10 famous faces and her score was borderline (39) at the Benton Facial Recognition Test.

# Writing and spelling

On May 1990, at the first control after the discharge, she complained of writing disorders, mainly in upper-case print. She claimed that her pre-morbid writing in both upper and cursive case was perfect (she was a teacher!). She refused to write in lower script case, since she never used to. In the first session non-words were also given; writing difficulties were precisely of the same order than with words. In addition, she demonstrated the same proficiency in spelling aloud words and non-words. For these reasons, only words were given in the experimental testing. The same words were generally given for upper case, cursive writing and oral spelling. Almost all lists of words given were controlled for length, word frequency and grammatical class. Sometimes, additional words were given for cursive writing, in order to increase the number of errors available for the analysis. The ability to write single letters in the two cases was also explored. Writing with letter blocks was prevented by the patient's dyslexia and, mostly, by severe difficulty in visual exploration.

# Qualitative Aspects of Writing

Samples of RI's writing in cursive and upper case collected over sessions are shown in Figure 2. In the first session (May 1990) (Figure 2A) cursive handwriting was good both for single letters and words, even if words tended to slop down on the right side of the line. No irregularity of the left-hand margin was observed. Letters had normal shape and size and their spatial relation within the word was respected. Writing speed was mildly reduced. When the patient was requested to write with eyes closed her performance deteriorate only marginally.

Upper-case print was, on the contrary, laborious, and markedly slower than cursive. The component strokes of letters were properly selected but inserted in anomalous position. Spatial relations among the component letters of a word were not respected. The occasional errors produced in cursive handwriting were generally letter omissions, particularly, omissions of geminate letters. Errors produced in upper case included both stroke errors within letters and letter errors within words, particularly, omissions, mislocations and repetition of stroke and omissions and repetitions of letters. When the patient was requested to write in upper case with eyes closed, an increasing number of errors and a clear alteration of the spatial relationships among the strokes within a letter and of the component letters within a word was observed.

On October 1990 (Figure 2B), the cursive did not show any significant worsening, while upper case writing was markedly deteriorated, with an increased number of errors. Although able to select the component strokes in proper sequence, RI found difficulty in identifying their correct direction and position. This was particularly evident with eyes closed; words were not legible for a person who did not follow the patient's hand while writing. On December 1990,

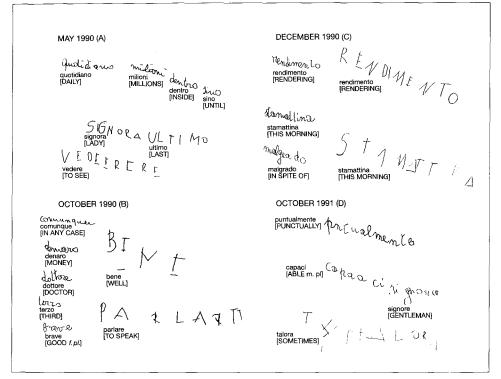


Fig. 2 – Samples of RI's handwriting collected over four sessions (from May 1990 to October 1991).

patient's writing did not seem markedly modified (2C) but a little slower.

One year later (October 1991), some more difficulties were detected also in cursive (Figure 2D). Writing in upper case was dramatically worse and very slow (on a sample of 44 words written both in cursive and upper case the mean time for writing single words was 7.11 sec and 50.93 sec respectively). The patient often complained to be unable to remember which letter of the word she was writing. Requested to write with eyes-closed, she stated to be unable to do it. When forced to write, the production was very slow (more than 10, 20 sec for each letter!) and difficult to interpret, mainly for the tendency to overlap the component strokes of letters and the component letters of the words.

Single letter writing was qualitatively comparable to writing letters in words. Figure 3 reports two examples of RI's spontaneous writing on October 1990 and one year later.

# Qualitative Analysis of Errors

Table I reports the error rate for words written in upper case print, over the four sessions. The progressive increment of errors is evident.

Table II summarises the percentage of the various types of stroke and letter errors produced in cursive and in upper case over the four sessions.

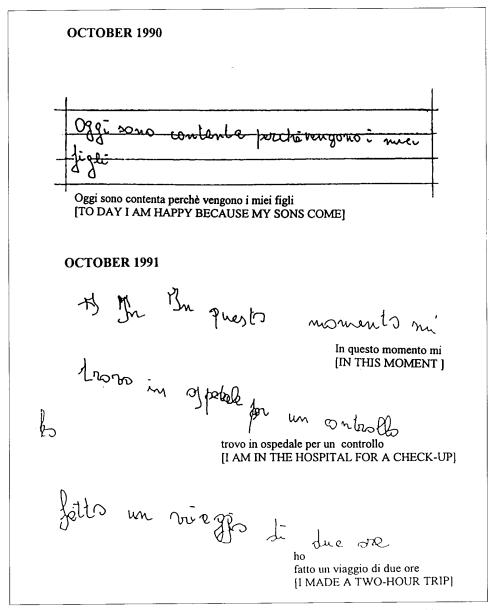


Fig. 3 – Two examples of RI's spontaneous handwriting (October 1990; October 1991).

The table confirms that the number of errors is higher in upper case (76%) than in cursive (20%), and indicates that, while in cursive letter errors (23/34) tend to prevail over stroke errors (11/34) ( $\chi^2$  = 8.47, p<.0036), in upper case the opposite pattern is observed (stroke errors 75/95 versus letter errors 20/95) ( $\chi^2$  = 63.68, p<.000). In upper case, omissions (of strokes and letters) (69/95) prevailed over repetitions (26/95) ( $\chi^2$  = 38.93, p<.000). In cursive, omissions and repetitions had approximately the same incidence (16/34 vs 18/34) ( $\chi^2$  = .24,

Sessions	May 1990	October 1990	December 1990	October 1991
Number of words	32	40	47	6
Number of errors/Number of letters	12/188 (6%)	32/236 (13%)	41/341 (12%)	10/44 (23%)

TABLE I Error Rate in Upper Case Print over Four Sessions

p = .63).

Word length seemed to influence the performance. Figure 4 shows that the mean number of error tends to increase as a function of the component letters of the words.

The correlation between errors and word length was however not linear, suggesting that in addition to word length, other factors have a bearing on the performance, e.g., letters may show a different tendency to elicit errors. A significant effect of error position in the word was remarked: on a sample of 138 upper case words, RI produced more errors in the right half (85/138) of the words than in the left half (53/138) ( $\chi^2 = 14.84$ ; p<.0001).

	May	1990	Octo 1990		Dece 1990		Octo 1991	ber	Total			
	<sup>1</sup> C	U	С	U	С	U	С	U	С	U		
Number of words	47	32	49	40	47	47	28	6	171	125	Tota	1
Number of errors	5	12	6	32	7	41	16	10	34	95	С	U
Letter omission % Letter repetition% Stroke omission % Stroke repetition%	80 0 20 0	8 25 33 33	0 50 50 0	3 0 59 37.5	14 28.5 57 0	27 0 61 12	12.5 69 6 12.5	40 0 40 20	21 47 26 6	19 3 54 24	68 32	21 79
Total letter errors % Total stroke errors %	80 20	33 66	50 50	3 97	43 57	27 73	81 19	40 60		***		

 TABLE II

 Quantitative Analysis of the Various Types of Error Produced over the Four Sessions

 $^{1}C = cursive; U = upper.$ 

# Incidence of the Type of Error on the Various Component Letters of Words in Cursive and in Upper-case Print

Table III reports the error rate for each alphabetic letter found in a sample of 141 words written both in cursive and in upper case.

The table confirms the tendency to produce stroke errors when writing in upper case on letters with repetitive strokes (42 errors on 240 letters — "A"; "E"; "F"; "H"; "M"; "N"; "Z" — with at least 3 strokes — vs 0 errors on 116 letters — "C"; "O"; "U" — with only one stroke). In cursive, letter errors prevailed over stroke errors (omissions) which were only observed on "m" and "t". Malformations as well as mislocations are not considered in this table.

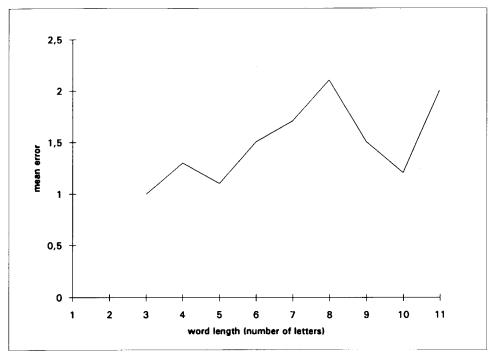


Fig. 4 – Relation between word length and the mean number of error in writing.

# Incidence of Error Produced on the Same Letters Written in Isolation and in Words

Errors produced on single letters were compared with errors produced on the same letters when written as part of words, in a sample of single letters and words written along four sessions. The comparison was confined to upper case "Z" "M" "N" "D", since only on these letters RI produced stroke errors both when written in isolation and in words. RI produced 13/102 (13%) stroke errors when these letters were written in isolation, and 27/104 (26%) stroke errors when the letters were written in words. The distribution of errors was significantly different in the two conditions ( $\chi^2 = 5.75$ , p< = .0165) confirming Ellis et al.'s observation (1987) that letters are more difficult to write as part of words than in isolation. This result, as well as the higher number of errors on the right half of the words, suggested that RI's performance seemed to be sensitive to increasing task demand.

# Relationship between Writing and Spelling

As in other forms of peripheral dysgraphia, no deficits in oral spelling was observed in RI throughout the four sessions, in which she performed correctly in 47/48, 48/48, 28/29 and 16/16, respectively.

141 words		Uppe	er case		Cursive			
Stroke Stro omission repe	Stroke repetition	Letter omission	Letter repetition	Stroke omission	Stroke repetition	Letter omission	Letter repetition	
A (N = 86)	3		2					
B $(N = 5)$								
C(N=23)				1				1
D(N=15)	1			1				
E(N=63)	11	1	3				3	
F(N=13)	8	6						
G(N=20)								
H(N=3)	1							
1 (N = 71)	3	2	2				1	
L(N=21)								1
M (N = 21)		2	2 3		4			
N (N = 47)	6	1	3	1				
O(N = 65)			1					
P(N=26)	2		2					
Q(N=3)								
R (N = 63)	2 3	1	3 3	2				5
S(N=39)	3	2	3					1
T (N = 65)	1	1		1	4	1		
U(N=28)			1					
V (N = 13)				1				
Z (N=7)	3							
Total	44	16	19	6	8	1	4	8
	Tota	al 60		ul 25	Tot	al 9	Tota	d 12
Total		8	35				21	

TABLE III Type of Errors Produced on the Various Letters in Upper Case and Cursive

### Comment

In the context of afferent dysgraphia, RI showed a dissociation between upper case and cursive writing. This finding, taken together with that reported by Kartsounis (1992), suggests that cases may dissociate at lower level than the allographic level (Patterson and Wing, 1989; DeBastiani and Barry, 1986).

In cognitive models of writing, afferent dysgraphia is interpreted, following Lebrun (1976) as a disorder of the graphic motor pattern execution due to the impairment of visual and kinaesthetic controls on hand movements due to right hemisphere lesion. According to this view, afferent dysgraphia is not a properly writing deficit, but part of a more general hand movement disorder that involves other tasks, first of all, drawing. This interpretation is supported by the observation that, unlike other forms of peripheral dysgraphias produced by lefthemisphere lesions, which can be observed in absence of major praxic or visuoconstructional difficulties, afferent dysgraphia is generally associated with visuoconstructional disorders. Baxter and Warrington (1986) described a left brain damaged patient that could not write words but wrote digits and performed well other types of nongraphic praxis. Similar dissociation of very closely related hand movements in patients with left cerebral lesion, were documented by Roeltgen and Heilman (1983), Anderson, Damasio and Damasio (1990), Coslett, Gonzales-Rothi, Valenstein et al. (1986), Papagno (1992). On the contrary,

apraxic constructional disorders, when explicitly explored, have been found consistently associated with afferent dysgraphia (see, for example, the patients described by Hécaen et al., 1956).

It remains, however, the problem to account for the preservation of cursive writing showed by RI. A possible hypothesis is that the hand movements necessary to write in upper case and in cursive differ with respect to the amount of visual and kinaesthetic control they require, because of the intrinsic structural features of cases. In upper case writing, the pen has to be continuously lifted and relocated on the paper in order to draw the component strokes of each letter and the component letters of words. Thus, the pen position must be continuously monitored to ensure the correct apposition of adjacent letters and strokes. In cursive handwriting, on the contrary, the movements tend to be continuous, only broken to dot "i", to cross "t" and to write the following word. RI's dysgraphia confirm this observation. The majority of upper case errors was made on letters with discontinuous strokes (E, F, M) and did not affect letters formed by continuous, curve lines (C, O, U) while in cursive, mislocations of i's dot and of t's cross were quite frequent.

While a "simple" defective sensorial feedback may convincingly account for the spatial features of the writing disorder (difficulty in maintain horizontal lines, mislocations, anomalous orientation of strokes, disproportional dimension), it less convincingly explains omissions and repetitions of strokes and letters. Smyth and Silvers (1987) demonstrated that, in normal subjects, the overall spatial arrangement of words on horizontal lines is affected by the absence of vision, while stroke and letter errors are produced in similar ways by the absence of vision as well as by addition of a secondary task such as counting or repeating nonsense syllables aloud. On the basis of this last observation, they concluded that vision, in addition to control writing orientation on the page, also plays a role (probably shared with the articular proprioceptive system) in maintaining the order in an output sequence of strokes.

Thus, in RI, the sensorial deficit can explain the spatial disorder of writing, while omissions and repetitions would require a more complex disorder of sensorial feedback, possibly consisting in inattention to both visual and kinaesthetic feedback during the execution of sequential movements (Ellis et al., 1987). This last disorder is supposed to be stressed in writing sequences of similar or identical strokes and letters rather than in writing different, non confusable, sequences of strokes and letters (Margolin 1984; Ellis et al., 1987; Smyth and Silvers, 1987). I addressed this issue by comparing the errors made by RI with and without the aid of vision and when she was requested to carry out with the left hand a tapping task, while writing with the right hand.

Aid Provided by Visual and Kinaesthetic Feedback and Effect of Tasks Competing with Writing for Attentional Resources

# Visual Feedback

Table IV reports the performance of RI in various conditions of writing. It is apparent that both the control of vision and the use of a felt pen (which

	May 1990	October 1990	December 1990
Upper case Eye-open Eye-closed Felt-tip pen	28/32 (87.5%) 32/9 (355%)	71/41 (173%) not evaluable	55/48 (141%) not evaluable 18/22 (81%)
Cursive Eye-open Eye-closed Felt-tip pen	2/47 (4%) 24/48 (50%)	6/49 (12%) 15/20 (75%)	6/48 (12.5%) 22/20 (110%) 2/22 (9%)

TABLE IV
Scores Obtained in Various Conditions of Writing in 3 Sessions (Number of errors/number of
words)

makes writing more legible) improved the performance.

# Kinaesthetic Feedback

When letters were passively traced out by her right forefinger, guided by the examiner, the patient was only able to identify 8 out of 30 upper case single letters and 3 out of 16 cursive single letters. She was also very poor in a comparable letter decision task when correct letters had to be discriminated from letters written in specular position, with additional strokes or upside-down. She recognised 13 out of 25 true letters and rejected 4 false letters (three normal subjects scored nearby 100% on all these tasks).

She was extremely sensitive to interfering tasks since she was virtually unable to write, only producing nonsense scrawls, when she was requested to write words with her right hand while tapping with the fingers of her left hand. When the patient was requested to write single letters, the performance did not improve. She alternated the tapping and the attempt to write, being completely unable to attend to the two tasks simultaneously.

# Effect of "Letter Confusability" on Letter Omissions and Repetitions

RI was requested to write on dictation words with one or two clusters of equal or similar letters (e.g.: ll, mm, nn, pp, tt, lt, ffl, mmu.. in cursive; BB, RR, CC, RB, LLE BBR, FFR.. in upper case) to assess whether they were more error-prone than the other letters of the words, as it occurs in patients with attentional defect to the sensorial feedback. The patient was requested to write on dictation 88 words in cursive (mean length = 6.8 letters) and 40 words in upper case (mean length = 7.6 letters).

The errors produced in cursive were very few, with a tendency to produce more letter omissions and repetitions on the letters of the clusters than on the other letters of the word (12/206 - 6% - omissions) and repetitions on one of the component letters of the cluster vs 8/399 - 2% - errors on all other letters of the words) ( $\chi^2 = 6.20$ , p = .013).

In upper case writing errors were not differently distributed between the letters of the cluster (5/96 - 5.2%) and the other letters of the words (12/210 - 5.7%) ( $\chi^2 = .03$ , p = .86). The high number of stroke errors, mostly on letters

such as "E" "F" and "N", was confirmed.

A further analysis was performed confined to geminate consonant whose errors were compared with those of the corresponding letters of the sample of words reported in Table III (in which double letters were present only occasionally). In cursive handwriting, errors produced were significantly higher in the former than in the latter sample (17/368 vs 20/201;  $\chi^2 = 5.08$ ; p = .0137). On upper case words, only a non significant increment of error was obtained on geminate letters (55/368 vs 11/94;  $\chi^2 = .64$ ; p = .42).

### Visual Imagery of Letters

RI was given a visual imagery task of upper case letters. Single letters were read aloud to the patient who was requested to tell the number of strokes, whether the letter had straight or curve strokes, was a "closed" or an "open" and, in the positive, if it was open up, down, toward left or right. Questions were balanced for positive and negative answers. She accepted as correct 23 out of 25 correct features and rejected 23 out of 23 false features.

### Comment

Both visual and sensory feedback were impaired in RI. The dramatic disorganisation of writing produced by an additional task competing for attentional resources such as the tapping task (even when performed with eyes open), suggests that also attention to the feedback was not full. The attentional defect hypothesis received further support by the higher number of errors produced on cluster of similar (or identical) letters, both in cursive and in upper case. The prevalence of letter errors in cursive, and of stroke errors in upper case can be tentatively interpreted by assuming that in cursive handwriting the elementary motor programs mainly consists of letters, while in upper case mainly consists of strokes. Consequently, an attentional fluctuation to the feedback that controls the execution of graphic motor patterns would favour, in cursive handwriting, letter errors and in upper case stroke errors.

RI's good performance in imagery tasks of letters excluded deficits at the allographic level.

### Digit and number writing

Approximately the same number of errors was produced in writing single digits (2/10; 10%) and digits within numbers (33/323; 10%). Digit errors as well as stroke errors were produced (36% digit errors; 24% stroke errors; 40% distortions). The patient showed the same slowness as in writing words.

# Drawing

Both copying and drawing on command was severely impaired (Figure 5). When presented with an object to copy, she needed long time to recognise it and, when she succeeded (in a minority of the case), she drew without checking the model. Interestingly, she tried not to move the pencil from the paper while

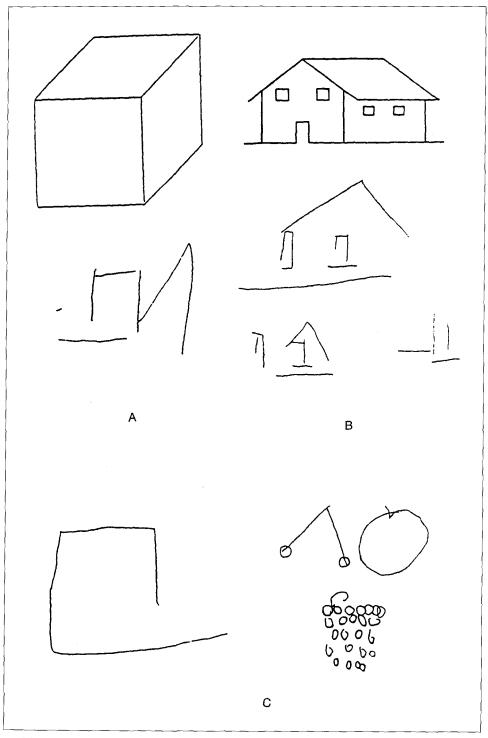


Fig. 5 - RI's drawings: copying (A-B) and on command (C).

	-			
	Large	Small	Total	
Upper case	25/35 (71%)	32/35 (91%)	57/70 (81%)	
Lower case	35/35 (100%)	33/35 (94%)	68/70 (97%)	
Cursive	29/35 (83%)	33/35 (94%)	62/70 (88%)	
Total	89/105 (85%)	98/105 (93%)		
Total	89/105 (85%)	98/105 (93%)		

TABLE V Scores Obtained in Reading Words Written in Different Case and Size (1 cm and 1/2 cm)

drawing (see the "square" in Figure 5). Qualitatively, drawings were oversimplified. The spatial relations between the various strokes were generally lost, making the object difficult to recognise.

# Reading and inverse spelling

RI produced only 3 errors (visual errors) on 189 isolated letters (in upper and lower case). She was able to correctly read 19/19 single digits, 21/23 2digit numbers, 35/42 3-digit numbers and 24/40 4-digit numbers. The majority of errors was visual in nature. Often, the patient read only some of the digits of the number, trying to guess the number.

She correctly read 14/18 (78%) upper case words on May 1990 and 56/82 (68%) upper case words on December 1990. Reading words in lower case print and in cursive was also impaired but to a lesser extent (lower case print: 79/93 - 85% - correct on October 1990 and 80/98 - 82% - correct on December 1990; cursive: 42/48 - 85% - correct on December 1990). The same types of error (visual errors) were produced on the three cases.

Since in some visual agnosic patients stimulus size can affect reading performance (Saffran, Fitzpatrick-DeSalme and Branch Coslett, 1990), the influence of size and case was controlled by giving thirty-five words in 6 different conditions: large upper case print (1 cm), small upper case print (1/2 cm); large lower case print, small lower case print; large cursive, small cursive. Results are reported in Table V.

Reading large letters was not significantly more difficult than small letters. Case significantly influenced the performance (upper vs lower vs cursive: 57/ 70 vs 68/70 vs 62/70:  $\chi^2 = 8.88$ ; p = .012). Upper case was significantly worse than lower case (57/70 vs 68/70:  $\chi^2 = 9.30$ ; p = .003); the same tendency was observed in cursive but the difference was not significant.

RI produced only one error on 40 items (10 nouns, 10 adjectives, 10 verbs, 10 function words) when requested to identify which word corresponded to the letters spelled aloud by the examiner, thus confirming the peripheral nature of her reading disorder.

### Comment

I advanced the hypothesis that case dissociation in reading was related to RI's difficulty to simultaneously appreciate discrete elements, as it occurs in simultanagnosia. As already mentioned, upper case letters are mostly formed by a series of discrete elements, the strokes, and words are formed by strings of isolated (i.e. discrete) letters. In lower case print and in cursive the discrete elements correspond more frequently to full letters and in cursive also to clusters of letters. Thus it is not surprising that upper case reading is the most penalised in a patient like RI affected by simultanagnosia, and that, in single letters and digits, reading is good.

### CONCLUSION

In line with the classical interpretation (Lebrun, 1976), afferent dysgraphia is not a writing deficit but an aspect of a complex visuospatial disorder consequent to the impairment of visual and proprioceptive feedback. The sensory deficit explains the spatial aspects of afferent dysgraphia, such as incorrect margins, sloping lines or anomalous spatial relations among strokes and letters, but not stroke and letter omissions and repetitions. These types of error seem rather generated by inattention to sensory feedback (Margolin, 1984; Ellis et al., 1987; Smyth and Silvers, 1987), namely, by an attentional deficit that prevents the continuous updating of the graphic motor programs during the production of sequential movements.

Ellis et al. (1987) argued that afferent dysgraphia could be fractionated into at least two dissociable clusters of symptoms: neglect-related features (tendency to write with a wide left margin, copying errors related to neglect dyslexia, failure to dot i's and to cross t's at the beginning of words) and feedbackrelated features (tendency to omit and repeat strokes and letters). In spite of occasional left-side extinction at double visual stimulation, at the time of the experimental testing RI did not produce neglect-related errors in writing, and feedback-related features largely prevailed.

Feedback-related features may be further fractionated into sensorial and attentional features, the former consisting of alteration of the spatial components of writing (lines, margins, spatial relation between words, letters and strokes), and the latter of omission and repetition of strokes and letters. In this perspective, afferent agraphic patients can be categorised in those who present selective damage in "spatial" components as the patient described by Hartman, Griggs and Wishwanat (1985)<sup>1</sup> and those with prominent "attentional" component, as RI.

The hypothesis of two types of feedback-related deficits (sensorial deficit and attentional deficit) may explain some difference observed between RI and the dysgraphic patient BV described by Ellis et al. (1987), who did not show case dissociation. Assuming that the sensorial deficit was more severe in RI than in VB, it may be argued that upper case writing was more impaired in the former since the spatial component is more critical in upper case writing than in cursive handwriting.

The finding that in upper case writing RI's most frequent errors were stroke errors, while in cursive letter errors prevailed can be accounted for by assuming

<sup>&</sup>lt;sup>1</sup> Cited by Margolin and Goodman-Schulman, 1992.

that graphic motor patterns would mainly correspond to letters in cursive and to strokes in upper case. Thus, the lack of attentional control which prevents an efficient updating of the graphic motor programs is more likely to elicit stroke error in upper case and letter error in cursive. Also the results obtained in writing words with clusters of similar or identical letters are consistent with this hypothesis. However, additional evidence is necessary to confirm it.

It has been claimed that cases can dissociate at the allographic level (Patterson and Wing, 1989; DeBastiani and Barry, 1986) or at the graphic motor pattern level (Kartsounis, 1992). RI's findings would confirm that case dissociates also at the level of execution of graphic motor pattern.

The hypothesis advanced to explain RI's dysgraphia assumes that cases dissociate because they are differentially dependent on sensorial efficiency and attentional resources. This interpretation is not in contrast with the hypothesis of a modular organisation of the peripheral aspects of writing, but it draws the attention to the role that non-modular factors may play in producing complex cognitive deficits.

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