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Spatial Agraphia

ALFREDO ARDILA AND MÓNICA ROSSELLI

Instituto Colombiano de Neuropsicologia, Bogotá, Colombia

Twenty-one patients with right hemisphere damage were studied (11 men, 10 women; average age = 41.33; age range 19–65). Subjects were divided into two groups: pre-Rolandic (6) and retro-Rolandic (15) right hemisphere damaged patients. A special writing test was given to each patient. The writing errors observed included literal substitutions, feature omissions and additions, letter omissions and additions, inability to maintain horizonal writing, inappropriate grouping and fragmentation of elements, and changes in handwriting style. Associated disorders included left-hemiparesis, visual field defects, spatial hemineglect, constructional apraxia, spatial alexia, and spatial acalculia. It is proposed that spatial agraphia is related to: (1) left hemi-neglect, (2) constructional deficits, (3) general spatial defects, and (4) some motor disautomatization and tendency to perseverate. In cases of right frontal damage, motor-associated deficits (iterations of features and letters) predominated, whereas in cases of posterior right hemisphere damage, spatial defects (inappropriate distribution of written material in the space, grouping of letters belonging to different words, and splitting of words) were more evident. Writing impairments are in general more noticeable in cases of retro-Rolandic damage.

Spatial and visuospatial agraphia have been considered as nonaphasic writing disorders, resulting from visuospatial defects that impair orientation and correct sequencing in writing (Benson & Cummings, 1985). It has been defined as "a disturbance of graphic expression due to an impairment in visuospatial perception resulting from a lesion in the nonlanguage-dominant hemisphere" (Hécaen & Albert, 1978, p. 66). According to Hécaen and Albert (1978) spatial agraphia presents the following characteristics: (1) some graphemes are produced frequently with one, two, or even more extra strokes; (2) the lines of writing are not horizontal but slant at variable angles of inclination to the top or bottom of the page; (3) writing occupies only the right-hand part of the paper; and (4) blanks are inserted between graphemes that make up the word, disorganizing the word and destroying the unity. Stroke and letter iterations and the

Address correspondence and reprint requests to Dr. Alfredo Ardila, Apartado Aéreo 17021, Bogotá, Colombia, South America.

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enlargement of the left-hand margin are significantly associated with right hemisphere damage, (Ardila, Rosselli, & Pinzón, 1989). Spatial agraphia has been reported in about 20% of the right retro-Rolandic damaged patients (Hécaen & Marcie, 1974).

Spatial agraphia correlates significantly with spatial alexia and spatial acalculia, and also with visual field and oculomotor defects, constructive apraxia, unilateral spatial agnosia, and loss of topographical notions (Hécaen & Marcie, 1974; Hécaen & Albert, 1978). Simernitskaya (1974) points to a deficit in automatic writing and a tendency to omit and confuse vowels rather than consonants. Also seen in cases of right hemisphere damage are changes in handwriting style, disorthography, and progressive increase of left margins ("cascade" phenomenon) (Ardila, 1984; Ardila *et al.*, 1989).

Only a few studies have been specially devoted to spatial agraphia. A further analysis of writing disorders in patients with right hemisphere damage is reported in this paper. It was hypothetized that motor-type errors would predominate in right pre-Rolandic patients, and spatial-type errors would predominate in right retro-Rolandic patients.

METHOD

Subjects. Twenty-one monolingual (Spanish), right-handed patients with right hemisphere damage were studied (11 men, 10 women; average age = 41.33; age range 19–65). These subjects presented various brain damage etiologies (vascular, 15; tumoral, 5; traumatic, 1). The cerebral damage had evolved in periods varying from 2 to 6 months. Patients had no background of previous neurological or psychiatric illness. Average schooling was 7.01 years (range = 5–15). All lesions were confirmed by means of computerized axial tomography (Figs. 1 and 2). Patients were further divided into two groups: pre-Rolandic (6 patients) and retro-Rolandic (15 patients) right hemisphere damage.

Testing procedure. In addition to the general neurological and neuropsychological exams, a special writing test was given to each subject. The following writing subtests were included:

1. Signature;
2. Writing of letters (dictation and copy);
3. Writing of syllables (dictation and copy);
4. Writing of words (dictation and copy);
5. Writing of sentences (dictation and copy);
6. Change in the handwriting style (cursive to script and vice versa);
7. Change from upper- to lowercase (and vice versa);
8. Spontaneous writing (description of a picture);
9. Spelling of words;
10. Recognition of spelled words;
11. Automatic writing (numbers from 1 to 10).

This writing test has been previously given to a normal population, matched by age and educational level.

Spanish possesses a phonologically transparent reading system, although the writing system is less transparent. Ambiguity in reading–writing system goes only in one direction: many words can potentially be written in different ways (orthography rules) (e.g., the spoken word /muxer/ (woman) might be written *mujer* or *muger;* the first corresponds to

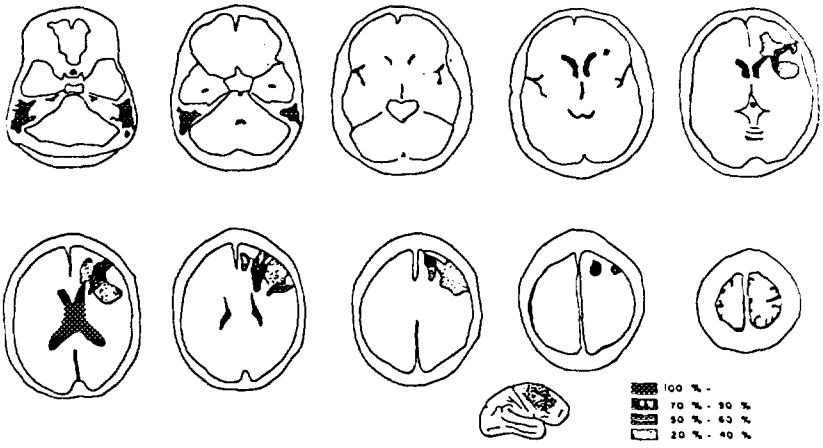


FIG. 1. CAT superimposition: Pre-Rolandic group. (Reproduced with permission from Ardila, Rosselli, & Pinzón, 1989).

the accepted spelling), but read in only one way (e.g., *mujer*—as any word or pseudoword—can be read in *only one* way, /muxer/). In other words, in Spanish homophonic heterography can be found, but homographic heterophony is absent. When writing, two different types of errors can be found: (a) orthographic errors (e.g., the word *mujer* is written as *muger;* both are read in exactly the same way, and both phonologically represent the spoken word /muxer/) and (b) errors due to *some* letter additions, letter omissions, or letter substitutions that change the written representation of the spoken word (e.g., if the word /muxer/ were written as *muje—r* omission—it no longer corresponds to the spoken word /muxer/). The first type of error is very frequently observed in Spanish-speaking subjects, particularly in low-educational-level subjects. The second type is extremely unusual, except in brain-

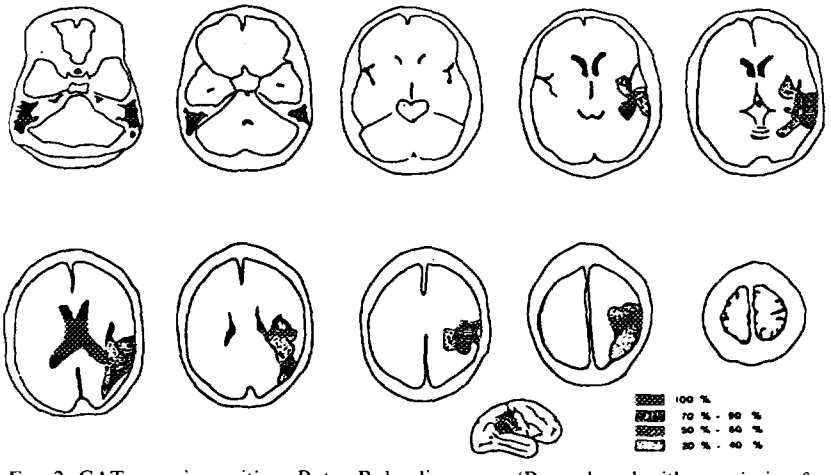


FIG. 2. CAT superimposition: Retro-Rolandic group. (Reproduced with permission from Ardila, Rosselli, & Pinzón, 1989).

TABLE 1
Percentage of Patients Presenting Different Associated Neurological and Neuropsychological Defects

	Pre-Rolandic	Retro-Rolandic
Left hemiparesis	83	60
Visual field defects	0	53
Spatial hemi-neglect	50	67
Constructional apraxia	50	73
Spatial alexia	33	73
Spatial acalculia	50	80

damaged individuals. It is very important to underline that, as a result of the simplicity of the Spanish reading–writing system, 1 or 2 years of school training is considered enough to learn to read and write any word (without errors of the second type, but not without errors of the first type). From the point of view of the Spanish language, only the second type of errors are considered as *real* writing errors; the first type of errors are interpreted as only "orthographic errors." In this research, the first type of error was not taken into account.

RESULTS

All the patients presented various associated neurological and/or neuropsychological disorders, especially left hemiparesis, visual field defects, spatial hemi-neglect, constructional apraxia, spatial alexia, and spatial acalculia. All of them but left hemiparesis were more frequently found in right retro-Rolandic patients. Table 1 shows the percentage of patients presenting these defects.

Wide left-hand margins were evident, as is the presence of the cascade phenomenon—i.e., a progressive increase or decrease of the left-hand margin. Patients began to write at one point on the page, and as they went on in writing, they began the following lines at points increasingly apart (or closer) thus forming an oblique line traced with the first letter of each line. Great difficulty in conserving the written line in a horizontal position was also observed, creating a slope of 13° *on average* (sometimes upward, sometimes downward). Figure 3 illustrates these phenomena.

In general, writing errors were more frequently found in patients with right retro-Rolandic damage. Errors appeared not only in writing words and sentences, but also in writing letters and syllables. Table 2 shows the percentage of patients presenting any error in the writing of letters, syllables, words and sentences. It is observed that in our current sample, about half of pre-Rolandic and three-quarters of retro-Rolandic right hemisphere-damaged patients presented some writing errors and spatial agraphia of variable degrees. In normal subjects, writing errors were found exclusively in the subjects with the lowest educational level.

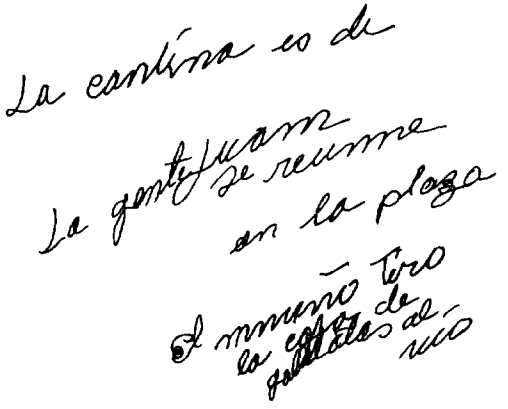


FIG. 3. "Cascade" phenomenon and unsteadiness to maintain a horizontal line in writing.

Different types of errors were considered: literal substitutions, letter additions, letter omissions, feature additions in letters, feature omissions in letters, and misgroupings of elements. For substitution and omission errors, 75% of errors were observed in consonants and only 25% of errors in vowels. It was disclosed that in right retro-Rolandic patients, misgrouping of elements represented the most frequent type of error. In right pre-Rolandic group, feature addition was the most frequent error. It is interesting to note that right hemisphere-damaged patients presented not only additions of features in letters and additions of letters in words, but also omissions of features in letters and omissions of letters in words. Omissions appeared particularly in posterior-damaged patients. The most frequently omitted feature was the horizontal stroke in the letter *t*. Table 3 presents the writing errors most frequently observed.

Feature additions represented the most important type of error in pre-Rolandic patients. Feature additions were specially observed in the letters *n*, *m*, and *u*, and also when writing the number 3. Letter additions were found with a slightly higher frequency in pre-Rolandic patients. In Spanish, two phonemes are written, duplicating a letter (*rr* and *ll*); errors were found very often with these graphemes (the patient wrote three,

TABLE 2
Percentage of Normal Subjects and Right-Hemisphere-Damaged Patients Presenting Errors in Different Writing Subtests

	Letters	Syllables	Words	Sentences
Normals	9	19	14	19
Pre-Rolandic	33	50	50	50
Retro-Rolandic	73	73	40	73

TABLE 3
Types of Errors Observed in Normal Subjects and Right-Hemisphere-Damaged Patients in Writing Subtests

	LIT	LAD	LOM	FAD	FOM	GEL
Normals	0.9	0.1	0.3	0.0	0.0	0.3
Pre-Rolandic	1.2	2.8	2.4	5.2	0.8	1.2
Retro-Rolandic	1.2	2.4	8.0	3.2	2.4	12.0

Note. Each cell represents the average of errors. LIT, Literal substitutions; LAD, letter additions; LOM, letter omissions; FAD, feature additions; FOM, feature omissions; GEL, grouping of elements.

four, and even five repeated letters instead of only two; e.g., *olla* (pot) → *ollla*). Iterations were disclosed not only for strokes and letters but also for syllables and even for words (see Figs. 3 and 4).

Disrespect to already used spaces was evident. When dictated a word or sentence, the patients often wrote superimposing it to a previously used space (i.e., the patient writes over a written word or drawn figure). The adequate distribution of writing on the paper was destroyed. Figure 4 illustrates this spatial disorganization in writing resulting from overlapped writing.

Several patients mentioned a certain disautomatization of the signature. However, this disautomatization was not restricted just to the signature, but also held true in general for writing. A switch in handwriting style was observed in several patients (according to their own reports) from a cursive handwriting to a printed-style handwriting. Usually when asked about this change, the patients simply answered that this (printed) writing style had become easier. Figure 5 presents an example of a patient in whom premorbid samples of writing were available.

Not only were inappropriate insertions of blanks in words observed, but also inappropriate groupings of elements, i.e., the patients joined

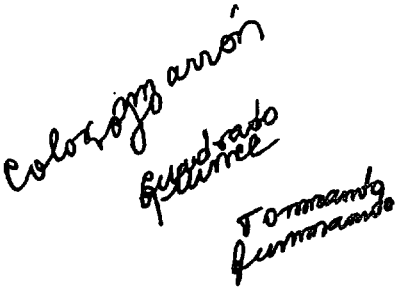


FIG. 4. Overlapped writing.

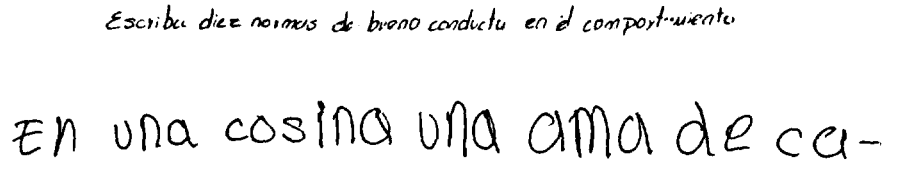
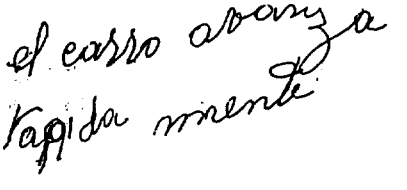


FIG. 5. Change in handwriting style. Handwriting sample before (top) and after (bottom) a right hemisphere lesion.

letters belonging to different words (e.g., *the house* is written *theho use*). As a matter of fact, this type of mistake (inability to correct using spaces to join and separate words) represented the most important type of error in retro-Rolandic patients. Figure 6 illustrates this type of writing error.

In our sample, constructional apraxia was evident according to the Rey–Osterrieth Complex Figure performance in 67% of the sample. Using Taylor's scoring system (Lezak, 1983), mean score was 13.09 (SD = 6.93). About half of pre-Rolandic and three-quarters of retro-Rolandic subjects presented an evident constructional defect (two or more standard deviations below the normative score) (see Table 1).

Intercorrelations between neurological and neuropsychological deficits, and error types in writing were calculated (Table 4). It was observed that feature additions significantly correlated with left hemiparesis. Constructional apraxia significantly correlated with literal errors and grouping of elements. The presence of an agraphia of spatial type (taking as cut-off criterion the presence of at least twice the number of errors observed in the normal subject with the maximum number of writing errors) was significantly associated with spatial hemi-neglect, constructional apraxia, spatial alexia, and spatial acalculia.



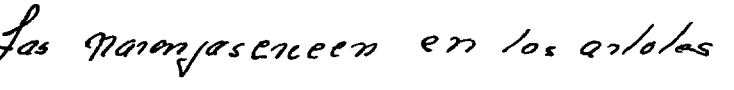


FIG. 6. Inability to use correctly the spaces to join (top, the word *rapidamente* (quickly) is written *rapida mente*, inserting an inappropriate blank) and separate words (bottom, the words *naranjas crecen* (oranges grow) are joined and written as a single word).

TABLE 4
Correlations between Neurological and Neuropsychological Deficits and Errors in Writing

	Visual defects	Spatial neglect	Constr. apraxia	Spatial agraphia	Spatial alexia	Spatial acalculia	LIT	LAD	LOM	FAD	FOM	GEL
Left	0.00	0.07	0.14	0.28	0.07	0.00	0.22	0.27	0.06	0.61	0.14	0.27
hemiparesis	NS	NS	NS	NS	NS	NS	NS	NS	NS	$p < .002$	NS	NS
Visual field		0.14	0.20	−0.11	0.28	0.33	0.30	−0.25	−0.05	−0.22	−0.13	−0.05
defects		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Spatial			0.27	0.36	0.55	0.39	0.24	0.24	0.25	0.24	0.15	0.24
hemi-neglect			NS	$p < .05$	$p < .005$	$p < .05$	NS	NS	NS	NS	NS	NS
Constructional				0.49	0.49	0.22	0.45	0.06	0.27	0.20	0.13	0.47
apraxia				$p < .01$	$p < .01$	NS	$p < .02$	NS	NS	NS	NS	$p < .01$
Spatial					0.60	0.37	0.50	0.55	0.70	0.55	0.23	0.75
agraphia					$p < .002$	$p < .05$	$p < .01$	$p < .005$	$p < .001$	$p < .005$	NS	$p < .001$
Spatial						0.58	0.50	0.16	0.35	0.31	−0.16	0.55
alexia						$p < .002$	$p < .01$	NS	NS	NS	NS	$p < .005$
Spatial							0.40	0.18	0.18	0.09	−0.18	0.18
acalculia							$p < .05$	NS	NS	NS	NS	NS
LIT								0.45	0.45	0.55	0.03	0.45
								$p < .02$	$p < .02$	$p < .005$	NS	$p < .02$
LAD									0.05	0.63	0.14	0.42
									NS	$p < .001$	NS	$p < .05$
LOM										0.44	0.14	0.23
										$p < .05$	NS	NS
FAD											0.13	0.44
											NS	$p < .05$
FOM												0.14
												NS

DISCUSSION

Several points in our results deserve special mention. Iterations have been considered the most distinctive type of error in right hemisphere-damaged patients (Hécaen & Marcie, 1974; Marcie & Hécaen, 1979). In the current patient sample, feature additions and letter additions clearly predominated in pre-Rolandic patients. Furthermore, feature additions significantly correlated with left-hemiparesis and, hence, frontal-lobe involvement.

Hécaen and Marcie (1974) mention the insertion of blanks between graphemes as a very important type of error in right hemisphere-damaged patients. Not only insertions of blanks, but also misgroupings of words, especially in retro-Rolandic patients, were observed in our sample. Misgrouping of elements was the best single sign of spatial agraphia (see Table 4), although it was 10 times more frequently observed in posterior-damaged patients than in pre-Rolandic patients.

Neglect represented an impairment particularly evident in our right hemisphere-damaged patients. Neglect was reflected in using left-hand margins that were too large in the presence of the abovementioned cascade phenomenon and even in the "mental representation" of the words. We had the opportunity to observe a patient, who, when words and sentences were dictated, tended to write only the right part of the word (e.g., *el niño llora* (the child cries) → *ño ra*).

Neglect might be also partially reponsible for iterations of strokes and letters. Once the stroke or letter is written, the patient neglects it, since it moves to the left visual field (Simernitskaya, 1975). However, iterations are also observed when drawing figures and the information remains in the same position in the visual field. Furthermore, neglect did not correlate with iterations. In consequence, iterations could be the result not only of a visual attentional defect, but—and even more feasible—of a motor-associated defect. Iterations could be explained as a consequence of some motor disautomatization and a tendency to perseverate, not inhibiting an initiated movement. It is worthy to note that frontal right hemisphere-damaged patients can also present iterations in speech (Ardila, 1984) resembling a certain acquired stuttering. It has also been proposed that in right hemisphere-damaged patients the phenomenon of the repetitions in writing can be caused in a manner analogous to the different forms of perseveration in speech (Marcie, Hécaen, Dubois, & Algelergues, 1965).

Hécaen and Marcie (1974) clearly relate spatial agraphia with constructional defects. In the current right hemisphere-damaged sample, indeed, constructional apraxia significantly correlated with spatial agraphia. Significant correlations were also found with literal substitutions and mis-

groupings of elements. According to Hécaen and Marcie (1974), these patients present a constructional apraxia for writing.

Summing up, spatial agraphia is characterized by: (1) feature and letter omissions, but also feature and letter additions; (2) inability to use correctly the spaces to join and separate words; (3) difficulty in conserving the written line in a horizontal position; (4) increased left margins and unsteadiness in maintaining left margins (cascade phenomenon); (5) disrespect of spaces and spatial disorganization of the written material; (6) disautomatization and changes in handwriting style; and (7) constructional apraxia for writing. Our results in general corroborate the Hécaen and Albert (1978) clinical interpretation of spatial agraphia.

Writing defects in right hemisphere-damaged patients can be associated with and depending on: (1) left hemi-neglect, reflected in increased and unsteady left margins; (2) constructional deficits in writing, reflected in disautomatization and changes in the type of handwriting and misgroupings of elements; (3) general spatial defects, reflected in the inability to use correctly the spaces between words, difficulty in conserving the written line in a horizontal position, disrespect to spaces, and spatial disorganization of the written material; and (4) some motor disautomatization and a tendency to perseverate. Although there are similar errors in both groups of patients, in right pre-Rolandic patients iterative errors (feature additions and letter additions) represented the most evident type of writing defect, whereas in right retro-Rolandic patients grouping of elements and letter omissions represented the two most evident types of writing errors. In the first case, impairment can be motor perseveration-based, whereas in the second, writing errors are more exactly related to spatial and constructional defects.

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