

SPATIAL ALEXIA

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(Received November 3, 1993)

Twenty-one patients with right hemisphere damage were studied (11 men, 10 women; average age = 41.33; range = 19–65). Patients were divided in two groups: pre-Rolandic (six patients) and retro-Rolandic (15 patients) right hemisphere damage. A special reading test was given to each patient. The observed errors included: literal errors (substitutions, additions, and omissions of letters), substitutions of syllables and pseudowords for meaningful words, left hemispatial neglect, confabulation, splitting of words, verbal errors (substitutions, additions, and omission of words), grouping of letters belonging to two different words, misuse of punctuation marks, and errors in following lines. It was proposed that spatial alexia is characterized by: (1) some difficulties in the recognition of the spatial orientation in letters; (2) left hemispatial neglect; (3) tendency to “complete” the sense of words and sentences; (4) inability to follow lines when reading texts, and sequentially explore the spatial distribution of the written material; and (5) grouping and fragmentation of words, most likely as a consequence of the inability to interpret the relative value of spaces between letters correctly.

Keywords: Alexia, neglect, right-hemisphere, hemi-inattention, reading disorders.

Different types of reading errors are expected to be observed in different cases of brain pathology (Benson, 1985; Benson & Ardila, in press; Friedman, 1988). Some mention of spatial alexia and reading disorders associated with right-hemisphere damage is found in the neurological and neuropsychological literature (e.g., Ardila, 1984; Ardila, Rosselli & Pinzón, 1989; Ardila & Rosselli, 1992; Ellis, Young & Flude, 1987; Hécaen, 1972; Hécaen & Algelergues, 1965; Hécaen & Marcie, 1974; Hutner & Liederman, 1991; Kinsbourne & Warrington, 1962; Marcie, Hécaen, Dubois & Anguelergues, 1965). Spatial reading defects resulting from right hemisphere damage most usually are included as a part of the hemispatial neglect syndrome (Bisiach & Vallar, 1988; De Renzi, 1985; Friedland & Weinstein, 1977; Heilman, Watson & Valenstein, 1985; Kolb & Whishaw, 1990; Weinstein & Friedland, 1977). Benson (1979) refers to *unilateral paralexias*, a condition in which the patient fails to read (neglect) one side of the word or sentence. Sometimes the patient, while reading, may substitute (confabulate) the left portions of the neglected visual field (Friedland & Weinstein, 1977). Very often, patients with spatial alexia have considerable difficulty in comprehending written material.

Shallice and Warrington (1980) introduced a distinction between peripheral and central acquired dyslexias (alexias). In central dyslexias, the patient can perceive a word correctly, but have difficulties with recognition, semantic processing, or phonological processing. In peripheral dyslexias the impairment is more of a perceptual type with the patient presenting difficulty in attaining a satisfactory visual word form. Three patterns of defects have been grouped under this peripheral dyslexia heading:

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Authors' research on acquired reading and writing disorders is supported by the Human Frontier Science Program.

(1) "letter-by-letter reading" (or spelling dyslexia) (Kay & Hanley, 1991; Patterson & Kay, 1982; Warrington & Shallice, 1980); (2) attentional dyslexia (Shallice & Warrington, 1977); and (3) dyslexia consequent to visual neglect (*neglect dyslexia*). Neglect dyslexia is most frequently observed associated with right hemisphere pathology (Riddoch, 1991), but some cases of right visual-field neglect dyslexia (associated with left hemisphere damage) have also been reported (Warrington & Zangwill, 1957; Hillis & Caramazza, 1990; Warrington, 1991).

Several research studies have been specially devoted to the analysis of reading disorders associated with right hemisphere pathology. Most of them represent single case reports (e.g., Behrmann, Moscovitch, Black & Mozer, 1990; Ellis, Flude & Young, 1987; Patterson & Wilson, 1990; Young, Newcombe & Ellis, 1991). A few research studies, however, included large samples of brain-damaged patients. Thus, Hécaen (1972) mentions that spatial alexia was observed in 23.4% of a series of 146 right-hemisphere damaged patients. According to Hécaen, spatial alexia is characterized by: (a) inability to fix the gaze on the word or text and to move from one line to another; and (b) neglect of the left side of the text. Kinsbourne and Warrington (1962) studied six right-handed patients with right hemisphere damage who showed neglect dyslexia. Three of the patients presented left homonymous hemianopia. Neglect-type of errors were observed associated with the tendency to replace initial letters by others. Spatial alexia has been usually reported associated with spatial agraphia, spatial acalculia, and other spatial defects (Hécaen, 1972; Hécaen & Marcie, 1974).

A further analysis of reading disorders associated with right hemisphere damage is reported in this paper. A sample of Spanish-speaking right hemisphere damaged patients from Bogotá (Colombia) was taken. Acquired reading defects were studied in this patient sample with the purely clinical purpose of describing the reading errors associated with right hemisphere pathology.

It was hypothesized that reading errors observed in cases of right hemisphere damage are not limited to left hemispatial neglect-type errors. General and extended spatially based reading errors were proposed to be observed. Departing from this, the name *spatial* (or *visuospatial*) alexia, instead of "neglect dyslexia," to refer to the reading disorders observed in cases of right hemisphere damage was preferred to be used. It was hypothesized that neglect represents only one (albeit, the most evident and important) clinical feature of spatial alexia. It was further considered that the term "neglect dyslexia" only partially describes the reading errors observed in cases of right hemisphere pathology.

This paper complements a recently published analysis of spatial agraphia in a group of right-hemisphere damaged individuals (Ardila & Rosselli, 1993) and uses the same patient sample.

Spanish language, 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 (orthographic rules) (e.g., the spoken word /muxer/ (woman) might be written *mujer* or *muger*; the first corresponds to 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/). There is only one possible way to read any word (or nonword) in Spanish. Consequently, from the point of view of the Spanish writing there is not any difference in reading meaningful words (e.g., *san*) and meaningless nonwords (e.g., *nas*) (Ardila, 1991; Ardila, Rosselli & Pinzón, 1989). In other words, in the Spanish language, homophonic heterography can be found but homographic heterophony is absent (Table 1). Correct writing may be difficult, but reading is particularly easy.

TABLE 1
Phoneme-grapheme Correspondence in Spanish.

Phoneme	Grapheme
/b/	b, v
/s/	c (before e, i), s, z
/tʃ/	ch
/d/	d
/f/	f
/g/	g (before a, o u) and gu (before e, i)
/i/	i, y (as a conjunction and in diphthongs)
/x/	j, g (before e, i)
/k/	c (before a, o, u) and qu (before e, i)
/l/	l
/λ/ or /j/	ll
/m/	m
/n/	n
/ɲ/	ñ
/p/	p
/r/	r
/r̄/	rr, r (at the beginning of a word)
/t/	t
/k/ + /s/	x
/j/	y
—	h
/a/	a
/e/	e
/o/	o
/u/	u

METHOD

Subjects Patients were selected at the Neurological Institute of Colombia and the Neurology Section of the San Juan de Dios Hospital (Bogotá, Colombia). Only those patients presenting the following characteristics were included in the sample: (1) a single brain lesion according to the CT scans; (2) age below or equal to 65; (3) right-handedness; (4) no background of previous neurological or psychiatric illness; and (5) at least five years of schooling (learning to read and write Spanish is much easier than learning to read and write English, and usually two-three years of formal education are considered to be enough to read and comprehend at the level of a newspaper written language).

Twenty-one monolingual (Spanish), right-handed patients with right hemisphere damage were studied (11 men, 10 women; average age = 41.33; range 19–65). These subjects presented various brain damage etiologies (vascular = 15; tumoral = 5; traumatic = 1). The cerebral damage had evolved in a period 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 (see, Ardila & Rosselli, 1993). Patients were further divided into two groups: pre-Rolandic (6 patients) and retro-Rolandic (15 patients) right hemisphere damage. Table 2 presents the general characteristics of the analyzed sample.

Testing Procedure Beside the general neurological and neuropsychological exams, a special Spanish reading test (Ardila, Rosseelli & Puente, 1993) was given to each subject. The following reading subtests were included:

TABLE 2
General Characteristics of the Sample.

Patient	Sex	Age	Years of Education	Etiology	CT scans	Category
1	F	34	5	tumor	convexital frontal	Prerolandic
2	F	53	5	vascular	infarction anterior branches MCA	Prerolandic
3	M	19	8	trauma	frontal hematome	Prerolandic
4	M	39	5	vascular	anterior cerebral artery	Prerolandic
5	M	63	10	tumor	posterior frontal	Prerolandic
6	M	32	15	tumor	anterior frontal glioma	Prerolandic
7	M	50	11	vascular	posterior cerebral artery	Retrorolandic
8	F	44	5	vascular	parietal-occipital	Retrorolandic
9	F	65	11	vascular	parieto-temporal	Retrorolandic
10	F	33	5	vascular	temporo-parietal	Retrorolandic
11	M	55	5	vascular	temporo-parietal hemorrhagic infarction	Retrorolandic
12	M	26	5	vascular	temporo-parietal- occipital	Retrorolandic
13	F	44	11	tumor	temporo-parieto- occipital glioma	Retrorolandic
14	F	16	7	vascular	temporal	Retrorolandic
15	M	45	5	vascular	parietal	Retrorolandic
16	F	49	5	vascular	insular and temporal hematome	Retrorolandic
17	M	38	5	tumor	temporal glioma	Retrorolandic
18	F	19	11	vascular	temporo-parietal	Retrorolandic
19	M	55	5	vascular	temporo-parietal	Retrorolandic
20	F	29	5	vascular	deep parieto- temporal infarction	Retrorolandic
21	M	60	5	vascular	temporo-parietal infarction	Retrorolandic

- (1) Reading of letters (20; 15 consonants, 5 vowels)
- (2) Reading of syllables (12; e.g., *pa*, *clus*, *trans*)
- (3) Reading of pseudowords (composed of two or more syllables) (11; e.g., *talo*, *fasaja*)
- (4) Reading of words (12; e.g., *casa* -house, *libro* -book, *ventana* -window, *bicicleta* -bicycle). All words were nouns and varied in the number of letters and syllables).
- (5) Reading of sentences (5; e.g., *Algunos gusanos se transforman en mariposas* -Some caterpillars become butterflies).
- (6) Reading a 108-words text (see Table 8).

Error analysis Empirically based, the following descriptive types of errors were analyzed:

Errors in Reading Letters, Syllables, and Words

- (1) Errors in reading single letters.

- (2) Literal substitutions in the middle (or at the end) of a word.
- (3) Substitutions of syllables or pseudowords for meaningful words.
- (4) Letter additions at the right side (or in the middle) of a word.
- (5) Letter omissions at the right side (or in the middle) of the word.
- (6) Left hemispatial neglect in words: one or several left-sided letters are omitted.
- (7) Confabulation in words: addition of one or several letters at the left side of the word, in order to become meaningful.
- (8) Splitting: the letters belonging to a single word are split as corresponding to two different words.

Errors in Reading Sentences and Texts

- (1) Left hemispatial neglect in sentences: one or several left-sided words are omitted in sentences.
- (2) Word substitutions (in the middle or at the end of the sentence).
- (3) Word additions (in the middle or at the end of the sentence).
- (4) Word omissions (in the middle or at the end of the sentence).
- (5) Confabulation in sentences: addition of one or several words at the left side of the sentence, in order to become meaningful.
- (6) Grouping: letters belonging to different words are read as belonging to a single word.
- (7) Misuse of punctuation marks: the patient does not stop reading when finding periods.
- (8) Errors in following lines in texts: the same line is read twice, one line is skipped, or words belonging to different lines are read as a single sentence.

Table 3 illustrates some examples of these different types of errors.

RESULTS

Most of the patients presented one or several associated neurological and/or neuropsychological disorders, specially left hemiparesis, visual field defects, left hemispatial neglect (according to Albert's cancellation test; Albert, 1973), constructional apraxia (according to the Rey-Osterrieth Complex Figure, using Colombian norms; Ardila, Rosselli & Puente, 1993; Rosselli & Ardila, 1991), spatial agraphia, and spatial acalculia, in a variable degree. All of them, but left hemiparesis, were more frequently found in right retro-Rolandic patients. Table 4 shows the percentage of patients presenting these associated deficits.

In general, reading errors were more frequently found in patients with retro-Rolandic brain damage. Errors appeared not only in reading words and sentences, but also in reading letters and syllables. Table 5 shows the percentage of patients presenting any error in reading letters, syllables, words, sentences, and texts. It was observed that, in our current sample, about one-third of pre-Rolandic and two-thirds of retro-Rolandic right hemisphere-damaged patients presented some reading errors and a spatial alexia of a variable degree. Errors were more frequently found in reading words and texts, than in reading letters and syllables.

Frequency of reading errors was higher in the retro-Rolandic than the pre-Rolandic group (Table 6). Letter omissions were observed only in the retro-Rolandic group. Two retro-Rolandic patients read single noncomposed words as two different words.

TABLE 3
Some Examples of the Different Types of Errors Observed in the Reading Subtests. Errors are Presented in Italics.

ERRORS IN READING LETTERS, SYLLABLES, AND WORDS	
(1) Errors in reading single letters	<i>h</i> → n; n → u; k → x
(2) Literal substitutions	Libro (book) → <i>libra</i> (pound)
(3) Substitutions of syllables and pseudowords for meaningful words	<i>t/a</i> (nonsense) → <i>tia</i> (aunt)
(4) Letter additions	<i>pensò</i> (he/she thought) → <i>pienso</i> (I think)
(5) Letter omissions	<i>ventana</i> (window) → <i>venta</i> (sale)
(6) Left hemi-spatial neglect in words	<i>ventana</i> (window) → <i>ana</i> (Ann)
(7) Confabulation in words	<i>dactilografía</i> (typewriting) → <i>estilógrafo</i> (stylograph)
(8) Splitting of words	Algunos gusanos se transforman en <i>mariposas</i> → unos gusanos se transforman en <i>maestro Posada</i>
ERRORS IN READING SENTENCES AND TEXTS	
(1) Left-spatial hemineglect in sentences	<i>El niño</i> tiró la caja de galletas al río → <i>tiró</i> la caja de galletas al río
(2) Word substitutions	La gente <i>se reúne</i> en la plaza → la gente <i>mañana</i> en la plaza
(3) Word additions	La cantina es de Juan → La cantina es de <i>don</i> Juan
(4) Word omissions	La cantina <i>es</i> de Juan → la cantina de Juan
(5) Confabulation in sentences	<i>La gente se reúne</i> en la plaza → <i>el perrito</i> murió en la plaza
(6) Grouping	Uno de ellos pensó <i>que era</i> → ellos <i>quieran</i>
(8) Inability to follow lines	<i>El otro trató de salir. Pensó que</i> quizás lo lograría. <i>Que era mejor intentar que dejarse llevar por la corriente y ahogarse inevitablemente. Entonces</i> nadó con todas sus fuerzas

Substitutions of syllable and pseudowords for meaningful words and left hemispatial neglect represented the most common type of mistake when reading syllables and words. Word substitutions in sentences and texts were observed in the majority of pre-Rolandic and retro-Rolandic groups. However, word additions when reading were found only in the second group. Thirteen of 15 retro-Rolandic patients omitted words

TABLE 4
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 acalculia	50	80
Spatial agraphia	50	73

TABLE 5
Percentage of Patients Presenting Errors or Failures in Each Reading Subtest.

	LTR*	SYL	PSE	WOR	SEN	TXT
Pre-Rolandic	17	33	50	50	33	33
Retro-Rolandic	33	40	80	93	67	100

*Letters (LTR), syllables (SYL), pseudowords (PSE), words (WOR), sentences (SEN), text (TXT).

when reading sentences and texts. Grouping of letters (reading two or more words or syllables as if they were a single word) was observed in five right retro-Rolandic damaged patients. Inability to stop (and changing the reading intonation) when periods appeared in the written material, and inability to follow lines in an ordered and sequential way, were found in both groups. However, these mistakes clearly predominated of the pre-Rolandic brain-damaged patients.

Table 7 shows the average number of errors for the different types of error categories that were analyzed. The average number of errors was lower in the right frontal (pre-Rolandic) damage group. Errors in these patients were sporadic and scarce. In the right retro-Rolandic group, on the other hand, the average number of errors was high, particularly with regard to the substitutions of syllables and pseudowords for meaningful words, left hemispatial neglect, confabulation, word omissions and word substitutions.

When reading texts, the patients often omitted left-sided sentences, words or letters. However, the specific point where the patients began to read in each line was not steady, but variable: sometimes they just omitted one or two letters; sometimes they omitted most of the line. Occasionally, a whole line was omitted or read twice. Table 8 presents an example of left hemispatial neglect when reading a text.

TABLE 6
Percentage of Patients Presenting Different Types of Errors in the Reading Subtests.

	Pre-Rolandic	Retro-Rolandic
<i>Errors in reading letters, syllables, and words</i>		
Errors in reading single letters	17	33
Literal substitutions	33	67
Substitutions of syllables and pseudowords for meaningful words	33	80
Letter additions	33	53
Letter omissions	0	60
Left hemi-neglect in words	33	80
Confabulation in words	33	53
Splitting of words	0	13
<i>Errors in reading sentences and texts</i>		
Left hemi-neglect in sentences	17	60
Word substitutions	67	87
Word additions	0	60
Word omissions	17	87
Confabulation in sentences	17	27
Grouping	0	33
Misuse of punctuation marks	17	40
Inability to follow lines	17	47

TABLE 7
Average Number of Errors per Patient.

	Pre-Rolandic	Retro-Rolandic
<i>Errors in reading letters, syllables and words</i>		
Errors in reading single letters	0.5	1.5
Literal substitutions	0.5	2.3
Substitutions of syllables and pseudowords for meaningful words	1.0	3.0
Letter additions	0.5	1.5
Letter omissions	0.0	2.1
Left hemi-neglect in words	0.3	2.0
Confabulation in words	1.0	5.0
<i>Errors in reading sentences and texts</i>		
Left hemi-neglect in sentences	0.5	3.5
Word substitutions	1.0	2.6
Word additions	0.0	1.7
Word omissions	1.2	4.5
Confabulation in sentences	2.0	3.5

DISCUSSION

Reading is not only a linguistic task (ability to match graphemes and phonemes, and understand the meaning of the words; ability to comprehend grammatical relationships, etc.). Reading also represents a spatial ability task. Spatial orientation of letters is meaningful (e.g., u and n; b and d, are distinguished only with regard to their spatial orientation). Letters and words are distributed in space, and evidently reading requires an unimpaired ability to explore the space. Reading proceeds in a specific spatial direction: initially, the most left located letters are read, and progressively reading moves within the same line towards the right. Each time a line is completed, reading continues on the line exactly below. Letters in words are separated by small spaces, but words in sentences are separated by longer (double) spaces.

It is understandable that disorders in exploration, recognition, and interpretation of spatial information impairs the ability to read. Spatial alexia represents a particularly complex but insufficiently clinically analyzed reading disorder. In severe cases,

TABLE 8
Example of reading a text. The omitted words and segments are written in italics.

<i>El Gusano y la Mariposa</i>
<i>Dos gusanos cayeron en el agua.</i>
<i>Uno de ellos pensó que era inútil tratar de salvarse ya que nunca lograría llegar hasta la orilla. Se dejó entonces llevar por la corriente y se ahogó.</i>
<i>El otro trató de salir. Pensó que quizás lo lograría. Que era mejor intentar que dejarse llevar por la corriente y ahogarse inevitablemente. Entonces nadó con todas sus fuerzas largo rato.</i>
<i>Cuando ya pensaba que no podía más y que aún la orilla estaba muy lejos, sintió que se convertía en mariposa y le aparecían unas enormes alas en su espalda. Entonces salió volando y escapó de morir ahogado.</i>

it seriously disables the patient not only to read aloud, but also to comprehend written material.

In our current sample of right hemisphere-damaged patients, spatial alexia was evident in most retro-Rolandic damaged patients, but defects in reading were also observed in frontal-damaged patients. It might be stated that about one-third of pre-Rolandic patients and two-thirds of retro-Rolandic patients presented some alexic defects of a variable degree.

Although, indeed, left hemispatial neglect, frequently associated with confabulation, represented the most evident reading error in our group of patients, as it has been usually pointed out in neuropsychology literature (e.g., Benson, 1979, 1985; Hécaen, 1972; Kinsbourne & Warrington, 1962), several different types of reading errors were also observed. Substitutions of syllables and pseudowords for meaningful words, substitutions, and additions and omissions of letters and words were also frequently found in our patients.

Errors in reading single letters were disclosed in one pre-Rolandic and five retro-Rolandic patients. Most frequently, the following mistakes were observed: $h \rightarrow n$; $n \rightarrow u$; $k \rightarrow x$; i was read as "number one"; d or $b \rightarrow p$. Spatial rotations and letter fragmentations (eventually associated with neglect) may underlie these mistakes.

Additions, omissions, and substitutions of letters and words in the *right* side (or in the middle) of words or sentences should be specially emphasized. These types of errors in reading words, sentences, and texts were found with a high frequency not only in pre-Rolandic, but very specially in retro-Rolandic patients. When reading, eyes move in a saccadic way from left to right. Letters and words situated at the right in the sentence or text, will become located at the left when advancing reading. So, additions, omissions, and substitutions of letters and words at the right side (or in the middle) of words or sentences may also represent a consequence of left hemispatial neglect. Eventually, some word substitutions could be taken as semantic paralexias (e.g., *Algunos gusanos se transforman en mariposas* -some caterpillars become butterflies \rightarrow *Algunos gusanos se transforman en huevos* -some worms become eggs).

The misuse of punctuation marks was observed in one pre-Rolandic and six retro-Rolandic patients. When reading texts, these patients did not stop at periods; and reading became monotonous and difficult to comprehend. The inability to follow lines (lines are skipped; one line is read twice; the patient after reading a line, states that *he/she does not know where to continue reading*; the patient begins reading a line but moves to the upper or lower one) was evident in one pre-Rolandic and seven retro-Rolandic patients. Evidently, although the conversion graphemes-phonemes may be preserved, understanding texts becomes impossible.

Grouping (reading two words as a single one) and splitting (reading one noncomposed word as two different words) represented a reading error observed in five and two of the retro-Rolandic patients respectively and none pre-Rolandic individual. Splitting appeared in long words, usually associated with some additional errors (substitutions, additions and/or omissions of letters).

Summing up, spatial alexia in our patient sample was characterized by: (1) some difficulties in the recognition of the spatial orientation in letters; (2) left hemispatial neglect, that, when reading, was not restricted to the left-sided words in the text. "Left" and "right" depend on the specific written segment the subject is currently reading; (3) some tendency to "complete" the sense of words and sentences: syllables and pseudowords become meaningful words; additions and substitutions of letters and words confer meaning to the written material; left hemispatial neglect very often was complemented with some left-sided letter and word confabulation; (4) inability

to follow lines when reading texts, and sequentially explore the spatial distribution of the written material: letters, syllables, and words are skipped; words belonging to different lines are read in a single sentence; punctuation is not respected; and reading becomes simply chaotic; and, (5) grouping and fragmentation of words, most likely as a consequence of the inability to correctly interpret the relative value of spaces between letters (small spaces separate the letters belonging to the same word; and large spaces separate different words in a sentence).

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