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Illiteracy and Brain Damage

2. Manifestations of Unilateral Neglect in Testing "Auditory Comprehension" with Iconographic Materials

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This report concerns the sentence–picture matching behavior of 100 neurologically healthy and 169 brain-damaged subjects, all of whom were unilingual adult right-handers. Within this population, 144 subjects were totally unschooled illiterates and the remaining 125 had received school education and thereafter had retained writing skills and reading habits. Brain-damaged subjects were tested less than 2 months after a first left- or right-hemisphere stroke. All subjects were administered an aphasia screening battery including, among other subtests, a set of six sentence-picture matching stimuli. For each of these six stimuli, subjects heard a sentence uttered by the examiner and were then requested to match this sentence with one of four drawings presented within a single display divided into four quadrants

This is the second of a series of four papers reporting on the results of a research project which originally and to a large extent remained focused on the effects of unilateral brain damage on the speech–language behaviors of unilingual right-handed adult illiterates. The topics of the other papers in this series are (a) aphasia testing in culturally contrasted neurologically healthy populations (Lecours, Mehler, Parente et al., in press-a) (b) naming, pointing, and repetition behaviors in illiterate as opposed to school-educated right-handed adults less than 2 months after a first unilateral CVA (*Idem*, in press-b), and (c) naming, pointing, and repetition behaviors within the same populations at a 6-month interval following initial testing. Research supported by The Harry Frank Guggenheim Foundation, New York. Requests for reprints should be sent to André Roch Lecours, Laboratoire Théophile-Alajouanine, Centre de Recherche du Centre Hospitalier Côte-des-Neiges, 4565 Chemin Queen-Mary, Montréal, Québec, Canada H3W 1W5.

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of equal surface. Three sentences were syntactically "simple" (noun subject + verb) and three were relatively more "complex" (noun subject + verb + one or two noun complements). Evidence of unilateral neglect was found in both left- and right-brain-damaged illiterates and literates. Moreover, the right neglect of left-brain-damaged subjects was manifest mostly when target sentences were relatively "complex" whereas the left neglect of right-brain-damaged subjects was manifest irrespective of the syntactic complexity of target sentences. Our data are interpreted as indicative of an interaction between two cognitive disorders resulting from dysfunctions of asymmetrically represented cognitive mechanisms. The implications of these findings with respect to clinical and research aphasia testing are discussed.

1. INTRODUCTION

The fact that certain right-hemisphere lesions can lead to dramatically impaired ability to attend to stimuli presented within the left visual field (unilateral neglect) has long been recognized in clinical neurology (Brain, 1941); various psychopathological interpretations have been proposed in relation to this phenomenon (Brain, 1941; Gainotti, 1968; Kinsbourne, 1970, 1977; Heilmann & Watson, 1977; Mesulam, 1981, 1983). Until recently, standard neurological teaching held that the presence of aphasia would make it difficult or impossible to recognize the existence of unilateral neglect if it existed at all in left-brain-damaged patients (Battersby, Bender, Pollack, & Kahn, 1956; Brain, 1941; Oxbury, Campbell, & Oxbury, 1974). Thus, although there had been early reports of right field inattention following left brain damage (de Renzi, 1982), it was only after the mid-fifties, and no doubt as a result of Denny-Brown's classical publications on the subject (Denny-Brown, Meyer, & Horenstein, 1952; Denny-Brown & Banker, 1954), that right-sided unilateral neglect following left-brain damage raised the interest of clinicians and researchers beyond the anecdote level (Bender, 1977; Chedru, 1976; Friedland & Weinstein, 1977; Pillon, 1981; Welman, 1969). Unlike Denny-Brown and collaborators (1952, 1954), several authors have claimed that unilateral neglect is less severe and/or less persistent in left versus right hemisphere lesions (Battersby et al., 1956; Chain, Leblanc, Chedru, & Lhermitte, 1979; Chedru, Leblanc, & Lhermitte, 1973; Costa, Vaughan, Horwitz, & Ritter, 1969; Critchley, 1953; Gainotti, 1968; Hécaen, 1962); it has also been suggested that the dysfunction behind unilateral neglect is not of the same nature in left- as in right-brain lesions (Gainotti, 1968).

The possibility of task-specific manifestations of right visual neglect among left-brain-damaged aphasics has been raised by several authors (Costa et al., 1969; Friedrich, Walker, & Posner, 1984; Huber, Luer, & Laas, 1983; Leicester, Sidman, Stoddard & Mohr, 1969; Tyler, 1969). The present paper concerns the manifestation of unilateral neglect as we have observed it in response to dimidiated iconographic materials used to test "auditory comprehension" in 99 left-brain-damaged and 70 right-brain-damaged adults.

2. TESTING MATERIALS

The aphasia screening battery[1] used in our research has been described elsewhere (Lecours, Mehler, Parente, et al., in press-a). In the present paper, we will limit our discussion to the sentence–picture matching task of this battery (one of the subtests intended to investigate "auditory comprehension"). This task is comprised of a total of six items: for each of these, the subject is requested to point to one of four drawings which corresponds to a sentence uttered by the examiner (the lexical components of these verbal stimuli were chosen on the basis of their presumably high frequency and familiarity).[2] When administering this subtest, each sentence stimulus may be repeated once should the subject so request or should he fail to respond to the initial presentation; scoring is then limited to the subject's reaction to this second presentation of the verbal stimulus. Whether scoring bears on a first or on a second presentation, it is only the subject's first response (or, eventually, an absence of response) which is scored.

For the first three items, the examiner says "Show me the drawing where,"[3] followed by a sentence of the "noun subject + verb" type, and the subject is requested to point to one of four drawings, the target, which corresponds to this sentence ("simple sentence comprehension" subtask). Each display is such that two drawings appear in its left half and two in its right half. Moreover, the four drawings in each display are related in such a manner (same or related actors, same or related actions, eventually same or related accessories) that each of the three nontarget drawings constitutes a compounded semantic, syntactic, phonological, and formal foil to the target one (Fig. 1). The targets were placed in the lower left quadrant in two displays and in the lower right quadrant in the other one.

For the other three items, the examiner says "Show me the drawing where,"[4] followed by a sentence of the "noun subject + verb + one or two noun complements" type, and the subject is requested to point to one of four drawings, the target, which corresponds to this sentence ("complex sentence comprehension" subtask). Each display is such that two drawings appear in its left half and two in its right half. Moreover, the four drawings in each display are related in such a manner (same actors, same or related actions, same accessories) that each of the three nontarget drawings constitutes a compounded semantic, syntactic, phonological, and formal foil to the target one (Fig. 2). The targets were placed in the upper right quadrant in two displays and in the lower right quadrant in the other one.

Errors in Experimental Design

With regard to the left–right distribution of the drawings meant as targets in the "sentence comprehension" subtasks, an unfortunate imbalance was therefore introduced in the MI-α test in the process of adapting it to the Portuguese language: two targets each were

[1] A Portuguese adaptation of an experimental—"MI-α—version of the Protocole MT-86 d'Examen Linguistique de l'Aphasie (Lecours, Nespoulous, Joanette, Lemay, Puel, Lafond, Cot, & Rascol, 1986).

[2] No word frequency data were available for the Portuguese language at the time the test was designed; this lack was probably not of major importance in the context of our research, given that the performances of brain-damaged subjects were compared to those of healthy controls.

[3] Alternatively, the examiner may use some verbal or gestural equivalent which can be modified or deleted once canalization of the subject's attention has been ascertained.

[4] Same comment as in the preceding footnote.

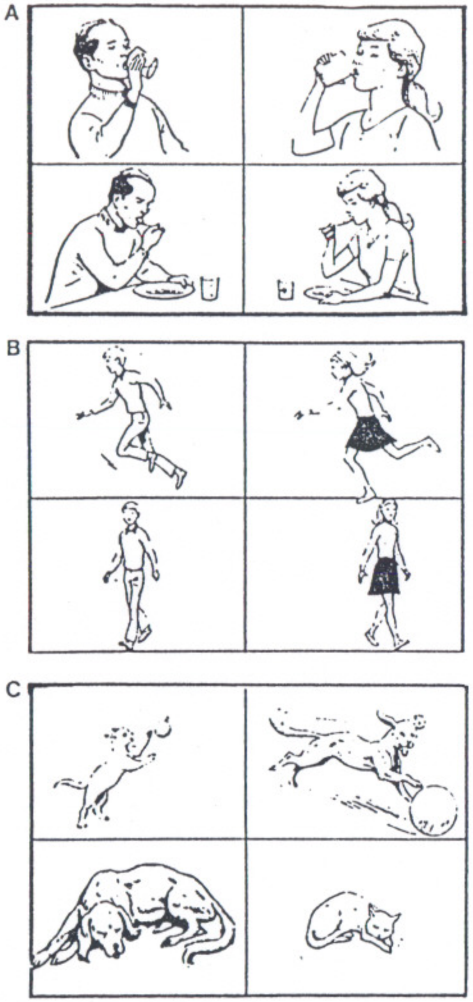

FIG. 1. The three displays of the "simple sentence comprehension" subtask. The targets are (A) the drawing of a man eating ("O homem come"); (B) the drawing of a girl walking ("A menina anda"); (C) the drawing of a dog sleeping ("O cachorro dorme"). The actual size of each display is 15 × 21 cm.

placed in the lower left, upper right, and lower right quadrants, and none in the upper left quadrant; moreover, all three targets of the "complex sentence" subtask were placed in the right half of the display (Figs. 1 and 2). As will be shown below (Tables 4 and 5), this imbalance was to some extent "corrected," as it were, by the subjects who participated in our research, apparently not caring whether our aim was to test "auditory comprehension" rather than "visual attention": on the one hand, controls often did not agree with us as to which drawings should be considered as the targets and, on the other hand, statistics should be good for something.

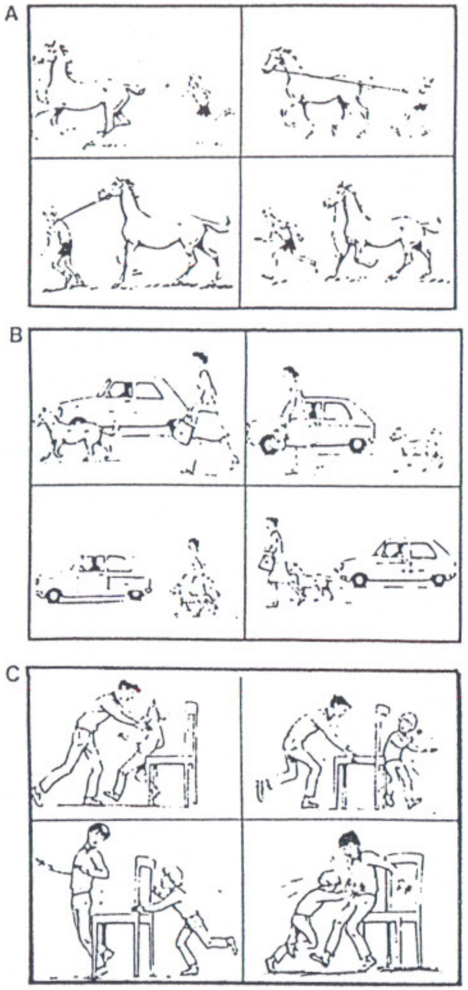

FIG. 2. The three displays of the "complex sentence comprehension" subtask. The targets are (A) the drawing of a horse pulling a boy ("O cavalo puxa o menino"); (B) the drawing of a dog walking behind a woman and a car ("O cachorro segue a mulher e o carro"); (C) the drawing of a small boy pushing a tall boy on a chair ("O menino pequeno empurra o grande na cadeira"). The actual size of each display is 15 × 21 cm.

3. SUBJECTS

The present report bears on 100 neurologically healthy (anamnesis and routine examination) and 169 brain-damaged subjects who were tested by speech pathologists and neurologists in Brasilia, Curitiba, Lisbon, Recife, Rio de Janeiro, Salvador de Bahia, and São Paulo. All subjects were unilingual, right-handed Lusitanophones, 40 years of age or older. Right handedness could be absolute or preferential, as determined through use of an Edinburgh-like (Oldfield, 1971) questionnaire composed of 20 items (writing and drawing excluded). Thirty-five subjects were Portuguese and 234 were Brazilian. Within this population, 144

TABLE 1

		Controls	Left strokes	Right strokes
ILLIT	Number	57	47	40
	Age	61.3	62.0	61.5
	M/F	20/37	20/27	28/12
LIT	Number	43	52	30
	Age	60.0	57.8	64.5
	M/F	21/22	29/23	20/10
	School	8.2	8.6	8.2

Note. ILLIT and LIT = illiterate and school-educated subpopulations; Controls, Left and Right strokes = neurologically healthy, left- and right-brain-damaged subpopulations; Number = absolute number of subjects per group; Age = average age per group, expressed in number of years; M/F = absolute number of males and females per group; School = average duration of school education in the literate subpopulation, expressed in number of years.

subjects were totally unschooled illiterates and the remaining 125 had received at least 4 years of school education and thereafter had retained writing skills and reading habits. Brain-damaged subjects were tested less than 2 months and, whenever possible, more than 2 weeks after a left-hemisphere (99 cases) or right-hemisphere (70 cases) stroke. Our experimental population therefore comprised six groups (Table 1). The six groups were statistically homogeneous with regard to age (Kruskall–Wallis test: $H(5) = 9.07$, $p = .11$). The six groups were not statistically homogeneous with regard to sex distribution ($\chi^2(5) = 16.4$, $p = .006$); nonetheless, distribution as to sex was comparable in illiterate versus school-educated left stroke subjects ($\chi^2(1) = 1.24$; $p = .27$) as well as in illiterate versus school-educated right stroke subjects ($\chi^2(1) = 0.001$; $p = 0.97$). The three groups of the literate subpopulation were statistically homogeneous with regard to number of years of school education (Kruskall–Wallis test: $H(2) = 0.25$, $p = .88$).

All of the 169 subjects of the brain-damaged subpopulation (a) reported no past history of neurological illness of any kind and (b) were hospitalized following a first single CVA (spontaneous neurological deficit of sudden onset with unequivocal signs of unilateral hemispheric damage). Neurological examinations were exhaustive and expertly conducted in most cases, although less so in others; cases were rejected if motility, somesthesia, and visual fields had not been systematically assessed (this seldom occurred).

At the time of initial M1-α testing,[5] all but 4 of the 169 brain-damaged subjects presented a hemiparesis (which turned out to be transient in certain cases) or a full-blown hemiplegia, including homolateral facial involvement of the central type (Table 2). In the 4 remaining subjects, all literates with left-brain stroke, the existence of the lesion was documented through computerized tomography. With regard to somesthesia (hemihypesthesia and/or unilateral tactile extinction) and visual fields (hemianopsia and/or unilateral visual extinction), examiners were requested to note their observations in terms of "deficit absent," "deficit present," or "deficit impossible to assess with a reasonable degree of confidence" (Table 2). As is discussed in Lecours et al. (in press-b), one might note that the latter notation ("unassessable")—which usually indicated that the examiner had reason to suspect the existence of a hemihypesthesia and/or visual field disorder but that a convincing clinical demonstration could not be made of it—was used (a) less often in left-stroke illiterates

[5] Retesting of survivors after a 6-month interval is now being completed.

TABLE 2
FREQUENCY OF MOTOR, SOMESTHETIC, AND VISUAL FIELD HEMIDEFICITS AMONG SUBJECTS OF THE FOUR GROUPS OF THE STROKE SUBPOPULATION (PERCENTAGES OF SUBJECTS PER GROUP)

		Left strokes		Right strokes	
		ILLIT	LIT	ILLIT	LIT
Hemiplegia or hemiparesis	Absent	0	8	0	0
	Present	100	92	100	100
	Unassessable	0	0	0	0
Hemihypesthesia or extinction	Absent	30	33	28	27
	Present	49	42	59	66
	Unassessable	21	25	13	7
Hemianopsia or extinction	Absent	72	63	65	60
	Present	5	8	20	33
	Unassessable	23	29	15	7

versus literates (22% as opposed to 27% of cases) and (b) more often in right-stroke illiterates versus literates (14% as opposed to 7% of cases).

4. RESULTS

At the time of initial testing, 5 of the 99 subjects of the left-stroke subpopulation, 2 illiterates and 3 literates (including two cases of full-blown jargonaphasia), were uncanalizable; that is, they could be tested neither in production nor in comprehension tasks as they had no understanding of what was required of them. For reasons pertaining to the field conditions of our research, three other illiterates (two with a left stroke and one with a right stroke) were not administered the sentence–picture matching tasks. Results to be presented here therefore bear on the sentence–picture matching behavior of (a) all control subjects, (b) 43 of the 47 illiterate and 49 of the 52 literate subjects with a left stroke, and (c) all right stroke subjects with the exception of 1 illiterate (Table 1).

4.1. *Global "Error Scores"*

Only the first response to each sentence–picture matching stimulus was taken into account in scoring. Any pointing response which did not correspond to "the target" was considered as an "error"; an absence of response (for instance, the subject stating that none of the drawings matched the sentence stimulus) was also considered as an "error." Global error scores were calculated by summation of "errors." These scores will now be considered from several different points of view (Table 3).

For either simple or complex sentences (and therefore for the total of both), the error scores of the subjects of any given—control or pathological—group of the illiterate subpopulation were always found to be

TABLE 3

ERROR SCORES FOR THE M1-α SENTENCE–PICTURE MATCHING SUBTEST (PERCENTAGES OF INADEQUATE RESPONSES PER GROUP)

		SIMP SENT	COMP SENT	Total
ILLIT	Controls	23.4	53.8	38.6
	Left strokes	40.3	77.5	58.9
	Right strokes	41.0	40.2	40.6
LIT	Controls	4.7	19.4	12.1
	Left strokes	21.1	50.3	35.7
	Right strokes	26.7	22.2	24.5

Note. SIMP SENT = "simple sentence" subtask (three items); COMP SENT = "complex sentence" subtask (three items); Total = combined error scores for the two subtasks (six items).

significantly greater than those of the corresponding group of the literate subpopulation. Using the χ^2 test on 2 × 2 tables opposing numbers of subjects who produced no or one versus two or three inadequate responses, the smallest figure found (p = 0) was related to complex sentences in control groups and the largest (p = .05) to the same in right-stroke groups.

Within both the illiterate and the literate subpopulations, application of the Kruskall–Wallis test (Siegel, 1956) revealed the existence of discrepancies in total and partial error scores. Application of the Dunn multiple-comparison procedure (Hollander & Wolfe, 1973) at an experiment-wise (EW) error rate of 0.05 thereafter showed the following:

(A) Left-stroke illiterates had significantly greater error scores than their controls for simple and for complex sentences.

(B) Left-stroke literates had significantly greater error scores than their controls for complex sentences, although not for simple sentences; statistical significance level could be reached in the latter case by raising the EW error rate to 0.06.

(C) Right-stroke illiterates had significantly greater error scores than their controls for simple sentences, although not for complex sentences (indeed, the complex sentences error score of right-stroke illiterates was actually lower, as seen in Table 3, than that of their controls).

(D) The simple and complex error scores of right-stroke literates did not significantly differ from those of their controls; statistical significance level could be reached in the case of simple sentences by raising the EW error rate to 0.07.

Application of the Dunn's multiple-comparison procedure (Hollander & Wolfe, 1973) at an EW error rate of 0.05 also showed that simple sentence error scores did not differ significantly in left as opposed to right-stroke subjects, within both the illiterate and the literate subpopulations whereas complex sentence error scores were significantly greater in left-stroke as opposed to right-stroke subjects, within both the illiterate and the literate subpopulations.

Finally, control illiterates and literates as well as left-stroke illiterates and literates showed significantly greater error scores for complex as opposed to simple sentences (Sign Test for Two Related Samples, p = .001 in all four cases), whereas no such difference was observed among either the illiterates or the literates of the right-stroke subpopulation.

TABLE 4

ITEM BY ITEM SCORES FOR THE "SIMPLE SENTENCE COMPREHENSION" SUBTASK (PERCENTAGES OF RESPONSES PER DRAWING PER GROUP)

	Controls		Left strokes		Right strokes	
	ILLIT	LIT	ILLIT	LIT	ILLIT	LIT
M EAT	82.5	100	60.5	81.6	64.1	66.7
M DRINK	10.5	0	27.9	8.2	17.9	10
W EAT	3.5	0	2.3	6.1	12.8	10
W DRINK	3.5	0	7.0	4.1	5.1	13.3
NO RESP	0	0	2.3	0	0	0
G WALK	64.9	93.0	44.2	69.4	56.4	86.7
G RUN	35.1	7.0	34.9	20.4	33.3	10
B WALK	0	0	4.7	4.1	2.6	0
B RUN	0	0	11.6	4.1	5.1	3.3
NO RESP	0	0	4.7	2	2.6	0
D SLEEP	82.5	93.0	74.4	85.7	56.4	66.7
D PLAY	12.3	0	11.6	2	23.1	6.7
C SLEEP	5.3	7.0	9.3	8.2	20.5	26.7
C PLAY	0	0	0	4.1	0	0
NO RESP	0	0	4.7	0	0	0

Note. M = man; W = woman; G = girl; B = boy; D = dog; C = cat; EAT = is eating; DRINK = is drinking; WALK = is walking; RUN = is running; SLEEP = is sleeping; PLAY = is playing; NO RESP = absence of response. Targets are "O homem come" (The man is eating), "A menina anda" (The girl is walking), and "O cachorro dorme" (The dog is sleeping).

4.2. *Item-by-Item Scores*

On the basis of an application of Fisher's Exact Probability test (Siegel, 1956) to sentence–picture matching results of given pairs of groups within our stroke subpopulation, item-by-item analysis (Figs. 1 and 2; Tables 4 and 5) yielded a number of statistically significant or quasi-significant results. Thus, compared to respective controls:

(A) In SS-1,[6] the man-drinks foil attracted left-stroke illiterates (p = .021) and the woman-drinks foil attracted right-stroke literates (p = .025).

[6] First item of the simple sentence subtask.

TABLE 5
ITEM BY ITEM SCORES FOR THE "COMPLEX SENTENCE COMPREHENSION" SUBTASK (PERCENTAGES OF RESPONSES PER DRAWING PER GROUP)

	Controls		Left strokes		Right strokes	
	ILLIT	LIT	ILLIT	LIT	ILLIT	LIT
H PULL B	49.1	83.7	27.9	46.9	66.7	90
B PULL H	43.9	11.6	48.8	32.7	25.6	0
H AFT B	5.3	2.3	7.0	6.1	7.7	10
B AFT H	1.8	2.3	11.6	10.2	0	0
NO RESP	0	0	4.7	4.1	0	0
D BHD W+C	47.4	74.4	16.3	40.8	66.7	83.3
W BHD D+C	15.8	2.3	39.5	20.4	7.7	6.7
C BHD W+D	29.8	11.6	18.6	18.4	23.1	10
W+D BHD C	7.0	11.6	23.3	20.4	2.6	
NO RESP	0	0	2.3	0	0	0
SB PUSH TB-C	42.1	83.7	23.3	61.2	46.2	60
SB PUSH C-TB	24.6	11.6	23.3	16.3	12.8	6.7
TB PUSH SB-C	21.1	0	39.5	16.3	23.1	6.7
TB PUSH C-SB	12.3	4.7	11.6	6.1	17.9	26.7
NO RESP	0	0	2.3	0	0	0

Note. H = horse; B = boy; D = dog; W = woman; C = car; S = small; T = tall; PULL = is pulling; PUSH = is pushing; BHD = is running, is walking, is riding behind; NO RESP = absence of response. Targets are "O cavalo puxa o menino" (The horse is pulling the boy), "O cachorro vai atras da mulher e do carro" (The dog walks behind the woman and the car), and "O menino pequeno empurra o grande na cadeira (The small boy pushes the tall boy on the chair).

(B) In SS-2, the girl-runs foil discriminated neither left-brain-damaged (p = .52) nor right-brain-damaged (p = .46) from control illiterates but attracted left-stroke literates (p = .054), whereas the boy-runs foil attracted left-stroke illiterates (p = .011).

(C) In SS-3, the cat-sleeps foil attracted right-stroke illiterates (p = .025) and literates (p = .024) (note that this particular item hardly discriminated left-stroke subjects from their controls).

(D) In CS-1,[7] the boy-pulls-horse foil attracted more responses from left-stroke literates (p = .011) and fewer from right-stroke illiterates (p = .053) and literates (p = .064) than from their respective controls. Moreover, the number of target responses increased in illiterate (p = .067) and to a lesser degree in literate right-stroke subjects compared to their respective controls.

(E) In CS-2, the woman-behind foil[8] attracted left-stroke illiterates (p = .0058) and literates (p = .0071); likewise the woman-and-dog-behind

[7] First item of the complex sentence subtask.
[8] Honni soit qui mal y pense!

TABLE 6
ALL SENTENCES AND ALL RESPONSES

		Controls		Left strokes	Right strokes
		Left	Right	Right	Left
ILLIT	D	48.2%	51.8%	36.9%	36.5%
	L			−14.9%	−11.7%
	p			.020	.015
LIT	D	38.8%	61.2%	48.8%	27.8%
	L			−12.4%	−11.0%
	p			.021	.054
ALL S	D	44.2%	55.8%	43.3%	32.7%
	L			−12.5%	−11.5%
	p			.002	.001

Note. ALL S = all subjects; Left, Right = left, right halves of the displays; D = distribution of responses (percentages); L = Losses by reference to controls (percentages); p = levels of statistical significance as calculated—for each group and each set of six half-displays—using the one-sided Kolmogorov–Smirnov test.

foil attracted left-stroke illiterates (p = .019). Here again, the proportion of target responses was greater among right-stroke subjects than controls although reaching significance level only for the illiterates (p = .048).

(F) In CS-3, the tall-boy-pushes-small-boy foil attracted left-stroke illiterates (p = .031) and literates (p = .0048), whereas the tall-boy-pushes-chair foil attracted right-stroke literates (p = .0095).

4.3. *Spatial Distribution of Responses*

Given the results presented above, the spatial distribution of responses was examined in relation to a number of oppositions: neurologically healthy versus left-stroke versus right-stroke subjects; subjects without versus subjects with a visual field defect; left versus right halves of displays; illiterate versus literate versus all subjects; simple versus complex versus all sentence stimuli; target versus foil versus all responses. Some of the observations thus made are now presented.

4.3.1. All sentences—All responses. When the spatial distribution of all of the 1555 (target + foil) responses to all (simple + complex sentence) stimuli[9] was considered, it was found (Table 6) that left-stroke subjects produced fewer responses to the right (and proportionally more to the left), and that right-stroke subjects produced fewer responses to the left (and proportionally more to the right) than did their controls: all losses (and reciprocal gains) were found to be statistically significant using the

[9] The 13 absences of responses listed in Tables 4 and 5 were not taken into account in our various studies of the spatial distribution of M1-α responses.

TABLE 7

ALL SENTENCES—ALL RESPONSES

	Controls			Left strokes	Right strokes
	Left	Right		Right	Left
D	44.2%	55.8%	VIS N	43.8%	33.2%
L				−12.1%	−10.9%
p				.004	.018
D	44.2%	55.8%	VIS −	42.0%	31.3%
L				−13.8%	−12.9%
p				.009	.006

Note. LEFT = left halves of the displays; RIGHT = right halves of the displays; D = distribution of responses (percentages); L = losses by reference to controls (percentages). VIS N, 66 left and 44 right stroke subjects with normal visual fields; VIS − = 26 left and 25 right stroke subjects either presenting a controlateral visual field defect or judged to be unassessable with respect to visual fields (see Table 2); p = levels of statistical significance as calculated for each group and each set of six half-displays using the one-sided Kolmogorov–Smirnov test.

one-sided Kolmogorov–Smirnov test (Siegel, 1956), whether the illiterate and literate subpopulations were considered separately, or else, collectively. Moreover, as expressed in percentages of losses (and controlateral gains) of responses to the left and right by stroke as opposed to control subpopulations, the global extent of the negative (and reciprocal positive) tropisms was roughly the same in left- and right-stroke subjects, and roughly the same within the illiterate and the literate subpopulations. Given the latter finding that the tropism effects held across the cultural dichotomy, further data related to these tropisms will not take into account the literacy–illiteracy opposition.

Further analyses showed that tropism effects were also roughly the same in subjects whose visual fields were otherwise clinically full versus those whose visual fields were observed either to be abnormal (hemianopia, extinction) or else unassessable (Tables 2 and 7): using in this respect the one-sided Kolmogorov–Smirnov test (Siegel, 1956), all relative losses in the half displays controlateral to lesions were found to be statistically significant (Table 7).

4.3.2. Simple versus complex sentences—All responses. When the spatial distribution of all (target + foil) responses was considered for simple as opposed to complex stimuli, it was found, as shown in Tables 8 and 9, that (a) the tropisms of left-stroke subjects depended almost exclusively on their responses to complex stimuli whereas (b) the tropisms of right-stroke subjects depended on both simple and complex stimuli. In the former subpopulation, a statistically significant difference (χ^2 test) existed

TABLE 8

ALL SUBJECTS—SIMPLE SENTENCES—ALL RESPONSES

	Controls		Left strokes	Right strokes
	Left	Right	Right	Left
D	61.0%	39.0%	37.5%	49.0%
L			−1.5%	−12.0%
0 or 1 R	15 (15%)	85 (85%)	76 (83%)	28 (41%)
2 or 3 R	85 (85%)	15 (15%)	16 (17%)	41 (59%)
p			.80	.0004

Note. Left, Right = left, right halves of the displays; D = distribution of responses (percentages); L = losses by reference to controls (percentages); 0 or 1 R, absolute numbers and percentages of subjects who produced no or one response in Left versus Right; 2 or 3R = absolute numbers and percentages of subjects who produced two or three responses in Left versus Right; p = levels of statistical significance as calculated using χ^2 test applied on 2 × 2 tables.

only for complex stimuli; in the latter, the difference was clearly significant for simple stimuli and nearly reached significance level for complex ones. (As a matter of fact, given that our results were predicted by classical neurology teachings in the case of right-stroke subjects, using a one-tailed rather than a two-tailed test would have been legitimate; i.e., one might consider that the complex sentence tropism does reach a level of statistical significance (p = .034) for our right-brain-damaged subpopulation.)

4.3.3. All sentences—Target responses. As shown in Table 10, several significant differences (χ^2 test) were observed between stroke and control subpopulations concerning the spatial distribution of target responses to

TABLE 9

ALL SUBJECTS—COMPLEX SENTENCES—ALL RESPONSES

	Controls		Left strokes	Right strokes
	Left	Right	Right	Left
D	27.3%	72.7%	49.3%	16.3%
L			−23.4%	−11.0%
0 or 1 R	76 (76%)	24 (24%)	49 (53%)	61 (88%)
2 or 3 R	85 (85%)	15 (15%)	43 (47%)	8 (12%)
p			.0001	.068

Note. Left = left halves of the displays; Right = right halves of the displays; D = distribution of responses (percentages); L = losses by reference to controls (percentages); 0 or 1 R = absolute numbers (and percentages) of subjects who produced no or one response in Left versus Right; 2 or 3R = absolute numbers and percentages of subjects who produced two or three responses in Left versus Right; p = levels of statistical significance as calculated using χ^2 test applied on 2 × 2 tables.

TABLE 10
ALL SUBJECTS—ALL SENTENCES

	Controls		Left strokes		Right strokes	
	L.F.	R.F.	L.F.	R.F.	L.F.	R.F.
TARG+	82 (82%)	33 (33%)	56 (61%)	14 (15%)	36 (52%)	20 (29%)
TARG−	18 (18%)	67 (67%)	36 (39%)	78 (85%)	33 (48%)	49 (71%)
p			.002	.007	.0001	.7

Note. L.F. = left halves of the displays; R.F. = right halves of the displays; TARG+ = absolute numbers and percentages of subjects who pointed to all targets; TARG− = absolute numbers and percentages of subjects who missed at least one target; p = levels of statistical significance as calculated using the χ^2 test applied on 2 × 2 tables.

all (simple + complex sentence) stimuli. These differences indicated a reduction in target responses in stroke as opposed to control subjects. More precisely, it was found that (a) subjects of the left-stroke subpopulation significantly differed from controls for both left and right halves of displays, whereas (b) subjects of the right-stroke subpopulation significantly differed from controls only for left halves of displays.

4.3.4. All sentences—Foil responses. As shown in Tables 11 to 13, several significant differences (χ^2 test) were also observed between stroke and control subpopulations when we considered the spatial distribution of foil responses to all (simple + complex sentence) stimuli. These differences indicated a greated production of foil responses in stroke as opposed to control subjects. More precisely, it was found:

(A) With regard to the distribution of foil responses homolateral to targets, a significant difference was found only for left-stroke subjects pointing in left halves of displays (Table 11).

(B) With regard to the distribution of foil responses by reference to target positions, significant differences were found for both left and right halves of displays within the left-stroke subpopulation whereas such a difference was found only for left halves of displays within the right-stroke subpopulation (Table 12).[10]

(C) With regard to the spatial distribution of foil responses irrespective of target positions, significant differences existed only for left halves of displays in left-stroke subjects and only for right halves of displays in right-stroke subjects (Table 13).

TABLE 11
ALL SUBJECTS—ALL SENTENCES

	Controls		Left strokes		Right strokes	
	L.F.	R.F.	L.F.	R.F.	L.F.	R.F.
FHmT−	94 (94%)	55 (55%)	74 (80%)	51 (55%)	59 (86%)	35 (51%)
FHmT+	6 (6%)	45 (45%)	18 (20%)	41 (45%)	10 (15%)	34 (49%)
p			.009	1	.11	.70

Note. L.F. = left halves of the displays; R.F. = right halves of the displays; FHmT− = absolute numbers and percentages of subjects who never answered on a foil homolateral to target; FHmT+ = absolute numbers and percentages of subjects who pointed at least once to a foil homolateral to target; p = levels of statistical significance as calculated using the χ^2 test applied on 2 × 2 tables.

TABLE 12
ALL SUBJECTS—ALL SENTENCES

	Controls		Left strokes		Right strokes	
	L.F.	R.F.	L.F.	R.F.	L.F.	R.F.
FRfT−	82 (82%)	33 (33%)	57 (62%)	14 (15%)	36 (52%)	20 (29%)
FRfT+	18 (18%)	67 (67%)	35 (38%)	78 (85%)	33 (48%)	49 (71%)
p			.003	.007	.0001	.7

Note. Production of foil responses by reference to target position: L.F. = left halves of the displays; R.F. = right halves of the displays; FRfT− = absolute numbers and percentages of subjects who produced no foil response; FRfT+ = absolute numbers and percentages of subjects who produced at least one foil response; p = levels of statistical significance as calculated using the χ^2 test applied on 2 × 2 tables.

5. DISCUSSION

5.1. Neurological Data

Given the neurological characteristics of our stroke subpopulations (Table 2), it is quite clear that our sample was (a) biased in favor of anterior (and anteroposterior) as opposed to posterior Sylvian strokes and (b) biased in favor of left as opposed to right strokes. In our opinion, this reflects the fact that a stroke patient with hemiplegia as opposed to one without, and also a stroke patient with obvious aphasia as opposed to one without, stands greater probability of being admitted to the wards of overcrowded general hospitals such as those in which our data were gathered. It may also be that probability of admission is somewhat greater for a male than for a female with hemiplegia but without aphasia (Table 1), a finding which would be less readily understandable if indeed it were the case.

5.2. Neuropsychological Data

Even before initial testing was completed for all subjects who participated in our Guggenheim research, perusal of the partial results convinced us that our pointing tasks elicited manifestations of unilateral neglect not

[10] Given the existence of absences of response, albeit limited in number, Table 12 is not entirely a duplication of Table 10.

TABLE 13

ALL SUBJECTS—ALL SENTENCES

	Controls		Left strokes		Right strokes	
	L.F.	R.F.	L.F.	R.F.	L.F.	R.F.
F 0–1	72 (72%)	82 (82%)	41 (45%)	69 (75%)	56 (81%)	41 (59%)
F 2–6	28 (28%)	18 (18%)	51 (55%)	23 (25%)	13 (19%)	28 (41%)
p			.0002	.3	.2	.002

Note. Spatial distribution of foil responses irrespective of target position; L.F. = left halves of the displays; R.F. = right halves of the displays; F 0–1 = absolute numbers and percentages of subjects who produced no response or a single foil response; F 2–6 = absolute numbers and percentages of subjects who produced from two to six foil responses; p = levels of statistical significance as calculated using the χ^2 test applied on 2 × 2 tables. The reason for basing statistical analyses on the opposition of (F 0–1) to (F 2–6) rather than on the opposition of (F 0) to (F 1–6) was to regroup at least 50% of the subjects within the group with a smaller foil production.

only in right-brain-damaged patients—which we expected, given the structure of the M1-α "oral comprehension" task and given that those of us who actually tested patients were instructed to avoid attracting subjects' attention to an eventual incomplete visual exploration of the displays and to note exclusively their initial responses[11]—but also in left-brain-damaged patients. In other words, it was in the course of relatively early phases of our research that we became aware that the left- as well as the right-brain-damaged individuals of our pathological subpopulations often tended to avoid pointing at images situated in the half-displays controlateral to their lesions; that is, they often showed a preference for pointing, presumably with the hand homolateral to their lesions (all but 4 of the 169 brain-damaged subjects presented hemiplegia or hemiparesis; see Table 2), to images situated in the half-displays homolateral to their lesions.

Our attempts to study the manifestations of unilateral neglect in our material and to demonstrate their reality in both left- and right-brain-damaged patients were thereafter plagued by three facts: (a) the M1-α test was not designed to study manifestations of unilateral neglect; (b) an error that occurred in the process of adapting our test to the Portuguese language led to right–left imbalance of presumed targets; (c) this error was such that it led in turn to imbalance in the right–left distribution of

[11] Or absence of response, which occurred only 13 times as opposed to 1555 actual pointing responses. In this respect, Chedru et al. (1973) observed that both left and right brain-damaged subjects with a visual field defect can take up to 15 sec to explore dimidiated visual stimuli in their entirety; likewise, those of us who tested patients noted that brain-damaged subjects—probably more so left brain-damaged subjects—would on occasion keep exploring the displays for 10–15 sec and spontaneously rectify pointing errors which had been produced on stimulus presentation and were explainable on the basis of visual neglect.

"simple" as opposed to "complex" sentence–picture matching stimuli (see 2. Testing Materials, above).

Nonetheless, our control subpopulations, particularly the illiterate one, saw to it that our mistake was in part corrected; that is, neurologically healthy control subjects often did not agree with us as to the identity of "correct" (target) responses (Tables 4 and 5), therefore rectifying to a large extent the right–left distribution of targets—"real" as opposed to "ideal"—(see Table 6, controls.)

5.2.1. Evidence from item-by-item analyses. As a matter of fact, very little could be learned about our patients' auditory comprehension abilities through item-by-item consideration of their results in sentence–picture matching tasks. On the other hand, there were a number of instances in which item-by-item analyses yielded results that could hardly be interpreted otherwise than by attributing them to unilateral neglect, left or right. Because of an interaction between cultural and pathological factors, this is strikingly illustrated by the behavior of illiterates—and, to a lesser extent, of literates as well—when presented with the first item of the complex sentence subtask: given that one of the presumed foils (boy-pulls-horse) in the left half of the display was accepted as the target by nearly half of the illiterate controls and by more than 10% of the literate ones (Fig. 2, Table 5), it becomes understandable—the intended target (horse-pulls-boy) being in the right half of the display—that right-brain-damaged subjects with left unilateral neglect should do "better" than their controls for this item. Likewise, right unilateral neglect might well explain why left-brain-damaged subjects, this time especially literate ones (whose behavior thus duplicated that of illiterate controls for this stimulus), accepted the intended boy-pulls-horse foil as the target more often than did their controls. Several other item by item results lead us to similar conclusions (see 4.2, Figs. 1 and 2, and Tables 4 and 5).

5.2.2. Spatial distribution of responses: 5.2.2.1. Overall tropisms. Comparing the global distribution of responses in stroke as opposed to control subjects firmly documented the existence of a left-side attraction and/or right-side avoidance in left-stroke subjects as well as the existence of opposite tropisms in right-stroke subjects (see 4.3.1 and Table 6). On the other hand, none of our data can be interpreted as indicating that tropisms were globally stronger or more obvious in any of the four pathological subpopulations: on the contrary, these data seem to justify the claim that, in the type of sentence–picture matching task that we used, roughly comparable tropism effects were present in left-stroke as well as in right-stroke illiterates and literates. Moreover, our results provide no indication that one should think in terms of a negative tropism for the controlateral "side" (unilateral neglect) rather than in terms of positive tropism for the homolateral "side." Finally, it is to be underlined that tropism effects were found to be independent of the presence or absence of a visual field defect (Table 7), which can be considered as a strong evidence that our subjects' behavior in M1-α sentence–picture matching demonstrated the existence of an essentially cognitive as opposed to a more peripheral sensory disorder. Of course, we are prepared to consider that the phenomena we have observed and documented for the best part might be related to the very nature of our M1-α sentence–picture matching subtests. In fact, given classical neurological knowledge, and given our own experience of the spectacular effects of certain right parietal lesions, we are inclined to believe that these phenomena were indeed task specific to a large extent. Moreover, they were no doubt enhanced by the fact that examiners deliberately avoided checking whether eventual manifestations of unilateral neglect could be countered by talking or signaling subjects into more attentive exploration of the drawing stimuli (as one often does in the course of bedside examination or rehabilitation-oriented evaluation of patients).

5.2.2.2. "Simple" versus "complex" sentences. Despite the imperfections of our experimental procedures, it is our impression that the statistical study we have performed on the results of our patients' sentence–picture matching behavior (as compared to that of controls) justifies the claim that, irrespective of the literacy factor, global tropism effects existed for both simple and complex sentences stimuli in right-brain-damaged subpopulations whereas such effects were manifest only in response to complex sentences stimuli in left-brain-damaged subpopulations. This particular point has become the object of another research project now being concurrently led in Canada and Brazil. Should this research confirm our present claim, some of the issues related to unilateral neglect might be reformulated in part and perhaps further clarified.

For instance, does the dissociation that we have observed between right- and left-brain-damaged subjects indicate—in line with classical conceptions (Battersby et al., 1956; Chain et al., 1979; Chedru et al., 1973; Costa et al., 1969; Critchley, 1953; Gainotti, 1968; Hécaen, 1962)—that manifestations of unilateral neglect are (somehow) related to right hemisphere "dominance" for "visuospatial" cognition and therefore should be more universally manifest (show a lesser degree of task specificity) following right than following left brain damage? Taken at first sight, our data might be considered to support an affirmative response to this question. But one might also wonder to what extent, when it is guided by linguistic information, the decoding of figurative drawings such as those constitutive of our sentence–picture matching tasks should be considered as predominantly attended to by one hemisphere rather than the other (cf. infra), that is, to what extent decoding of this type indeed depends on what has become to be known as the visuospatial dominance of the right hemisphere (Hécaen, Penfield, Bertrand, & Malmo, 1956).

Furthermore, is the dissociation observed between "simple" and "complex" items in left-brain-damaged subpopulations indeed linked to the linguistic (syntax? length of stimuli-sentences?) complexity of the tasks presented to patients, or is it linked to iconographic complexity of the visual stimuli (Chain et al., 1979), or else to both? Given that levels of syntactic versus iconographic complexity are in near absolute overlap in the M1-α sentence–picture matching tasks (Figs. 1 and 2), this question, which we specifically tackle in our more recent project, cannot be answered on the basis of the data reported here.

On the other hand, should the neglect phenomena observed among left-brain-damaged subjects considered as inherent to "sensory" aphasia, as suggested by Tyler (1969), or else as the manifestations of a disorder associated to aphasia? With regard to our own materials, the latter is in our opinion more than likely since retrorolandic lesions were underrepresented in all four of our brain-damaged groups (see 3. Subjects, above). Perhaps rather the neglect phenomena observed in left-brain-damaged subjects when tested with the M1-α witnesses to an interaction between two cognitive disorders, each related to an asymmetrically represented function. According to this view, right unilateral neglect would become clinically manifest once and only once the residual decoding abilities of the damaged left hemisphere are exceeded.

5.2.2.3. Tentative hypotheses. Considering our data and the above comments there is at least one (potentially boxological) scenario which might be compatible with the former and some of the latter. In order to be successfully achieved, the M1-α sentence–picture matching tasks that we used in our research might involve an interaction between several cognitive mechanisms related to (a) *decoding* linguistic information as auditorily presented in the form of a stimulus sentence, (b) *exploring* and *decoding* a visual information made of four figurative drawings presented in a single display which can be described as left–right dimidiated, and (c) *mapping* the stimulus sentence on one of the four drawings.

On the other hand, it would be in line with basic tenets of current neuropsychology to postulate or believe (a) that the human brain masters two basic strategies for decoding information, one founded on sequential (Type S) and the other on cotemporal (Type C) activities; (b) that sequential treatment of information is best managed by the left and cotemporal or holistic treatment by the right cerebral hemisphere; and (c) that certain types of information are, by nature or education, more economically and better decoded through sequential or cotemporal strategies.

Given the structure of the M1-α sentence–picture matching tasks (Figs. 1 and 2), one can feel quite confident in asserting that decoding of the stimuli sentences—in which syntax for instance, is, primordial while prosody could be nearly irrelevant— is mostly attended to by Type S decoding devices. In view of the simultaneity of visual information, a holistic (Type C) appreciation of the corresponding displays might well

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