

Syntactic comprehension in Broca's aphasic Spanish-speakers: null effects of word order

FEGGY OSTROSKY-SOLIS†,
JOSE MARCOS-ORTEGA‡, ALFREDO ARDILA§,
MONICA ROSSELLI¶ and SILVIA PALACIOS†

† Department of Psychophysiology, Faculty of Psychology, National Autonomous University of México, México D.F.

‡ Colegio de México e Instituto Nacional de Psiquiatria, Mexico D.F.

§ Miami Institute of Psychology, Miami, Florida, USA

¶ Florida Atlantic University, Davie, Florida, USA

(Received 18 December 1996; accepted 21 December 1998)

Abstract

The syntactic and nonsyntactic strategies used for understanding sentences by Spanish-speaking Broca's aphasic patients in off-line tasks were analysed. It is emphasized that given the characteristics of syntax in Spanish, such as its flexibility (greater freedom in the order of constituents), the function of the direct object with the preposition *a* (to) and the effect of determiners, research with Spanish-speaking patients will allow for a characterization of specific disorders that cannot be generalized on the basis of research conducted in other languages. A linguistic instrument was applied to 10 Broca's aphasic patients. A forced choice task was used in which the patient listened to 190 different reversible sentences and was asked to select one of four options presented on a plate; each option contained a pair of animals performing a specific act and only one option was correct. The results showed significant differences in the use of syntactic and nonsyntactic strategies. Broca's aphasic patients used only morpho-syntactic marks with high cue validity. No significant effects of word order were found. These findings imply the existence of specific off-line linguistic mechanisms that influence the comprehension in non-fluent aphasic patients.

Introduction

A central and controversial problem in the study of syntactic comprehension in Broca's aphasia is the nature of the underlying grammatical impairment that is present. Syntax in sentence comprehension involves several levels of analysis, such as the use of word order constraints, recognition of morpho-syntactic cues (both free and bound morphemes), mapping constituents into syntactic categories and the assignment of thematic roles. Some researchers have assumed that the grammatical deficit in Broca's aphasia affects all syntactic processing. Accordingly,

Address correspondence to: A. Ardila, 12230 NW 8 Street, Miami, Florida 33182, USA;
e-mail: aardila@compuserve.com

there is a central syntactic deficit where syntactic knowledge is lost, affecting both production and comprehension (Caramazza and Zuriff 1976, Caplan 1981, Caramazza and Brendt 1985). Others have postulated a comprehension impairment essentially different from production and suggested that agrammatics have no syntactic knowledge for analysing sentences and that they interpret them on the basis of heuristic strategies (Caplan and Hildebrandt 1988). However, more recent views have suggested that the problem in agrammatism is related to impaired access and processing over a preserved knowledge base (Prather *et al.* 1991, Bates, Wulfeck and MacWhinney 1991). Still other groups have postulated a closed-class hypothesis, where only sub-parts of the syntactic process may be impaired and the syndrome is restricted to inflection and function words spairing of word order. (Bradley, Garrett and Zurif 1980, Zurif and Grodzinsky 1983, Bates, Friederici and Wulfeck 1987). According to recent views, knowledge of closed class elements is preserved while the underlying cause is a problem with access and use of closed-class elements in real time (i.e. in on-line studies) (Friederici 1988, Garret 1992, Zurif *et al.* 1993, Pulvermuller 1995, Blackwell and Bates 1995).

As Blackwell and Bates (1995) point out, one of the difficulties in concluding that morphology is selectively vulnerable in agrammatism is that much contemporary research on agrammatism has been carried out in English, which is a language that follows strict subject-verb-object (SVO) word order and relies little on morphology, making it difficult to separate language-specific aspects of the syndrome. To date, data on syntactic comprehension in Spanish, both in normal and aphasic subjects, is sparse. In contrast to English, which is a word order language with relatively little emphasis on morphology, Spanish, like Italian, depends less on word order and more on a rich morphological system. However, unlike Italian, Spanish is considered a language that allows great flexibility in word order. Syntactic rules of Spanish allow for various displacements of constituents of a sentence without modifying its essential meaning. For example, the canonical sentence, '*Juan ama a María*' (John loves Mary) can be expressed in five other—more marked ways: *Juan a María ama*, *A María ama Juan*, *A María Juan ama*, *Ama Juan a María*; and *Ama a María Juan*, while in English and French, if the sentence does not have a passive form or subordinate clauses, the canonical order is the only one permitted. For example: 'John loves Mary' or '*Jean aime Marie*'. On the other hand, the canonical order in Spanish for intransitive sentences may be verb-subject ('*ayer vino Juan*', yesterday came Juan), while in English, given the fact that word order is a very important cue, if the sentence is intransitive, the SV of the SVO order is still preserved (MacWhinney, Bates and Kliegl 1984).

The morphological system of Spanish, bound inflectional morphemes prepositions and articles is also richer than other languages, such as English. For example, there are markers, such as verb inflections, which allow for the assignment of roles and eliminate ambiguity that could be generated if understanding depended on order only. In verb conjugation, Spanish has a higher number of morpho-syntactic cues (bound morphemes) that allow for obtaining information which is not obtained with verbs in English. Free function morphemes such as articles and prepositions can mark syntactic categories. In Spanish when the preposition '*a*' is used in sentences with a transitive verb, it shows that the phrase it precedes is the direct complement.

With regard to word order, it has been reported that in English, Italian and German, the SVO word order is the canonical one (Bates, Friederici and Wulfeck

1987). However, in Japanese, it is SOV (Hagiwara and Caplan 1990) and in a previous study with normal subjects we found that in Spanish, although the canonical order is also SVO, canons seem to be related to the distance between the arguments or the nouns (N) and the verb (V). The N that appears after the verb (N-V-N) is considered the one that receives the action and thus it becomes the patient of the sentence; the N that is left is given the role of agent. Thus in Spanish, due to its flexibility in the position of the arguments, the canonical order seems to be related to the V-O structure, the noun or argument that follows the verb is the patient and that is the most reliable due to grammatical roles. Thus, once the patient is identified, the noun that is left is assigned the role of agent. In this sense, strategies based on constituent structure are not heuristic, but syntactic. They can be explained in terms of the properties of transitive verbs, which subcategorize a nominal phrase as their internal argument. In the resolution of ambiguous sentences with N-N-V, N-V-N and V-N-N structure, Spanish-speakers tend to interpret the noun that immediately follows the verb as the object and the noun that precedes the verb as the subject (Marcos and Ostrosky-Solis 1995).

According to a series of cross-linguistic studies on sentence comprehension and production in Broca's aphasia which compared English, German and Italian aphasic patients, grammatical morphology appears to be more impaired than word order principles in every language studied. However the degree to which grammatical morphology is retained by aphasic patients depends upon the strength or importance of those morphemes in the patient's premorbid language (Bates, Friederici and Wulfeck 1987). According to Blackwell and Bates (1995), cross-linguistic studies have shown that in agrammatic patients there is a pattern of morphological vulnerability with relative sparing of word order, although aphasics do tend to retain the cues of their languages and preserve the language-specific ratios of cross-class morphology. Thus, many of the underlying characteristics of Broca's aphasia may be obtained cross-linguistically, but they manifest themselves in ways that interact with the cue values of the languages. Hagiwara and Caplan (1990), in a study of Japanese native-speaker aphasic patients, have also suggested that the canonicity of thematic role order determines the ease of different sentence types and that language-specific factors, rather than universal-language factors, influence the sentence comprehension mechanisms that are retained by aphasic patients.

In recent studies Marcos and Ostrosky-Solis (1995), described the syntactic and nonsyntactic strategies used by neurologically intact subjects to assign words of specific syntactic categories (subject, object, prepositional object) to thematic roles (theme and goal). They found that Spanish syntax has specific characteristics such as flexibility of word order (free stylistic movement of constituents), the use of the preposition 'a' as a sign of the direct or indirect object, and important determination effects as a marker of the agent (subject). The results indicate that subjects understand sentences with a simple structure via syntactic strategies based on superficial signs (agreement, presence or absence of a preposition, passive morphology). However, complex structure sentences (passive, pseudocleft) and those that do not respect the SVO canonical order are interpreted with heuristic (order of constituents), lexical-pragmatic (knowledge of the world) and functionalist (animation) strategies.

Since Spanish is a flexible word order language with a rich morphological system where certain free function morphemes are cues to mark syntactic categories, an

analysis of language disorders in Spanish aphasics could provide information about language brain organization that cannot be generalized from studies in other languages. The purpose of this study was to investigate the off-line syntactic strategies used by Spanish speaking aphasics for understanding focusing on the function of thematic role order and syntactic morphology (i.e. absence/presence of the preposition 'a' and definite/indefinite article 'el/un').

An attempt was made to ascertain if the interpretation of these sentences, in regard to the assignment of the thematic roles of agent and patient is: (1) guided by the grammatical rule pertaining to the function of the preposition; or (2) if this formal procedure interacts with heuristic strategies, (the order of the constituents) or super strategies, (the position held by nominal phrases with respect to the verb).

Method

Participants

Ten aphasic subjects (5 males and 5 females) were tested. All subjects were right-handed. The mean age was 54.8 years (range 44–77 years) and the mean years of education was 9.8 (range 3–17). Diagnostic criteria included the Western Aphasia Battery-Spanish version (Kertesz, Pascual-Leone, Pascual-Leone 1990) adapted and validated in a Mexican aphasic population (Gonzalez and Venegas 1994), a CT scan information when available and clinical history. Eight patients had suffered a cerebral vascular accident and two had a closed head trauma. The mean number of years post-onset of aphasia was 3.25, ranging from 1–6.5 years.

Patient's scores on the Western Aphasia Battery were characteristic of Broca's aphasia. Patients demonstrated relatively normal comprehension (mean coefficient comprehension 6.8, range 4–8) while measures of output fluency were severely depressed (mean coefficient 2.8, range 0.8–4). On a picture description task depicting a familiar scene (a simple sketch of a house, lake, people and animals), all subjects demonstrated agrammatical speech with reduced utterance length and sentence complexity, along with more omissions of function words than content words. A group of 30 non-brain damaged controls were included as a reference group.

Materials

We designed a linguistic instrument to assess the off-line syntactic and nonsyntactic strategies used by controls and aphasics to assign words to specific syntactic categories (subject, object, object of the preposition) and to thematic roles (theme, goal).

A forced choice task was used in which the subjects listened to 190 different reversible sentences and were asked to select, by pointing to one of four options presented on a plate. Each option contained a pair of animals performing a specific act and only one option was correct. 1 = Correct action and animal corresponding to the sentence; 2 = Same action, same animals, reversed roles; 3 = Same animals but performing a different action; and 4 = Different pair of animals and the same action. Four pairs of animals and five different transitive verbs were used. Based on real world knowledge both animals were equally able to perform the action: (1) pull, duck, rooster; (2) hit, camel, horse; (3) bite, rabbit, skunk; (4) kick, tiger,

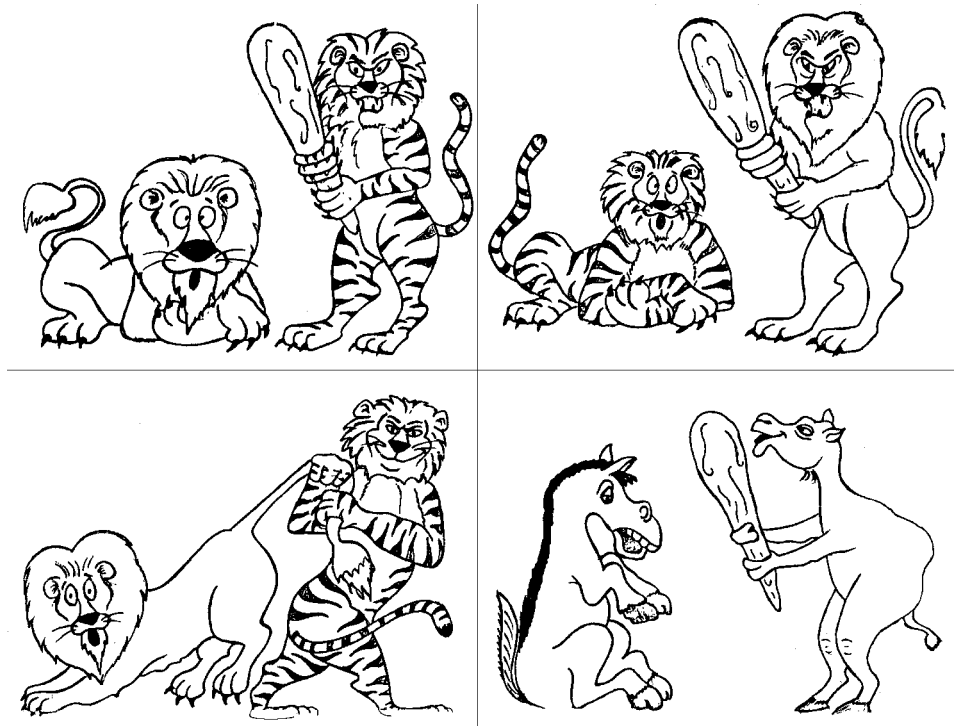


Figure 1. Example of pictures used. The subjects were instructed that a pair of animals appeared in each sentence, one of which performed an action and the other received it. The task was to point out which picture set depicts the action described by the sentence. In each plate four options were presented and only one option was correct. 1 = correct action and animal corresponding to the sentence; 2 = same action but performed by the inverse animal; 3 = same animals but performing a different action; and 4 = different pair of animals and the same action. Percentage of correct answers and type of errors were analysed.

lion; and (5) pick at, duck, rooster. The position of the matching picture was randomized within sentence-distractor types. An example of the pictures for this task are shown in figure 1.

The effects of four factors were studied: sentence type, thematic role, effect of preposition and the use of the definite/indefinite article. A description of these factors follows:

- (1) To evaluate the effect of sentence type, we included 90 active, 65 passive and 40 pseudocleft reversible sentences; and
- (2) To evaluate thematic roles, we included assessment and manipulation of, (a) order of constituents and (b) analysis of the internal structure.

(a) *Order of constituents*

According to the position of the nominal phrases representing the agent (Agt) and the patient (Pat) of the transitive verb (TV), there were three different orders in the corpus for the active sentence, six for the passive and four for the pseudocleft. All the orders of constituents allowed in Spanish for each type of sentence were used, without generating ungrammatical sentences. In half of the sentences the first noun was the agent and in the other half the second noun was the agent.

Table 1. Active sentences with the preposition 'a' anteceding the direct object

Sentence type	Determination		Correct	
			Aphasics % (SD)	Controls % (SD)
SVO	Ag. Determinado	<i>El león golpeó a un tigre</i>	70.83 (23.91)	100.00 (0)
	Ag. Indeterminado	<i>Un león golpeó al tigre</i>	73.88 (12.54)	98.66 (5.16)
OVS	Ag. Det.	<i>A un tigre golpeó el león</i>	51.39 (24.28)	100.00 (0)
	Ag. Ind.	<i>Al tigre golpeó el león</i>	57.50 (26.33)	100.00 (0)
SOV	Ag. Det.	<i>El león a un tigre golpeó</i>	60.00 (18.95)	100.00 (0)
	Ag. Ind.	<i>Un león al tigre golpeó</i>	46.67 (14.98)	98.66 (5.16)
OSV	Ag. Det.	<i>A un león el tigre golpeó</i>	62.36 (22.70)	100.00 (0)
	Ag. Ind.	<i>Al león un tigre golpeó</i>	58.75 (23.08)	97.33 (7.03)
VSO	Ag. Det.	<i>Golpeó el tigre a un león</i>	63.61 (25.32)	98.66 (5.16)
	Ag. Ind.	<i>Golpeó un tigre al león</i>	61.94 (19.46)	98.66 (5.16)
VOS	Ag. Det.	<i>Golpeó el tigre un león</i>	44.58 (13.05)	97.33 (7.03)
	Ag. Indt.	<i>Golpeó al tigre un león</i>	57.50 (24.90)	96.00 (8.28)

Percentage of correct responses per sentence type (mean and standard deviation). All the sentences are grammatically correct (the/a lion hit a/the tiger).

(b) Internal structure

Analysis of the position held by the syntactic categories with respect to the verb; that is, direct object before or after the verb and proximity to the verb. For example, TV-Agt-Pat ('*Golpeó un tigre a un león*' 'hit a lion (nom) a tiger (acc)') vs TV-Pat-Agt ('*Golpeó a un león un tigre*' 'hit a tiger (acc) a lion (nom)').

Preposition

We investigated what function the preposition 'a' had in the interpretation of pragmatically reversible sentences in which a transitive verb appears, where, according to the normal place given in grammatical treatises, the preposition precedes the direct complement, which coincides with the patient of the action of the transitive verb. We also attempted to explore the effect of more subtle grammatical knowledge, which has to do with the consequence of isolating the preposition, such as when the preposition 'a' is used alone, versus contracting the preposition, as when it is used in coalescence with the definite article *el*, thus *a + el*

Table 2. Active sentences without the preposition 'a' anteceding the direct object

Sentence type	Determination		Correct	
			Aphasics % (SD)	Controls % (SD)
NVN	1 st N Determin	<i>El león golpeó un tigre</i>	44.58 (29.19)	100.00 (0)
	1 st N Indet.	<i>Un león golpeó el tigre</i>	50.41 (20.72)	65.33 (31.59)
NNV	1 st N Determin	<i>El león un tigre golpeó</i>	64.58 (28.24)	94.67 (9.15)
	1 st N Indet.	<i>Un león el tigre golpeó</i>	56.52 (25.48)	28.00 (34.47)
VNN	1 st N Determin	<i>Golpeó el tigre un león</i>	47.64 (25.82)	94.67 (9.15)
	1 st N Indet.	<i>Golpeó un tigre el león</i>	49.58 (25.27)	34.67 (25.59)

Percentage of responses assigning the first noun the role of the agent (mean and standard deviation). All sentences are syntactically ambiguous but not ungrammatical.

= 'al'. The preposition 'a' was presented in half of the sentences, while the contraction 'al' was presented in the other half.

Determiners

The definite and indefinite articles were distributed in the same proportion in all the arguments; the combination of definite agent and indefinite patient was presented in half of the sentences, while the reverse was presented in the other half.

Five different sentences were generated for each type of sentence, totalling 190 sentences. The sentences were randomized, with the same order for all the subjects. The list of the sentences used is provided in the appendix. Only one example is included since, based on the nouns and verbs used, the other sentences can be easily deduced.

Procedure

Before starting, we evaluated whether or not the subjects were able to name and correctly point to, the animals and the verb used. The subjects were instructed that a pair of animals would appear in each sentence, one of which would perform an action and the other, receive it. The task was to point out which picture in a four picture set depicted the action described by the sentence. The procedure was illustrated with two examples in which the structure and the lexical items were different from those used in the sentences which the subjects had analysed. The sets of pictures were present during sentence presentation. Sentences were spoken twice with a normal intonational contour by the experimenter. Subjects were not limited in their time to respond, thus demonstrating the off-line nature of the present investigation. The sentence was repeated to the patient on request. No feedback with respect to the accuracy of the answer was given to the patient. The

Table 3. Passive Sentences

Sentence type	Determination		Correct	
			Aphasics % (SD)	Controls % (SD)
Pat-V-Ag	Ag. Determinado	<i>Un tigre fue golpeado por el león</i>	51.25 (25.86)	98.66 (5.16)
	Ag. Indeterminado	<i>El tigre fue golpeado por un león</i>	57.77 (25.76)	100.00 (0)
OVS	Ag. Det.	<i>Por el león fue golpeado un tigre</i>	38.19 (19.61)	96.00 (11.21)
	Ag. Ind.	<i>Por un león fue golpeado el tigre</i>	53.47 (21.18)	93.33 (12.34)
SOV	Ag. Det.	<i>Un tigre por el león fue golpeado</i>	49.58 (20.72)	98.66 (5.16)
	Ag. Ind.	<i>El tigre por un león fue golpeado</i>	48.75 (23.07)	98.66 (5.16)
OSV	Ag. Det.	<i>Fue golpeado un tigre por el león</i>	57.92 (20.83)	100.00 (0)
	Ag. Ind.	<i>Fue golpeado el tigre por un león</i>	51.94 (25.19)	98.66 (5.16)
VSO	Ag. Det.	<i>Fue golpeado por el león un tigre</i>	60.97 (22.17)	93.33 (12.34)
	Ag. Ind.	<i>Fue golpeado por un león el tigre</i>	48.47 (22.91)	98.66 (5.16)
VOS	Ag. Det.	<i>Por el león un tigre fue golpeado</i>	57.08 (24.35)	94.66 (9.15)
	Ag. Indt.	<i>Por un león el tigre fue golpeado</i>	55.00 (26.63)	98.66 (5.16)

Percentage of correct responses (mean and standard deviation).

190 randomized sentences were presented in three consecutive sessions, held at one-week intervals, each of which took about half an hour.

Results

Separate analyses of variance were calculated for each group (controls and Broca's aphasics). In the statistical analysis, only answers relating to the right or wrong assignment of thematic roles were considered: (1) correct action and animal that correspond to the sentence; and (2) same action but reversed roles. Moreover, error types were quantified for each subject: (3) same animals but performing a different action; and (4) a different pair of animals and the correct action. The percentage of correct responses for each sentence type was entered into an analysis of variance with repeated measures, followed by an analysis of simple effects when interaction reached significance level ($p < .05$).

For the active voice sentences, we performed two types of analysis: (1) three different word orders \times two article combinations (definite/indefinite); and (2) three different word orders \times two different uses of the preposition (presence/absence) \times two article combinations (definite/indefinite). Table 1 and table 2

Table 4. Pseudocleft-Agent Sentences

Sentence type	Determination		Correct	
			Aphasics % (SD)	Controls % (SD)
Pat-V-Ag	Ag. Determinado	<i>Fue el león lo que golpeó a un tigre</i>	50.83 (26.09)	98.66 (5.16)
	Ag. Indeterminado	<i>Fue un león lo que golpeó al tigre</i>	51.25 (14.10)	100.00 (0)
Ag-Pat-V	Ag. Det.	<i>Fue el león lo que a un tigre golpeó</i>	60.41 (18.76)	98.66 (5.16)
	Ag. Ind.	<i>Fue un león lo que al tigre golpeo</i>	48.47 (20.83)	97.33 (7.03)
V-Pat-Ag	Ag. Det.	<i>Lo que golpeó a un tigre fue el león</i>	76.25 (14.32)	93.33 (9.75)
	Ag. Ind.	<i>Lo que golpeó al tigre fue un león</i>	57.08 (23.00)	97.33 (7.03)
V-Pat-Ag	Ag. Det.	<i>Lo que a un tigre golpeó fue el león</i>	67.50 (23.79)	98.66 (5.10)
	Ag. Ind.	<i>Lo que al tigre golpeó fue un león</i>	58.33 (30.10)	98.66 (5.16)

Percentage of correct responses (mean and standard deviation). Sentence type is defined according to the position held by the agent and the patient. All these sentences are grammatical and mean 'What the/a lion hit was a/the tiger.'

presents the percentage of correct responses in the experimental and control group, for the active sentence with the preposition 'a' (to) and the active sentence without the preposition 'a'.

For the passive voice sentences, we analysed six orders \times two article combinations (table 3); and for the pseudocleft sentences, we analysed four different word orders \times and two different uses of the preposition (stressed/unstressed) (table 4).

Active reversible sentences without a preposition

These sentences might be considered syntactically ambiguous due to the absence of the preposition 'a'. In any event, we assumed that the first nominal phrase represented the subject of the sentence and therefore the agent of the action and scoring was made in accordance with this assumption.

For normal controls there was a significant main effect of order ($F(5,45) = 9.703$; $p < .001$) and of the article ($F(5,45) = 12.72$, $p < .001$), with no significant interaction of variables. With respect to order, the subjects gave a significantly higher number of correct responses when given the argument-verb-argument (AVA) order ('*El león golpeó un tigre*', 'the lion hit a tiger') than in the VAA order ('*Golpeó el león un tigre*', 'hit a tiger a lion') and gave a higher number of correct responses when given definite article ('*El tigre golpeó un león*': 88%; 'the tiger hit a lion') than with the indefinite article ('*Un tigre golpeó el león*': 33%, 'a tiger hit the lion'). This means that they defined the agent in the argument preceded by the definite article 'el' in a significantly higher number of cases than in those preceded

ACTIVE SENTENCES WITHOUT PREPOSITION: EFFECT OF WORD ORDER AND DETERMINATION

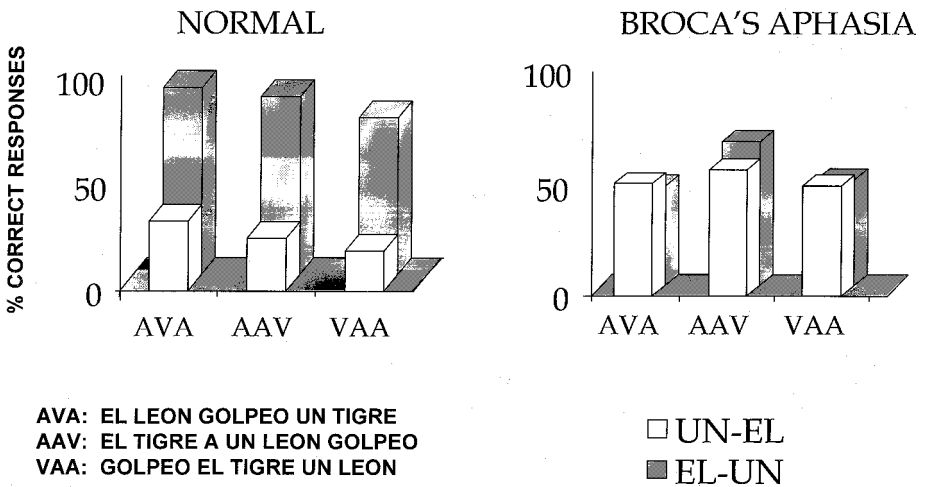


Figure 2. Average percentages of correct responses for reversible ambiguous active voice, determinate and indeterminate sentences for the group of normal subjects and for the group of Broca's aphasic.

by the indefinite 'un'. As we stated before, this type of sentence is ambiguous; that is, syntactically, no agent or patient is defined. Notwithstanding, the subjects tended to grant the role of agent to arguments preceded by the definite article 'el'.

For Broca's aphasics, unlike the normal group, there was no significant effect of order or of definite article. The patients found it extremely difficult to understand these sentences and obtained percentages below chance; for example, given the determinate AVA order, which was the simplest one for normal subjects, the average accuracy percentage was 44%.

Figure 2 shows average percentages of correct responses for reversible ambiguous active voice, determinate and indeterminate sentences for the control group and the aphasic patients.

Active reversible sentences with preposition

When studying the effect of the preposition, for normal controls there was a significant main effect of the preposition ($F(5,145) = 3.041, p < .001$) with no significant interaction with order; thus, the average of correct responses of normal subjects using active sentences with a preposition was close to 100%.

For Broca's aphasics, there was a significant main effect of the preposition ($F(1,11) = 4.465, p < .05$) and an interaction of order and preposition ($F(2,22) = 6.391, p < .006$). The post hoc simple effect tests ($p < .05$ error) show that the preposition had a significant effect in respect to the A-V-A structures ('*El león golpeó un tigre*', 'the lion hit tiger (acc)'), where the percentage of correct responses rose from 44.5% ('*El león golpeó un tigre*', 'the lion hit a tiger') to 70.8% ('*El león golpeó a un tigre*', 'the lion hit a tiger (acc)') and in the V-A-A structure, in which the

ACTIVE SENTENCES BROCA'S APHASIA

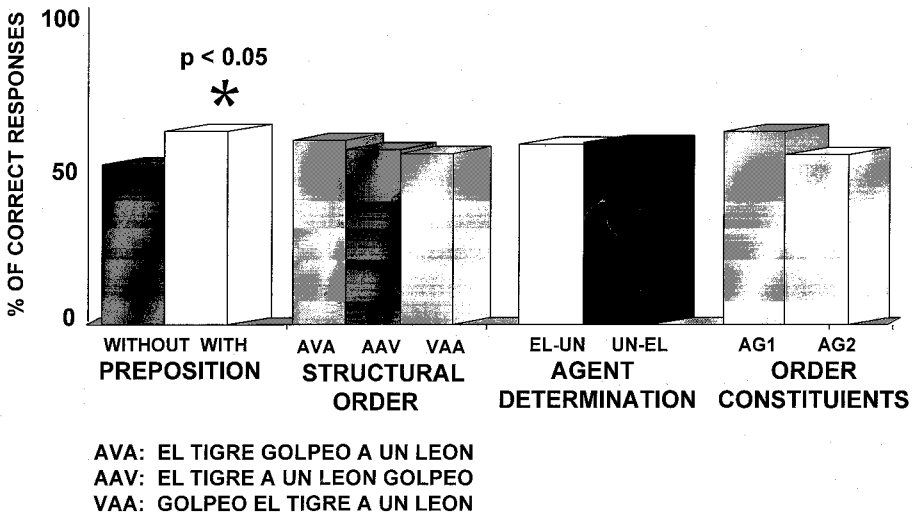


Figure 3. Average percentages of correct responses given by aphasic patients to active sentences in the four conditions worked with: presence/absence of a preposition; structural order (Agt-TV-Pat, Agt-Pat-TV, TV-Agt-Pat); determinate (*el/un*); order of constituents(agent in first position vs. agent in second position).

average number of correct responses rose from 47% (*Golpeó el león un tigre*, 'hit lion tiger') to 63% (*Golpeó el león a un tigre*, 'hit the lion a tiger (acc)'). The presence of the preposition did not increase the percentage of correct responses in the A-A-V structures (*El león un tigre golpeó*, 'the lion a tiger hit').

In active sentences with a preposition, there was no significant main effect of word order or determinate, however there was a significant interaction between structural order and order of the constituents ($F(2,22) = 5.501$; $p < .001$). The post hoc simple effect tests ($p < .05$ error) show more first-noun choice on the Agt-TV-Pat, with chance performance on the other two word orders, Agt-Pat-TV and TV-Pat-Agt.

Figure 3 shows the percentages of correct responses given by aphasic patients to active sentences in the four conditions worked with: presence/absence of a preposition; structural order (Agt-TV-Pat, Agt-Pat-TV, TV-Agt-Pat); determiner (*el/un*); and orders of constituents (agent in first position vs. agent in second position).

Passive reversible sentences

In passive sentences, irrespective of the order of the sentence, the average of correct responses by normal controls was close to 100%, with no significant effect of word order or of the definite/indefinite status. Aphasic subjects performed at chance level on all passive sentences, and no significant effect of word order or of the definiteness was found.

PASSIVE SENTENCES BROCA'S APHASIA

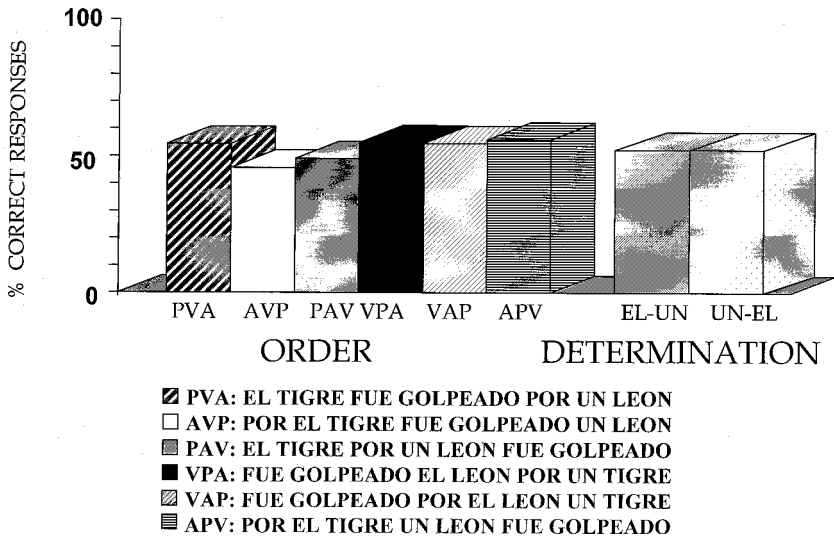


Figure 4. Average percentages of correct responses by aphasic patients to passive sentences in the six different orders used in the determinate and indeterminate sentences.

Figure 4 shows the percentages of correct responses by aphasic patients to passive sentences in the six different orders used in the definite and indefinite sentences.

Pseudocleft-agent reversible sentences

In normal controls, the percentage of correct responses to the grammatical rule of the function of the preposition was frequently close to 100%. However, we found a significant effect of structure ($F(5,145) = 12.72, p < .00001$). The percentage of correct responses for each of the structures is shown in table 5.

The post hoc statistical tests (simple effects; experimental error, $p < .05$), allow for an interpretation of the effect of this order. If we agree that the canonical structure in Spanish is SVO, we propose the hypothesis that when the order is not canonical, there will be a tendency to interpret the first nominal phrase as the agent of the transitive verb. Our results show that sentences that have an Agt-TV-Pat order are among those that obtained the highest percentage of correct answers. However, their values do not vary significantly from those obtained with the TV-Pat-Agt structure. On the other hand, sentences that are most likely to have incorrect answers, which differ substantially from all the others, have the Agt-Pat-TV structure.

The above indicates that it is not the canonical SVO order that directs the interpretation, nor is it the absolute order in which the nominal phrases appear. The explanation seems to be found in the position of the direct complement with

Table 5. Pseudo-Cleft Agent Sentences Percentage of correct answers in each structure by the normal subjects

		Mean	S.D.
1. Agt TV-Pat	<i>Fue el tigre lo que golpeó a un león</i> (It was the tiger that attacked a lion)	90.87	10.05
2. Agt TV-Pat	<i>El tigre fue lo que golpeó a un león</i> (The tiger was what attacked a lion)	90.75	11.19
3. Agt Pat-TV	<i>Fue el tigre lo que a un león golpeó</i> (It was the tiger which is what attacked a lion).	87.94	12.08
4. Agt Pat-TV	<i>El tigre fue lo que a un león golpeó</i> (The tiger was what attacked a lion)	84.45	15.05
5. TV-Pat Agt	<i>Lo que atacó a un león fue el tigre</i> (What attacked a lion was the tiger)	79.32	17.83
6. Pat-TV Agt	<i>Lo que a un león golpeó fue el tigre</i> (What attacked a lion was the tiger).	75.65	20.86

Results of a posteriori analysis of simple effects (experimental error of $p < .05$)

1 2 3 4 5 6

Note: The types of sentences underlined by a common line do not differ significantly. The structures that are not underlined by a same line differ significantly to $p < .05$.

respect to the transitive verb. The greatest probability of correct answers occurs when the direct complement (patient) appears immediately after the transitive verb, even if the agent appears later. Inversely, the least probability of correct interpretation arises in cases where the direct complement falls before the transitive verb, irrespective of its position with respect to that of the agent. This situation does not change if, instead of considering the position of the nominal phrase represented by the agent, we take into account the position of the elements 'lo que', which precede the subordinate sentence and, anaphorically or cataphorically, operate to make the relative pronoun that serves the function of subject of the transitive verb co-referential with the nominal phrase that identifies the agent.

The conclusions that may be drawn from the results with normal controls in pseudocleft agent reversible sentences with a preposition are: grammatical knowledge of the function of the preposition 'a' as a mark of the direct complement guides, in most cases, the syntactic processing with respect to the assignment of thematic roles. This grammatical knowledge, which hierarchically plays the most important role in the interpretation of sentences, is not the only resource used by the subjects, rather it interacts with other strategies. The nature of the other strategies is not, however, heuristic. It refers, more than to processes related to canonicity and order of constituents, to grammatical aspects, upon a requirement that the direct complement, subcategorized by the transitive verb as an internal argument, appear immediately to the right of the verb.

In view of the above, the coalescence of grammatical markers and specific syntactic structures was needed to correctly interpret the sentences. For Broca's aphasics, unlike the normal group, there was a null effect of word order, but a significant main effect of the preposition ($F(1,11) = 6.32$ $p < .02$). An individual analysis of the performance of each patient revealed that irrespective of order, the use of the preposition 'a' as a morphosyntactic cue significantly affected the assignment of thematic roles. Irrespective of the structural order, TV-Pat-Agt ('Lo

PSEUDO-CLEFT ACTIVE SENTENCES BROCA'S APHASIC

EFFECT OF WORD ORDER AND PREPOSITION

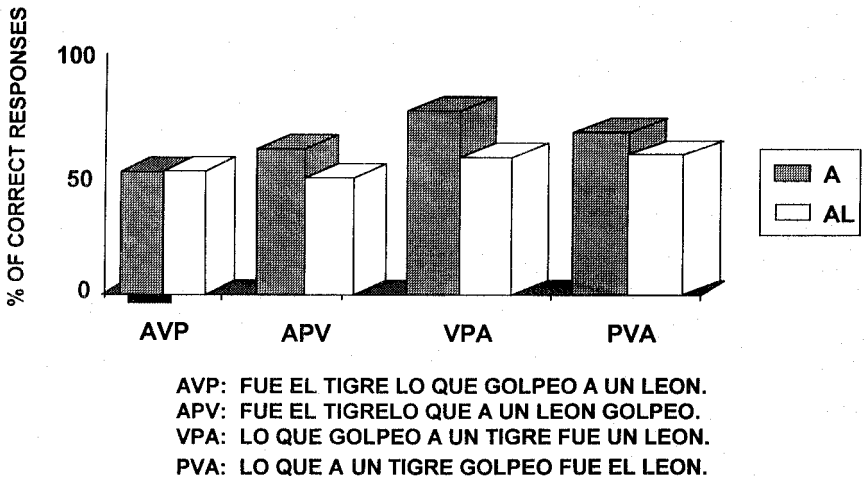


Figure 5. Average percentage of correct responses by aphasic patients to pseudocleft sentences containing a preposition stressed 'a' and unstressed 'al', in the four word order used.

que golpeó a un tigre fue el león 'What the lion hit was the tiger') or Pat-TV-Agt (*Lo que a un tigre golpeó fue el león* 'What the lion hit was a tiger'), sentences that contained this marker obtained higher percentages than chance (76%). When the contraction *a+el* = 'al' was used, performance was within chance levels (53%). Figure 5 shows the percentage of correct responses by aphasic patients to pseudocleft agent reversible sentences containing the preposition 'a' and the contraction 'al', in the four word order used.

Discussion

Psycholinguistic and neurolinguistic studies on comprehension in Spanish are still scant, even though it is the first language for about 10% of the world population. It is interesting to point out as well that the United States represents the fifth largest Spanish-speaking country in the world after Mexico, Spain, Argentina and Colombia, with over 20 million Spanish speakers.

Our results show that the strategies used by Spanish-speaking people are not identical to those used by speakers of other languages. For example, the work of Cuetos and Mitchell (1988) suggests that the principles that guide the off-line syntactic analysis of self-embedded sentences are different in English and Spanish. Hoover (1992) reaches similar conclusions. He stated, for example that Spanish speakers understood self-embedded sentences, such as the following: *El carnicero [que el boxeador ayudó a matar] avisó al gitano* differently from English-speakers. Kail (1989), with a functionalist approach, also shows that the strategies for understanding English and Spanish are different. She used a corpus of 54 transitive reversible sentences, which were heard by 10 subjects. The same task was

introduced differently: five were asked to select the subject and the other five, the agent of the action of the verb. The effect of four factors was studied: the order of constituents, the preposition 'a', agreement and clitic pronoun. The results indicate that the decisive factor is the preposition. Agreement and the clitic pronoun also influence the interpretation, but not the order. Our results agree with regard to the preponderance of the preposition, but not with regard to the order factor. In our investigation with neurologically intact subjects, order is a factor that unquestionably plays an important role in analysis. She acknowledges however that the effect of order may have been greater had the sentences not contained a preposition to mark the object. To our knowledge, there is little more than the above mentioned research on the processes of understanding Spanish.

The results of our experiment show that, for the interpretation of sentences, normal subjects followed different strategies. The first depends on grammatical knowledge of the function of the preposition 'a' as a sign of the direct object. Another strategy depends, it would seem, on intuitions concerning the canonical grammatical structure and is observed in a tendency to interpret as a subject (agent) the nominal phrase that precedes the transitive verb and as the object (patient), the one that appears immediately after the verb. For example, in sentences such as '*Un león golpeó un tigre*', ('a lion hit a tiger') the tiger is given the role of the patient because it is placed immediately after the verb, while the lion is assigned the role of agent. However, when the word order is changed from SVO to VSO '*Golpeó un león un tigre*' ('hit a lion a tiger'), the role of patient is assigned to the lion because of its position following the verb. This differs from the descriptions made by other cross-linguistic studies in normal subjects (Bates, Friederici, Wulfeck and Juarez 1988, Wulfeck, Bates and Capasso 1991, Caplan and Futter 1986) with languages such as English in which the canonical order is S-V-O. The principles that allow for a modification of this order are limited. For Italian, the canonical order is also S-V-O, however, Italian has greater flexibility in permitted movements in comparison with English. In Japanese, the canonical order is S-O-V, (Hagiwara and Caplan 1990). Accordingly, our research with normal subjects (Marcos and Ostrosky-Solis 1995) shows that in Spanish, the use of structural strategies (canonical order) is essential for understanding and for assigning thematic roles. When the preposition is lacking and/or when the order does not correspond to canonical order in Spanish ((S)-V-O), other cues are utilized for comprehension. Among these other strategies is the use of articles to mark the agent or patient. On presenting a noun in a sentence preceded by the definite article '*el*' or the indefinite article '*un*', different information about the noun is being provided for assigning thematic roles. The different strategies interact individually and consistently.

Unlike normal subjects, Spanish speaking patients with Broca's aphasia did not use structural strategies in active sentences, such as the canonical order of the sentence. They used free functors such as articles, nor could they process passive sentences. Neither syntax complexity nor canonical order affected subject performance. As long as the preposition 'a' was present, the subjects performed at the same level on sentences in which the order was canonical (TV-Pat) or not (Pat-TV). Likewise, both in simple sentences such as active and in pseudocleft sentences, the only significant factor was the uncontracted preposition and there were no significant differences of order or definiteness. The absence of use of these other strategies produced comprehension alterations. However, even in active sentences containing a preposition, the performance of the aphasic patients was less

efficient than that of normal subjects (70 % accuracy vs 98 % in normals). This means that in Broca's aphasics, free functor morphemes are available for processing. However the patients do not process all the morphology because in passive sentences that contain two signs '*por*' and the verbal termination '*ado*', the results obtain by chance. Nor was a significant effect found in the processing of sentences with the contracted preposition '*al*', which suggests that the coalescence *a + el* could be affecting performance. Apparently the preposition '*a*' is resilient to brain damage because it is a crucial source for information for thematic assignment in Spanish.

In contrast to studies conducted in other languages with Broca's aphasics (Bates, Friederici, Wulfeck and Juarez 1988, Wulfeck, Bates and Capasso 1991, Caplan and Futter 1986, Hagiwara and Caplan 1990), our patients use no principle of word order or surface markers such as the determiner. One possible explanation of this fact lies in the differences between Spanish and languages like it which admit greater flexibility in the order of constituents. The fact that comprehension strategies are different seems to follow from this. We are not however by any means the first to point out that the procedures for interpreting sentences in English can be different from those used in other languages.

In addition to the authors mentioned above with respect to Spanish, this is clearly established by Bates, Friederici, Wulfeck and Juarez (1988) and MacWhinney, Bates and Kliegel (1984). However, from our work, theoretical and methodological contradictions are observed. Their perspective denies the existence in normal subjects of syntactic processing that goes beyond the recognition of certain markers or surface cues. The results, obtained with the pseudocleft-sentences in normal subjects however can be appreciated only by quite subtle syntactic analysis. Moreover, the manner in which these authors treat the order of constituents, in absolute terms, differs from the manner in which we have interpreted the effect of this factor as a strategy based on intuition upon the sentence structure.

With regard to the use of preposition '*a*', there is a very extensive bibliography. Both Spanish scholars (Gili and Gaya 1964, Seco 1980, Real Academia Española 1978 among many others) and linguists concerned with other subjects (Comrie 1989, Hooper and Thomson 1980, Molho 1980) have analysed the 'rules' for its use and even its stylistic nuances. They all agree that when it is used in sentences with a transitive verb, the preposition shows that the phrase it precedes is the direct or indirect complement. It also appears that phrases that specify the end purpose or circumstance of the action of the verb.

It is also interesting to observe that in our patients verbal memory did not explain patient performance. The most difficult sentences were active reversible sentences without a preposition (44 % of accuracy). In contradistinction, the subjects obtained a 76 % accuracy in pseudocleft sentences with a preposition. Thus, presence of the preposition rather than the length is what determined the performance pattern.

Summarizing, findings indicate that in Spanish speaking Broca's aphasics, there is no significant effect of word order (or a null effect). Although the use of the preposition '*a*' is an essential factor for assigning thematic roles, not all free morphemes were processed. Thus, there are process alterations both in morphology and syntax. The unique characteristics of Spanish demonstrate the importance of generating specific models in Spanish to provide for a better account

of the specific characteristics of agrammatic comprehension in Spanish speakers. Accordingly, we will be in a position to generate specific diagnostic and rehabilitation techniques for Spanish-speaking patients.

Acknowledgement

The authors express their gratitude to Gabriela Castillo, Esther Gomez and Felipe Cruz for their invaluable help in analysing the data used in this research. Our most sincere gratitude to Dr Hugh Buckingham for his most valuable support and advice when reviewing this paper. This research was partially supported by grants given to the first author DGAPA-IN301494 and CONACYT H-3764.

References

- BATES, E., FRIEDERICI, A., WULFECK, B. and JUAREZ, L. 1988, On the preservation of word order in aphasia: cross-linguistic evidence. *Brain and Language*, **33**, 323–364.
- BATES, E., FRIEDERICI, A. and WULFECK, B. 1987, Sentence comprehension in aphasia: a cross linguistic study. *Brain and Language*, **32**, 19–67.
- BATES, E., WULFECK, B. and MACWHINNEY, B. 1991, Cross-linguistic research in aphasia: an overview. *Brain and Language*, **41**, 123–148.
- BLACKWELL, A. and BATES, E. 1995, Inducing agrammatic profiles in normals. Evidence for selective vulnerability of morphology under cognitive resource limitation. *Journal of Cognitive Neuroscience*, **7**, 228–257.
- BRADLEY, D. C., GARRETT, M. F. and ZURIF, E. B. 1980, Syntactic deficits in Broca's aphasia. In D. Caplan (Ed.) *Biological Studies of Mental Processes* (Cambridge, MA: MIT Press).
- CAPLAN, D. 1981, On the cerebral organization of linguistic functions: logical and empirical issues surrounding deficit analysis and functional localization. *Brain and Language*, **14**, 120–137.
- CAPLAN, D. and FUTTER, CH. 1986, Assignment of thematic roles to nouns in sentence comprehension by agrammatic patient. *Brain and Language*, **27**, 117–134.
- CAPLAN, D. and HILDEBRANDT, N. 1988, *Disorders of Syntactic Comprehension*. Cambridge, Mass: MIT Press.
- CARAMAZZA, A. and BERNDT, R. 1985, A multicomponent deficit view of Broca's aphasia. In M. L. Kean (Ed.) *Agrammatism*. (Orlando: Academic Press).
- CARAMAZZA, A. and ZURIF, E. 1976, Dissociation of algorithmic and heuristic processes in language comprehension: evidence from aphasia. *Brain and Language*, **3**, 37–76.
- COMRIE, B. 1989, *Language Universals and Linguistic Typology*. (Oxford: The University Press of Chicago).
- CUETOS, F. D. and MITCHELL, C. 1988, Cross-linguistic differences in parsing: restrictions on the use of the late closure strategy in Spanish. *Cognition*, **30**, 73–105.
- FRIEDERICI, A. 1988, Agrammatic comprehension: picture of a computational mismatch. *Aphasiology*, **2**, 279–284.
- GARRETT, M. 1992, Disorders of lexical selection. *Cognition*, **42**, 143–180.
- GILI, F. and GAYA, S. 1964, *Curso Superior de Sintaxis Española*. (Barcelona: Bibliograf).
- GONZÁLEZ, B. and VENEGAS, H. 1995, *Adaptación del Western Aphasia Battery al Español de México, Como un Complemento Auxiliar en el Diagnóstico de la Afasia*. (Mexico: Colegio Superior de Neurolingüística y Psicopedagogía).
- HAGIWARA, H. and CAPLAN, D. 1990, Syntactic comprehension in Japanese aphasic: effects of category and thematic role order. *Brain and Language*, **38**, 159–170.
- HOOPER, P. J. and THOMSON, S. A. 1980, Transitivity in grammar and discourse. *Language*, **56**, 251–299.
- HOOVER, M. L. 1992, Sentence processing strategies in Spanish and English. *Journal of Psycholinguistic Research*, **21**, 275–299.
- KAIL, M. 1989, Cue validity, cue cost, and processing types in sentence comprehension in French and Spanish. In B. Macwhinney and E. Bates (Eds) *The Crosslinguistic Study of Sentence Processing* (Cambridge: Cambridge University Press).
- KERTESZ, A., PASCUAL-LEONE, P. and PASCUAL-LEONE, G. 1990, *Batería de las afasias Western. The Western Aphasia Battery en versión y adaptación castellana*. (Valencia: Nau Libres).

- MACWHINNEY, B., BATES, E. and KIEGL, R. 1984, Cue validity and sentence interpretation in English, German, and Italian. *Journal of Verbal Learning and Verbal Behavior*, **23**, 127–150.
- MOLHO, M. 1980, Sur la grammaire de l'objet en Espagnol. *Travaux de linguistique et de littérature*, **18**, 213–225.
- MARCOS, J. and OSTROSKY-SOLIS, F. 1995, Estrategías para la asignación de papeles temáticos en la interpretación de enunciados en Español. In D. Pool (Ed.) *Estudios en Lingüística Formal* (Mexico: Colegio de México).
- PRATHER, P., SHAPIRO, I., ZURIF, E. and SWINNEY, D. 1991, Real time examinations of lexical processing in aphasics. *Journal of Psycholinguistic Research*, **20**, 271–281.
- PULVERMÜLLER, F. 1995, Agrammatism: behavioral description and neurological explanation. *Journal of Cognitive Neuroscience*, **7**, 165–181.
- REAL ACADEMIA ESPAÑOLA 1978, *Esbozo de una nueva gramática de la lengua Española*, (Madrid: Espasa-Calpe).
- SECO, R. 1980, *Manual de gramática española*. (Madrid: Aguilar).
- WULFECK, B., BATES, E. and CAPASSO, R. 1991, A cross-linguistic study of grammaticality judgments in Broca's aphasia. *Brain and Language*, **41**, 311–336.
- ZURIF, E., SWINNEY, D., PRATHER, P., SOLOMON, J. and BUSHHELL, C. 1993, An on-line analysis of syntactic processing in Broca's and Wernicke's aphasia. *Brain and Language*, **45**, 448–464.
- ZURIF, E. B. and GRODZINSKY, Y. 1983, Sensitivity to grammatical structure in agrammatic aphasics: A reply to Linebarger, Schwartz and Saffran. *Cognition*, **15**, 207–221.

Appendix: sentence construction

Five different sentences were generated for each of the types of sentences. Only one example is included since, based on the nouns and verbs used, the other sentences can be easily deduced.

The definite and indefinite articles were distributed in the same proportion in all the arguments; the combination of determinate agent and indeterminate patient was presented in half of the sentences, while the reverse is presented in the other half.

I. Active reversible sentences without preposition

Order	Example
Argument-Verb-Argument	<i>El león golpeó un tigre</i> 'The lion hit a tiger'
Argument-Argument-Verb	<i>El tigre un león golpeó</i> 'The tiger a lion hit'
Verb-Argument-Argument	<i>Golpeó el león un tigre</i> 'Hit the lion a tiger'

II. Active reversible sentences with preposition

1^o noun as agent

Order	Example
Agent-Verb-Patient	<i>El león golpeó a un tigre</i> 'The lion hit a tiger (acc)'
Agent-Patient-Verb	<i>El tigre a un león golpeó</i> 'The tiger a lion (acc) hit'
Verb-Agent-Patient	<i>Golpeó el león a un tigre</i> 'Hit the lion a tiger (acc)'

2^o noun as agent

Order

Patient-Verb-Agent

Example

A un león lo golpeó el tigre
 'A lion (acc) hit the tiger'

Patient-Agent-Verb

A un león el tigre lo golpeó
 'A lion (acc) the tiger hit'

Verb-Patient-Patient

Golpeo a un león el tigre
 'Hit a (acc) lion the tiger'

III. Passive reversible sentences

1^o noun as agent

Order

Agent-Verb-Patient

Example

Por el tigre fue golpeado un león
 'By the tiger was hit a lion'

Agent-Patient-Verb

Por el tigre un león fue golpeado
 'By the tiger a lion was hit'

Verb-Agent-Patient

Fue Golpeado por el león un tigre
 'Was hit by the lion a tiger'

2^o noun as agent

Order

Patient-Verb-Agent

Example

El tigre fue golpeado por un león
 'The tiger was hit by a lion'

Patient-Agent-Verb

El tigre por un león fue golpeado
 'The tiger by a lion was hit'

Verb-Patient-Patient

Fue golpeado el león por un tigre
 'Was hit the lion by tiger'

IV. Pseudocleft agent with preposition (stressed 'a'/unstressed 'al')

1^o noun as agent

Order

Agent-Verb-Patient

Example

Fue el tigre lo que golpeó a un león
 'It was the tiger what hit a lion (acc)'

Agent-Patient-Verb

Fue el tigre lo que a un león golpeó
 'It was the tiger the lion'

2^o noun as agent

Order

Verb-Patient-Agent

Example

Lo que golpeó a un tigre fue un león
 'What hit a tiger (acc) it was a lion'

Patient-Verb-Agent

Lo que a un tigre golpeó fue el león
 'What a tiger (acc) hit it was the lion'