



UNIVERSITA' DEGLI STUDI DI SIENA
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**Impoverishment of grammatical features in a non fluent aphasic speaker:
the grammatical nature of minimal structures**

Author: Maria Garraffa

Advisor: Prof. Luigi Rizzi

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Doctoral Program in Cognitive Science
Department of Philosophy and Social Sciences
Interdepartmental center of cognitive studies on language
University of Siena
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Impoverishment of grammatical features in a non fluent aphasic speaker:
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Corresponding Author: Miss. Maria Garraffa

Maria Garraffa
garraffa@unisi.it
Dept. of Science of communication
CISCL-Interdepartmental center for Cognitive studies on language
Complesso San Niccolò, Via Roma, 43
53100 Siena – Italia

Abstract

The present study is an examination of an Italian aphasic speaker (M.R.) with non-fluent speech following a focal lesion in the left hemisphere.

We develop an explanation of M.R.'s language impairment compatible with theories of generative syntax and with some observations on parsing strategies. The explanatory framework we adopt considers the grammar to be an integral part of on-line language processing.

A series of experiments was run across modalities (production, comprehension and grammaticality judgment), with the aim of defining impaired linguistic structures grammatically. Results of the various experiments show selective impairment in some selective configurations involving object movement in relative clauses, in Wh-questions and in clitic object constructions.

Comprehension deficit of non canonical sentences has been attested since Caramazza and Zurif's seminal work (1976). In the present case-study a similar subject/object asymmetry emerges from interrogative sentence production, which have been found to be selectively impaired for object movement of animate arguments. An interesting data was obtained testing attraction effects with clitics and prepositional modifiers. M.R. does not manifest attraction effects if a clitic object is a potential intervenier of the relevant agreement relation; prepositional modifiers induce a significative attraction effects. We will speculate on these effects has precise phenomena related to syntactic conditions on minimal structures.

This case study lends support to the hypothesis that the present linguistic deficit is an impoverishment of procedural capacities. This impoverishment is grammatically driven, and it manifests itself in reduced syntactic structures. M.R.'s linguistic competence is not different to a non-impaired grammatical system. M.R. has the capacity to analyse sentences respecting syntactic phrase structures but not in the way normal speakers do. Crucially, this approach to aphasia does not assume the existence of a specific grammatical deficit, as the so-called agrammatism.

Summary of findings

In the theoretical linguistic model (Chomsky, 2000) the language faculty is defined as the manifestation of a particular cognitive faculty; a system of neural networks specified for linguistic computation. It is therefore reasonable to assume that the theoretical architecture of the linguistic model has a correlation in the organization of neural structures. According to this approach, linguistic principles correspond to specific mental computations.

In this approach on language studies recent psycholinguistic investigations have integrated grammatical data with neurophysiological evidence to built spatial and temporal maps of the neural networks involved in language computation. Many studies of sentence processing have shown different effects according to the kind of information being parsed, from which assumptions concerning the way the mind / brain deals with different linguistic information can be drawn. For example, in Italian interesting evidence comes from an self paced reading experiment comparing the differences between, on the one hand, processing of syntactic violations, such as subject-verb number agreement (as in: The beautiful baby runs/run in the garden) and, on the other hand, semantic violations (e.g. selection features as in: The trailhead whistles/sprouts at the station) (De Vincenzi et al. 2003). In the case of the syntactic violations, a delay on the verb followed by a quick return to the baseline was found, while the semantic violations gave rise to an increase in reading time after the verb, which lasted until the end of the sentence. More interestingly, a similar dissociation was obtained using the EEG technique. Syntactic violation elicited an electrophysiological component in the left anterior areas in the

300-500 msec time frame, while semantic violations gave rise to a more central and later component, the so-called N400.

This kind of evidences supports the view that there are distinct computations for different types of linguistic information: syntactic and semantic. Many data have been collected using these and other psycholinguistic and neurolinguistic techniques and attempts have been made to formulate models of language parsing; however, there are divergent opinions on how the data are to be interpreted (see Osterhout, L. 2000; and Osterhout et al., in press) and a detailed cross-languages research is necessary.

As an example, the model elaborated by Angela Friederici (see Friederici, 2002 for an overview) is consistent with De Vincenzi's type of evidences. In this model three temporally and spatially distinct phases of language comprehension are postulated: an early structural process subserved by the anterior part of the left hemisphere (as observed for categorial violations); a second post-syntactic phase where lexical-semantic and argument structure are processed (with corresponding activation distributed over the left and the right temporo-parietal areas); and a process of structural reanalysis subserved by centro-parietal areas (as observed with brain imaging techniques). Many subsequent investigations have developed more finely-tuned models of language processing and linguistic theory could be an interesting source to define the different linguistic computations.

Further evidence supporting grammatical distinctions in the computation of linguistic information comes from the study of subjects with cerebral lesions.

This is a particularly interesting empirical source providing the possibility of exploring specific properties of the linguistic faculty not manifested in normal speakers and evident in a non-fully fledged cognitive system.

In a study on grammatical deficit (otherwise called Broca aphasia, or agrammatism), Friedmann and Grodzinsky (2000) proposed that in patients with non-fluent speech the omission of items from the functional lexicon is sensitive to the position of these elements in the syntactic tree. Recently, cross-linguistic data have shown that not all the functional lexicon is

damaged in Broca's aphasia and a more detailed investigation is plausibly linked to the retrieval of closed class items in a grammatical structure (see chapter 1 of the present study).

For example, many cross-linguistic studies (see chapter 1 of the present work) have shown a disassociation in the omission in the system of verbal inflection: agreement is preserved while temporal morphology is omitted.

Agreement and temporal dependencies are similar in the sense that both are related to feature matching. For example, the agreement relation requires the number feature to be copied from the subject onto the verb, and in doing so establishes a configurational agreement relation. In temporal concordance a temporal adverb and the finite verb must share their tense feature.

In addition, the two grammatical dependencies have positional differences (these are well attested in the linguistic literature since Pollock's comparative studies on the Romance languages; Pollock, 1989). In the tree structure they occupy different syntactic phrases in a parametrized order. On the basis of this evidence, Friedmann developed the influential Tree Pruning Hypothesis. This is a pure representational account of grammatical disorders and a reflection on the source of the agrammatic syndrome is necessary.

A distinction between Tense and Agreement dependencies was also found in a recent study on processing in adults speakers (De Vincenzi, et al, *in preparation*). In an ERP experiment on morphosyntactic feature matching, agreement violations were detected in an early phase while violations of temporal morphology were detected in a successive temporal window. This could be an indication of a sequential parsing model where purely formal syntactic operations, such as subject-verb agreement, precede post-syntactic analyses, such as the interpretation of incongruent temporal features.

This approach directly links evidence from language processing with evidence from linguistic theory. The different features comprising morphosyntactic information may be differently parsed both in temporal and in spatial terms, in line with theoretical evidence from linguistic models.

Differences in temporal and topographical patterns expressed in a model such as Friederici's along with data from neuropsychology are taken as

evidence for the view that grammatical analysis is part of the parsing strategy, grammatical options are parsing strategies.

In this sense, an aphasia such as the one studied in the present work, may be explained as an impoverishment of the syntactic processing.

The experiments presented here have been conceived in terms of this framework: testing **grammatical properties as essential components of sentence processing**.

The linguistic variables selected are mainly related to locality conditions in the sentence, implemented in a precise structural map as a rich cartographic set of tree positions (Cinque G., 2002; Belletti A., 2004; Rizzi L., 2004).

The cartographic approach is a recent theoretical methodology codified to define a map of syntactic positions in the tree structures. The fundamental idea behind this approach is that during the building of a syntactic sequence structural information is directly readable from the map. Not only is there a geometric constraint in the implementation of structural relations, but other information, such as interpretative distinctions, is also structurally organized.

In the cartographic approach, neurolinguistic and psycholinguistic experiments showing dissociations between grammatical features, such as Tense and Agreement, in aphasia or distinctions in the computation of different grammatical violations, could provide evidence for the presence of different structural positions in which different classes of grammatical features are implemented. Such experiments provide a rich source of evidence with which to corroborate linguistic theory.

Experiments and results

The results of various experiments run to investigate M.R. linguistic competence show selective impairment in object movement. The so-called canonicity effect has been well-attested since Caramazza and Zurif's seminal work (1976). Furthermore, in the present study a similar

subject/object asymmetry emerges from interrogative sentence production, which have been found to be **selectively impaired for object movement of animate arguments**. This canonicity effect can be analyzed as a grammatical phenomenon (see Garraffa and Grillo, submitted). Structures resulting from movement, chains, obey certain locality principles, and may be subject to intervention effects due to the minimality condition (Rizzi, 1990; 2005). In a recent work, Grillo (2005), proposed that in agrammatic patients sets of features normally associated with syntactic heads can be underspecified where processing capacities are reduced thus giving rise to selective minimality effects: structures where a dependency is constructed over an intervening DP are more problematic. Recent research on the processing cost of *crossing* relations vs. *nesting* supports this view (see Erdozia and Laka, 2006 for a study on agreement violations in Basque).

Furthermore, this impoverishment in the syntactic representation seems directly explainable in cartographic terms. In the cartographic approach, formal features (such as *WH*, or Discourse related features) are more prominent functional shells and they are represented in the upper periphery of the clause.

“Animacy” could be codified in a low tree position, close to the Noun lexical head. These features emerge in cases of grammatical impoverishment such as in aphasia and play a prominent role in the grammatical coding of the structure. Many studies on the role of animacy in processing have demonstrated rapid access to this kind of information (as an example see Kuperberg et al., 2006).

Such asymmetries are found in M.R.’s utterances that show selective impairment of object movement for animate arguments, supporting the idea of a distinction in the grammatical implementation of features.

Normal syntactic representation

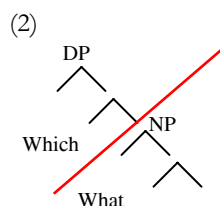
(1a). $_{CP/IP[+Wh, Nom, \phi sing, \theta 1, N, +Animacy]}$ [$+ Animacy$] $_{VP[N, +Animacy]}$
Chi **pro** hai baciato < Chi > ?
 Who have [2°sing]kissed < Who >?

Agrammatic syntactic representation

(1b) $_{CP[+ Animacy]}$ [$+ Animacy$] $_{VP[+Animacy]}$
Chi **pro** hai baciato < Chi > ?
 Who have [2°sing] kissed < Who >?

Furthermore, M.R.’s question production showed evidence of difficulties with object extraction in D-linked interrogative operators, such as “Quale” (Which). Copies of the traces were found in-situ in her speech , e.g. “ *Quale libro hai letto un libro?*” (lit. Which book did you read a book?). An increase in processing cost attributed to the more subtle structural properties of extraction in D-Linking sentences, is a well-attested phenomenon (see for example De Vincenzi, 1990, Rizzi, 2002 and Hickok and Avrutin, 1995).

In our system these data on interrogatives may be interpreted as grammatical reduction of some of the formal features implemented in the syntactic tree. The result could be a reduced structure, *truncated* in Rizzi’s sense. Futhermore more the only preserved wh-dependencies (also in object extraction) is *what* operator. The peculiar data on wh-dependencies could be motivated by a configuration ad (2).



An interesting linguistic evidence to support the present positional distinction comes from a study on semantic properties of Definiteness restriction (Heim,1987). In her investigation on *wh*-traces and definite variables Heim presents data related to “definiteness” of the moved *wh*-phrase, (example in (3) from Heim,ibidem pag. 27).

- (3) a. ??Which one of the two men was there in the room/*drunk?
 b. ??Which actors were there in the room/*laughing?
 c. ?Who was there in the room when you got home?
 c. What is there in Austin?

A sort of definiteness restriction could be the source for a selection of a minimal structure.

Subsequently we studied **locality conditions in attraction configurations** in a grammaticality judgment task. Much work in the psycholinguistic literature (e.g. Bock and Miller, 1991) shows that an intervening element, situated between the elements sharing an agreement relation, and mismatched in the relevant feature, attracts agreement, as expressed in the abstract configuration in 4.

- (4) **X** ... **Z** ... **Y**
 [...,φSingular] [...,φPlural] [...,φSingular]

*The boat of the American **soldiers** leaves in the fog*

The boat of the American **soldiers leave in the fog*

Attraction is readily explainable in terms of locality conditions, even in absence of c-command (see for example ellipsis phenomena), and it offers a good testing ground for the proposal outlined here.

A recent study on the structural properties of agreement shows different effects in terms of different syntactic relations: linear precedence vs. hierarchical order (Franck et al. 2006). In this study, attraction effects with two different classes of interveners: prepositional modifiers (5a) and clitic object pronouns (5b) in French, were investigated.

(5a) [Subj... N_{head}...N_{mod}...] AgrS

(5b) [Subj...N_{head}...] [AgrOP PRO_{clitic}] AgrS

The main finding of this experiment is a significant numbers of attraction errors with clitics comparison with prepositional modifiers. The authors explained this effect as due to differences in the structural relations involved: in 5b the intervening constituent, the clitic, is in a c-command relationship with the agreement head whereas the prepositional modifier in 5a. is merely in a configuration of linear precedence. We investigated intervention in our case study with a grammatical judgement task, looking in particular at the different intervention effects in terms of their different structural relations, as in 6a and 6b (examples of the formalization expressed in 5).

(6a) [La nave dei soldati] parte/partono nella nebbia

[The boat of the soldiers] leave/leaves in the fog

(6b) Il corridore [li inseguono/insegue]

The runner [them exceed/exceed]

M.R.'s responses show significant attraction effects caused by the intervention of a prepositional modifier, as in (6a). No effect was found with object clitics, as in (6b).

We attribute the absence of attraction effects with object clitics in this Italian aphasic speaker to non-computation of agreement relations in the object position, it being an intervener in the subject-verb relation.

Crucially, no effect was found with normal Spanish speakers (Anton-Mendez, 1996) where object clitics are not active elements for agreement.

(7a). Las manzanas **las** he comido [No Agr]

The apples them (pl) I have eaten

(7b) Le mele **le** ho mangiate

The apples, them (f.pl.) I have eaten (f.pl.)

The same explanation holds in both cases: the intervention of a clitic in absence of a fully-fledged AgrO projection is not enough to induce

minimality effects in Spanish speakers nor in M.R.

The present approach on acquired language disorders makes precise predictions regarding the nature of the reduction in the procedural capacities and is compatible with parsing models that posit *on-line* construction of a syntactic representation during language production (De Vincenzi, M.; 1991). In this approach the parser's preferences will be tied to both the structural characteristics of the sentence and to the predictions of the parsing principle.

An important aspect to the interpretation of our results in terms of a reduction of processing capacity was formalized in De Vincenzi's (1991) in a parsing strategies called *Minimal Chain Condition* :

MCC: Avoid postulating unnecessary chain members, but do not delay required chain members. (De Vincenzi M.; 1991)

In this sense we should expect limitations in forming chains over an intervening element where there is a reduction in the number (and quality) of features associated with each syntactic node. To test this prediction we investigates M.R.'s **comprehension of relative clauses**.

The relevant variables of this study are word order and agreement mismatch between subject and object, allowing non-ambiguous interpretation. Non-standard word order, NP-NP-V, and Agreement mismatch force the grammatical system to build a syntactic chain to reach the correct interpretation. A clear impairment arises in non-canonical configurations.

The presence of a preverbal subject in the relative clause, as in *I ragazzi che IL MAESTRO ha salutato* (lit. The boys that THE TEACHER has greeted), forces M.R. to revise her decision and the sentence is interpreted using agreement morphology.

Revision of a post-verbal subject in the relative clause, as in *I ragazzi che ha salutato IL MAESTRO* (lit. The boys that has greeted THE TEACHER),

takes place on the embedded verb. At this point material should probably be deleted for a limited memory source.

In the processing of obligatory filler-gap constructions (such as a relative clause) the parser prefers to close the dependency and form a grammatical object: a syntactic chain. The differences between relatives with pre-verbal subjects and those with post-verbal subjects show the importance of making more finely grained distinctions in the impaired system: differences in number features, which play a marginal role in normal language (probably due to the presence of higher order features) do, however, play a role in helping to cross a potential intervener in an impaired system.

The advantage of this approach is that it explains the way in which various elements are integrated in the syntactic structure. Furthermore we can formulate precise predictions compatible with linguistic evidences.

The natural course of this approach is a systematic study on features disambiguations involved in the grammar of languages. This could be underlined different linguistic strategy for argument marked languages and for agreement marked languages.

In the state of art of language disorders a well-known and productive approach to agrammatism found a deficit in recognising traces, a kind of empty position, in the linguistic string (Grodzinsky; 1990; 2000). According to this hypothesis, traces are deleted and their interpretations are not recoverable in the syntactic representation.

This approach to language impairment is not clear about how linguistic information is integrated in the structure, and consequently why traces should have a different nature. In Grodzinsky's system on agrammatic comprehension the interaction between an incomplete grammatical representation and a non-grammatical heuristic is established [NP1= Agent]. This heuristic is necessary in comprehension tasks, where the subject must assign thematic roles. The 'first agent' strategy applies only on NP's that have not received a thematic role by grammatical analysis. So a purely syntactic condition [- θ] selects the elements to which the strategy applies. In processing terms this means a syntactic analysis must first be made before

the application domain of the strategy can be defined. Only after inconclusive thematic role assignment does the possibility of using the strategy arise.

An approach in terms of reduced information regarding a given grammatical principle and compatible with parsing strategies is more appropriate under the view that procedural capacity has a grammatical nature.

Furthermore, well known problems such as cross-patient variability or the varying complexity of different syntactic strings are not difficult to overcome, since the processing costs could be structurally defined.

In sum, a neurological event can generate a reduction in the syntactic processing. This has visible and selective effects, verifiable by looking at the application of grammatical variables.

Crucially for the present approach, we observed impairment in comprehension and production of non-canonical structures due to the intervention of an extraneous element serving as a possible antecedent of the syntactic chain.

The fundamental spirit of this study is to account for the phenomena discussed in this case study, and possibly grammatical deficit in general, in terms of well-defined grammatical patterns.

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