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THEORETICAL LINGUISTICS PROGRAMME, BUDAPEST UNIVERSITY (ELTE)

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Grammaticality Judgments by Broca's Aphasics

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1. MODULARITY

1.1. The aim of this paper is to show on the basis of linguistic data from Broca's aphasics that the first stage of a speaker's sentence processing activities is clearly modular.

1.2. The central claims of the modular approach are the following. According to Fodor (1983) a system is modular if each module is cognitively impenetrable, informationally encapsulated, and domain specific, and the operation of each one is mandatory.

Grodzinsky (1990) suggests that the language parsing device has two central properties of the modular system: any knowledge external to it (nonlinguistic knowledge) does not enter into its considerations, and knowledge it possesses cannot be used by systems external to it. This seems to be so even in conditions such as cases of language impairment.

1.3. Aphasiological data provide support for modularity: for the distinctness of linguistic processing from cognitive processes generally, and, within the language system itself, for the distinctness of syntactic, lexical and semantic computations. (Grodzinsky 1993, Zurif et al 1993).

The input and the output of the modules can be defined. The output of one module is processed by another modul as an input. The *non-final* output does not become "visible" in healthy cases because of the *seriality* of modules.

1.4. There is evidence for the interaction of a syntactic parsing module and an order-preserving, phonological-lexical storage module during the first stage of sentence processing. The linguistic symptoms of Broca's aphasia can be explained as disturbances and asynchronies in the interactions of these two modules.

2. TRANSPARENCY

Some strong hypotheses and methodological principles need to be assumed if conclusions are to be drawn from aphasics' linguistic performance with respect to the healthy (intact) system.

2.1. We have adopted the transparency hypothesis in our investigations. According to this hypothesis it is possible that aphasics' performance reflects fairly straightforwardly the normal system minus the impaired subcomponent(s). (Garett 1980, Bradley, Garett & Zurif 1980, Linebarger, Shwartz & Saffran 1983, Linebarger 1990, Frazier, Flores d'Arcais & Coolen 1993)

The basis of the method relying on selective preservation/loss of linguistic capabilities is the observation that simultaneous loss of skill X and selective retainment of skill Y indicate that independent underlying mechanisms can be hypothesized for skills X and Y, especially if we have the reverse situation with other patients, who have retained skill X and lost skill Y. (Marin, Saffran & Schwartz 1976, Ades,

Steedman 1982, Grodzinsky Swinney & Zurif 1985, Grodzinsky 1990, Linebarger 1990). Furthermore, if the output of skill Y is processed by another component as input in healthy cases then, if the contribution of that component is lost due to an injury then the output of Y becomes "visible". It is an additional assumption of such an analysis relying on selective retainment/loss of linguistic skills that skills X and Y are intuitively of the same complexity and require their inputs to be retained in memory to a similar degree.

The usefulness of these hypotheses and methodological principles will become apparent in what follows.

3. BROCA'S APHASIA

There are several classifications of aphasia, which rely on different criteria. We have adopted the so-called "neo-classical" classification in our investigations and we speak of Broca's aphasics accordingly. It is widely known that about 20% of aphasics display unambiguously the symptoms of some type of the neoclassical classification. "Mixed" symptoms are much more widespread. This carries over to the cases examined in this study.

3.1. Broca's aphasia (subsequent to the injury of the fronto-temporal lobe of the left hemisphere) has the following basic characteristics. The patient's

spontaneous speech is fragmented, comprising verbs and nominal expressions that are often conjugated incorrectly. Speech comprehension is appropriate. In test that require sentence repetition there is a deficit similar to but larger than that in spontaneous speech. Injuries of Broca's field entail the impairment of access to grammatical formatives (derivation and inflectional suffixes, prepositions, articles, postpositions, i.e. "closed-class" word classes that denote grammatical relations and not objects in the world).

In contrast, Wernicke's aphasics are characterised by continuous, spontaneous fluent speech, which is syntactically coherent (with respect to the use of case endings, agreement, the use of articles, conjunctions or prepositions) This kind of fluent speech is semantically incoherent.

4. AUTONOMOUS SYNTACTIC PROCESSING

4.1. Broca's aphasia shows several, selectively retained syntactic skills. The impairment of access to closed-class words (if injuries are less severe) is mainly manifested in fragmented speech; however, the function of syntactic self-correction is present. The patient therefore has maintained his/her intuitions concerning grammaticality in some way. S/he has the awareness for instance of the inability to use certain syntactic

functions. The paradoxical nature of these intuitions is striking. Furthermore, patients typically signal/hint at memory disturbances.

4.2. One of our patients' spontaneous speech for instance showed fragmentation, agrammaticality, syntactic self-monitoring and hints at memory disturbances. The patient was 37 years of age, a car mechanic, suffering from a stroke which resulted in extended fronto-parietal hypodensity of the left hemisphere.

4.3. In the course of a sentence repetition test the patient gave answers that are suggestive of a autonomous syntactic parser module that functions at an initial stage of sentence processing. The main argument for this is the fact that for the patient the *performance* of the parser can be *assessed* and *predicted*. We will demonstrate this below.

The autonomy of the input of the parser can be manifest in patients' attempts to repeat sentences. This autonomy means that the parser is orientated to syntactic properties of the material to be processed, and retains this information as the syntactic output of the first stage of processing. If this output is not processed further then it can become visible as the "product" of the parser.

4.4. We can outline the *performance of our patient's parser* as follows. In comparison with the initial sentence it is possible for the parser:

- a/ to approximate the class of the "initial" predicate; its case frame was retrievable;
- b/ if a different predicate was retrieved, then the suffixes were identical to the case frame of the "original" predicate;
- c/ if the predicate is missing the parser stops; for instance it cannot list only the NP's from the target sentence;
- d/ filling one slot from the argument frame of the predicate with selectional restrictions that were the same as (or very much like) the original.
- e/ knowledge about missing, lexically or phonologically null arguments is manifest in further search attempts that either mention case endings without a content word, or link them to pronouns or neologisms, in repetition of case endings, or in compensatory speech (aimed at concealing the deficit).

Some samples from the test for sentence repetition follow:

(K stands for the therapist who utters the sentence to be repeated. P stands for the patient's replies. The test was in Hungarian, the glosses below contain the relevant details only):

a/. K: Péter beszélgetett Marival.
 Peter talk-3.pers/past Mary-with
 Peter talked to Mary.

P: Péterrel beszélinnával
 Peter-with talk-3.pers/present..inná-with (nonsense-
 word)

b/. K: Marival találkozott János.
 Mary-with meet-3.pers/past John-nom
 John met Mary

P: Marival....beszélgetett volna vele.
 Mary-with talk -3.pers/past would have her-with
 Ö beszélgetett vele..Marival.
 He talk-3.pers/past her-with ...Mary-with.

c/. K: Mari megcsinálta az ágyat és Péter lefeküdt.
 Mary made the bed and Peter went in the bed.

P: Mara.....Mara.....Mara...mmmmmm

d/- e/ K: Sándor küldött egy képeslapot Marinak.
 Alex send-3.pers/past a postcard-acc Mary-dat.
 Alex sent Mary a postcard.

P: Sándor...jött és akkor írta..... és azt...

Alex....came and wrote-acc.....and that-acc

akkor ment hozott egy... na mi az a.... mit...

then went brought-acc a xxx what is that what-acc

K: Képeslap.

Postcard-nom.

P: Épetlapot, képeslapot édeslapot.

Nonsense word-acc nonsense word-acc sweetcard-acc

K: Mit csinált vele?

What did he do with it?

P: Képeslapot adott a kis gyerekeknek adott oda és

Postcard-acc gave the little child-dat gave and

He gave a postcard to the little child

és akkor ment haza

and then went home

and then he went home.

5. GRAMMATICALITY JUDGMENTS

5.1. It can be seen that the patient's spontaneous speech and repetitive performance is agrammatical. Thus it may seem strange that such a patient can correctly assess the grammaticality of some sentences. What is more, he can assess sentences he cannot produce correctly either in spontaneous speech or in repetitive tests. For instance s/he can correctly assess grammatical and ungrammatical instances of the use of the accusative or of the dative, while the use of these is impaired in his speech.

5.2. We tested a total of six Broca's aphasics (including the patient characterized above in the repetition test) at the National Institute for Rehabilitation and at the Neurology Polyclinic in Szeged.

We asked the patients to judge whether the sentences were acceptable or unacceptable. For instance *A gyerek látja őt* ("The child sees him-Acc") is a good sentence. An unacceptable sentence: **A gyerek látja én* ("The child sees I-Nom"). Acceptable: *A mama berakta a ruhát a szekrénybe* ("Mother put the clothes into the wardrobe"). Unacceptable: *A szín berakta a fázást a lisztbe* ("The colour puts cold into the flour"). The first pair of sentences above involves formal rules of syntactic case and number agreement, and the second pair involves selectional restrictions imposed by the verb on its arguments. The patients were required to give a quick response "as s/he feels", and no explanation was

required. Every patient was given the test five times, thus grammaticality judgments were required for 35 acceptable and 35 unacceptable sentences (70 sentences in all). Acceptable and unacceptable variants all figured in *minimal pairs* in the test. Patients therefore were not required to assess the grammaticality of single sentences. Their judgements showed whether they were able to sense the opposition between the members of minimal pairs. Since a grammaticality judgement on one member of a minimal pair entails judgment of the other member, therefore members of minimal pairs were placed at a distance from each other, separated by members of other minimal pairs. (E.g. the unacceptable variant of the first sentence was fifteenth on the list). Sentence patterns were filled with different words in each test and sentences were assessed in varying orders but we did not change the structures themselves.

5.3. RESULTS

The results of the five tests have been evaluated in the following way. Those minimal pairs whose acceptable component was always judged as good and whose unacceptable component was always judged as bad by the patient were considered as easy tasks from the point of view of grammaticality judgments. Minimal pairs where the patient did not judge correctly (acceptable sentences were termed as bad, and conversely) were considered as



difficult tasks from the point of view of grammaticality judgments. Only those minimal pairs were classified as easy tasks where every patient gave correct judgments in every test. Hesitations ("good...good?...bad!") were disregarded.

The empirical division of the test-material into easy and hard tasks : examples

(The glosses below contains the relevant details only.)

EASY TASKS:

1. ARGUMENT+CASE ENDING

Judgments of case endings, person and number suffixes of the verb, agreement in person, number and definiteness between Verb and NP's

A gyerek ült a széken.

the child-nom sat the chair-in

'The child sat in the chair.'

* *A gyerek ült a szék.*

the child-nom sat the chair-nom.

Mari szeret úszni.

Mary likes swim-inf.

'Mary likes to swim.'

**Mari szeret úszik.*

Mary likes swims.

Erzsi bízik az orvosban.

Liz trust-sing./3.pers the doctor-in.

'Liz trusts the doctor.'

**Erzsi bízunk az orvos.*

Liz trust-plur./1.pers the doctor-nom.

2. ANAPHORIC AGREEMENT IN PERSON AND NUMBER

Judgments of agreement in person and number between anaphora (*himself*-type) and its antecedent (content NP)

A gyerek látta magát a tükörben.

the child-nom saw himself-3.pers/acc the mirror-in

'The child saw himself in the mirror.'

**A gyerek látta magadat a tükörben.*

the child-nom saw himself-2.pers/acc the mirror-in

3.V-ANAPHORA (copying only bar V)

János magas volt és Mari is.

John tall was and Mary too

'John was tall and Mary too.'

**János magas volt és ezt tette Mari is.*

John tall was and this-acc did Mary too

**'John was tall and so did Mary.'*

HARD TASKS:

1.pro-SUBJECT

(*pro* in the position of repeated Subject. Judgments of the lexical material in the syntactic position of the repeated Subject)

Anyukám azt gondolta, hogy megkapta az állást.

'My mother_i thought that [pro=she_i] had got the job.'

**Anyukám azt gondolta, hogy Anyukám megkapta az állást.*

**'My mother_i thought that my mother_i had got the job.'*

2. ANAPHORA + CASE HIERARCHY

(Judgments of the case assignment of the anaphora and its antecedent. For instance: *NP+nom* and *himself-acc* is grammatical but the reverse is not.)

A vezető látta önmagát a tükörben.

the driver-nom saw himself-acc the mirror-in

'The driver saw himself in the mirror.'

**Önmaga látta a vezetőt a tükörben.*

Himself-nom saw the driver-acc the mirror-in

3. SENTENTIAL INTERTWINING

(Judgments of the lexical material in the syntactic position of the NP was moved from the subordinate clause into the main clause)

Mari a könyvet mondta, hogy megveszi Jánosnak.

Mary the book-acc said that (she) buys John-dat

'As for Mary, it was the book that she said she would buy (it) for John.'

**Mari a könyvet mondta hogy a kabátot megveszi Jánosnak.*

Mary the book-acc said that the coat-acc buys John-dat.

** 'As for Mary, it was the book that she said she would buy the coat for John.'*

4. AGREEMENT BETWEEN CONJUNCTION OF RELATIVE CLAUSES AND
THE LEXICAL OR PRONOMINAL HEAD

(Judgments of *the pot that* versus * *the pot who*)

Erzsi letette az edényt, amely nehéz volt.

Liz down put the pot-acc that heavy was.

'*Liz put down the pot that was heavy.*'

**Erzsi letette az edényt, aki nehéz volt.*

Liz down put the pot who was heavy

5. VP ANAPHORA

(Judgments of the choice from structures like
so did Liz and *so was Liz*.)

Péter festette a kaput és ezt tette Erzsi is.

Peter painted the gate-acc and this-acc did Liz too.

'*Peter painted the gate and so did Liz.*'

**Péter festette a kaput és ilyen volt Erzsi is.*

Peter painted the gate-acc and such was Liz too.

6. GAPPING

János látott egy kutyát és Péter egy macskát.

John saw a dog-acc and Peter a cat-acc

'*John saw a dog and Peter a cat.*'

**János látott egy kutyát és Péter egy kutyát.*

John saw a dog-acc and Peter a dog-acc

7.ASPECT

(Judgments of the compatibility of (progressive or perfective) aspect of the verb and the time adverbial)

Két napon át készítette az ebédet.
for two days (she) was making the dinner-acc.
'She was making the dinner for two days.'

**Két napon át elkészítette az ebédet.*
for two days (she) has made (= 'completed making') the dinner-acc

8.SELECTIONAL RESTRICTIONS

(Judgments of the compatibility of thematic roles, selectional restrictions and lexical features of NP's in argument positions)

A mama elküldte a gyereket a boltba.
the mother sent the child-acc the shop-in.
'The mother sent the child in the shop.'

* *A mama elküldte az érzést a filozófiába.*
the mother sent the feeling-acc the philosophy-in.

9. AGREEMENT OF RECIPROCAL ANAPHORA

(Judgments of the agreement of person and number suffixes on antecedent NP and reciprocals (each other type). The NP and the reciprocal are not adjacent.)

A férfi meg a nő beszélgetett egymással.

the man and the woman talked each other-with

'The man and the woman talked to each other.'

* *A nő beszélgetett egymással.*

the woman talked each other

10. UNFOCUSSABLE SENTENCE ADVERBIAL IN FOCUS

(Presumably- perhaps-type of unfocussable adverbials in the position dominated by the 'S' node and in the heavy stressed Focus position -- immediately preceding the Verb. (The capitals and " stand for Focus position))

János talán elkésett.

'John perhaps came late.'

**János "TALÁN késett el.*

John it is PERHAPS came late.

11. ALL 3 ARGUMENTS PRECEDE THE VERB

(Judgments of the case endings and agreement of person and number suffixes between NP's and Verb. All NP precede the Verb)

A gyereket a boltba a mama elküldte.

the child-acc the shop-to the mother-nom sent-sing/3.pers

'The mother sent the child to the shop.'

* *A gyerek a boltba a mama elküldtem.*

the child-nom the shop-to the mother-nom sent-sing/1.pers

6. DISCUSSION

6.1. The relevant factors of judgements

The fact that Broca's aphasics are capable of making correct grammaticality judgments with some minimal pairs and not with others is a problem that deserves further study. The problem is the following: what are the factors facilitating or impeding judgment of certain minimal pairs? Let us suppose that grammaticality judgments for minimal pairs require some kind of (implicit) analysis of these data. Let us examine what kind of information has to be used with easy tasks and what kind of information should be used with hard tasks.

6.2. Easy tasks require the use of the following kinds of information.

6.2.1. The parser has to be able to take the predicate of the sentence as the starting point of dependencies that are to be analysed. (The task of one argument V-anaphora.)

6.2.2. The case frame of the predicate has to be retrievable.

6.2.3. Control of case assignment to main syntactic constituents should be possible. The parser has to be capable of checking whether every case ending of the predicate has been assigned, and whether every argument has received case (ending). (The tasks of arguments+case endings.)

6.2.4. The parser has to be capable of sequentially checking grammatical agreement (person and number) of syntactic constituents (and that of the suffixes expressing person and number). (Tasks related to subject and object agreement in person, number and definiteness, antecedent--reciprocal agreement in person and number).

6.3. Hard tasks require radically different kinds of grammatical information for grammaticality judgments.

6.3.1. The structure of the entire sentence has to be stored in memory and in the stored structure it is necessary to retrieve and compare lexical material filling two distinct syntactic positions. This is necessary either because one has to determine whether it is possible to repeat a constituent that has occurred

earlier (pro-subject, sentence-intertwining), or in order to be able to judge the grammaticality of referring back to some constituent as antecedent in a coordinating clause (VP anaphora), or in order to be able to judge with verbs that can be deleted when repeated, whether the syntactic environment of the explicit occurrence of the verb is in contrast with the syntactic environment of the deleted form of the verb (gapping). Thus contrast is impossible if a noun phrase from the syntactic environment of the first (explicit) occurrence of the verb is repeated in the second clause, and is adjacent to the position containing the gap (see the sentence with an * with the gapping task).

6.3.2. One has to assess the compatibility of two lexical items that occupy distinct syntactic positions. The problem arises with the occurrence of the second lexical unit, and in order to judge compatibility the lexical realisation of some preceding syntactic position has to be recalled (features of conjunctions and lexical heads of relative clauses, features of conjunctions and demonstratives of relative clauses, compatibility of aspect and time adverbials, compatibility of selectional restrictions and features of NP's in argument position, interpretation of sentence adverbial that cannot occur in Focus position). These tasks require the comparison of features like +alive/-alive, concrete/abstract, progressive/perfective, instrument/object/agent etc.

6.3.3. One of the conditions of an appropriate grammaticality judgment is the comparison of an

internal/final position of sentence structure (stored in memory) to the first position, which has to be accessed again. This requires reanalysis of sentence structure (following lexical insertion), in such a way that a stepwise check of case endings and agreement markers on adjacent constituents does not yield correct grammaticality judgments. (Case agreement: anaphora and case hierarchy, number agreement: reflexives following a verb in the singular).

6.3.4. The correctness of case assignment to NP's has to be assessed without any knowledge of the V that assigns case; or, once the V becomes known the entire chain has to be recalled and case/number/person agreement verified. (3 arguments preceding V).

7. POSSIBILITIES FOR EXPLANATION

7.1. The empirical properties of easy tasks are based on the expectations/requirements of the primary syntactic parser. These are of a verifying/synchronising kind; they are based on the principle that the parser when activated starts from an initial state and seeks something that has to match something. Search is effected in stepwise checks. This could be paraphrased as follows: "Take predicate X and its case frame as a starting-point. Assign cases from the case frame and make the case of constituent Y agree with that of constituent X; make constituent Y agree with the verb in person and number;

let constituent Z agree in person and number with constituent W, etc."

7.2. Judgments in easy tasks are based on information that can be used fast. It is possible for the parser to place this information into its own operational memory while parsing goes on. (What the predicate is, the latest case assigned, what other cases are yet to be assigned, what suffixes are on the verb, what person and number it has etc.). This kind of information can be extracted by processing short phoneme sequences and is carried by the parser in the form of its changes from one state to another ("what it is seeking to match what") and is retained while parsing goes on.

7.3. With hard tasks judgments do not depend on sequential formal requirements of the primary parser. In the case of hard tasks it is necessary to load short term memory, which stores on-line phonological-semantic input. (Vallar & Baddeley 1984, Vallar & Shallice 1988). The reasons for this are the following:

7.3.1. In order to judge grammaticality it is necessary to backtrack to earlier syntactic positions of the structure to be processed. In order to do this the structure of the entire sentence has to be stored in short-term memory.

7.3.2. It is necessary to identify lexically and to segment the sequence of phonemes that serves as input. Furthermore phonological and lexical segments have to be

stored in an order-preserving manner, in order that lexical units (and their semantic features) that occupy different syntactic positions could be comparable and the judgments concerning reoccurrence, anaphora, compatibility or incompatibility of semantic features could be made.

8. THE ROLE OF THE CLOSED CLASS WORDS

8.1. Linguistic symptoms of Broca's aphasia are mainly defined as impairment of access to closed class words (the class of grammatical formative). Indeed, fragmentation or agrammaticality of spontaneous speech, poor sentence repeating skills and good sentence comprehension skills may be correlated with this fact. Closed class words (including case endings, suffixes, articles, postpositions and prepositions, conjunctions etc.) are the elements of a structure-analysing and structure-building complex in on-line speech comprehension and production. (Bock 1989). Closed class words can be used as indicators for the speaker since these formatives mark the beginning and the end of noun phrases and other phrases, the units of constituent structure, boundaries of main and subordinate clauses, word order etc. They impose structure on a string of words.

8.2. Speakers access open class words (words that refer to entities in the world) and closed class words by two

distinct access systems. (This is manifest in the opposition between Broca's and Wernicke's aphasia as well.) Yet there are two arguments in favour of the hypothesis that these two access systems have to interact, especially during on-line sentence comprehension. (Saffran 1985, Saffran & Martin 1988).

8.2.1. Accessing closed-class words influences access to open-class words as well. Formatives for instance can radically reduce search time in the lexicon, if formal information is available as to whether one has to search for a verb, a noun or an adverb, for example.

8.2.2. In on-line speech processing identification of closed class words as indicators of structure can help build and indentify structure before the order-preserving phonological-lexical representation of the input is deleted from short term memory storage. (Linebarger 1990). Time is an important factor here because continuous processing of (heard) sentences requires great operational speed and there are few possibilities for halts and backtracking during processing.

8.3. A possible explanation for the contradiction between agrammatical spontaneous speech of Broca's aphasics and the division of grammaticality judgments into easy and hard tasks may be related to temporal factors and to operational speed. Impairment of access to closed-class words does not mean that patients are unable to use formatives; instead, it means that accessing closed classes is slower during on-line sentence processing than with healthy cases. (Data in 4.4. reflect this.) In other

words, patients do not recognize a sequence of formatives as structural markers fast enough in order to construct constituent structure while phonological-lexical input is available in short term memory. (The capacity of short term storage is necessarily reduced and indeed short-term in character, since processing is on-line and the next input is always there to exclude previous inputs.)

9. INTERACTION OF MODULES

9.1. On the basis of 7.3. we can summarise characteristic properties of hard tasks for grammaticality judgments as follows: a necessary condition of correct judgments is the storage of phonological-lexical input during sentence parsing in order to effect the comparisons and checks that are necessary. It is telling, for instance that performance becomes poorer with an argument + case ending task (classified as an easy task otherwise) if all three argument NP's precede the verb; in this case the parser, which is slow on account of its impairment is late to receive its input (the verb which is responsible for case assignment).

It can be seen in the case of easy tasks that patients were able to provide good grammaticality judgments on the basis of the expectations and checking moves of the primary parser. On the basis of the transparency hypothesis outlined in 2.1. and the methodological

principle of selective loss/retainment of linguistic skills we can say that these tasks reflect the functions of one of the modules of sentence processing. There exists a syntactic parser with autonomous input (the parser recognizes the syntactic properties of the sequence of sentences to be processed) and with autonomous output in that the results of processing are represented as syntactic information for the next processing module. The data of the repetition test presented in 4.4. support this hypothesis, and so does the information used in solving easy tasks. An account of this syntactic information present in the output of the parser can be characterised as follows:

- a/ the representation of coarsely parsed constituent structure and a verb class.
- b/ representation of category, person and number information for terminal positions in constituent structure, which are marked by formatives.

9.2. It is crucial that the output of the parser contains no specific lexical information. Lexical information would be necessary in order that a correspondence could be established between terminal positions and certain lexical segments of order-preserving phonological storage. This is in fact the first stage of sentence comprehension proper, the integration of structural and lexical information. However, access to closed class words is impaired and therefore the construction process is slow and the

integration and interpretation of some lexically processed input sequence of phonemes is deferred. This input sequence would have to be retained too long because of the impairment of the parser. Sentence repetition halts and grammaticality judgments become erroneous if they have to be based on properties of lexical insertion.

9.3. The explanation of the division of grammaticality judgments into hard and easy tasks is therefore related to the modularity of sentence processing and to disturbances in the interactions of these modules. It can be assumed that in the first phase of processing the parser selects structural cues. Broca's aphasics are capable of structural analysis (which is slowed down in comparison with normal standards) but they cannot make use of its results in further interpretive processes because they are unable to integrate the output of the syntactic parser with the segments of short-term phonological-lexical storage. Disturbances in the interaction of the two modules lead to a division in grammaticality judgments and to the characteristic linguistic symptoms of (slight) Broca's aphasia.

9.4. The explanation presupposes a seriality of modules (the output of the parser has to be integrated with phonological-lexical segments). This is supported by the insight that if the parser gave no syntactic output during the first phase of processing, then Broca's

aphasics could have made judgments on sentences only after semantic interpretation had taken place. What really happened was in fact the reverse of this. Patients could not make use of their unimpaired or slightly impaired lexical representations to judge sentences with incompatible lexical-semantic features. Patients could not make correct judgments on the basis of lexical-semantic features in cases where this was in principle possible. They were deprived of this possibility by the modularity of sentence processing.

10. CONCLUSIONS

10.1. The seriality of the modules, primary (approximate) parsing during processing, followed by integration with the content of phonological-lexical stores seems to be necessary in the on-line interpretation and memorising of utterances that occur during fast speech. It is possible that with the processing of writing or visual material the integration of the output of parsing with the content of lexical storage is be different from what is the case in speech processing.

The output of primary parsing need not correspond to some level of representation in a descriptive grammar. The integration of the output of the parser and the content of lexical storage simply indicates the points where processing modules meet.

10.2. Neuropsychological data exclude any doubt about the thesis of modularity in the construction of grammar. Data from aphasia show that linguistic processing and overall cognitive activities can be separate, and that language is an autonomous system that can be impaired with persons who are otherwise not mentally impaired or debilitated. The linguistic processing system itself is modular, as shown by the divisions between lexical processing, syntactic parsing and the semantic interpretation of syntactic structures.

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