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THEORETICAL LINGUISTICS PROGRAMME, BUDAPEST UNIVERSITY (ELTE)

MANAGEMENT OF CAPACITY REDUCTION  
IN BROCA

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## 1 Introduction

### 1.1 Prelude

The development of research on Broca's aphasia has yielded a number of markedly different scientific trends. In the 1970s it was often claimed that agrammatism involves a total loss of syntactic competence (cf. Caramazza and Zurif (1976), Berndt and Caramazza (1980)). Later this picture was abandoned, and starting from the early 1980s the view has been established that aphasics are in fact not deprived of the whole of their syntactic competence. Currently there are a number of competing theories of agrammatism, which appear to cluster around two fundamental hypotheses. One popular assumption is that although in essence the grammar in aphasia is intact, one aspect of it or other is deficient, which is the source of apparent breakdown of patients' quality of performance. This view then holds that even though there is no absolute loss of competence, what we face is a disappearance or impairment of some specific component of the grammar. This class can be termed as the *grammar-based* or *competence theories*. The alternative group can be characterised as the *capacity limitation* approach, or the *performance theories*. This is the antithesis of the 1970s position: the fundamental proposition here is that patient's grammar is wholly preserved, and the deficiency lies with some aspect of the performance system.

The present case study builds on work in this second school of thought, more particularly on the concept of rapid decay of syntactic information discussed in Kolk and van Grunsven (1985), Haarmann and Kolk (1991), Haarmann and Kolk (1994) and Kolk (1995). Kolk and colleagues have adopted a steady, even decline of grammatical information and did not consider other alternatives. However, here I will argue for a different pattern of the decay of syntactic information, namely a *fast-slowng down decline*. This dynamic pattern involves a very fast initial decline in syntactic activation level followed by a gradually slowing rate of decay. We hypothesize the existence of a human parser whose functioning is constrained by the grammar but which has its own *independent* operational principles. Critical support for this assumption will

be derived from the finding that patients actively influence and modify syntactic structure in order to approach *smaller load* on the parser, which may result in an output which is actually *more complex* from a purely grammatical perspective. Also, it will be suggested that at some level of its operation, the parser relies on *linearity* rather than on hierarchical relations, although its production is confined by the grammar, which licenses only a hierarchical structure. These results will allow us to draw important conclusions about the relation of the abstract system of grammar and the performance systems it is embedded in.

I will also give a critical overview of some of the main theories of agrammatism particularly in view of the findings, and more generally, conflicting them with questions raised by the structure of the Hungarian sentence as described in É.Kiss (1992, 1994).

## 1.2 Remarks on the test type

Let us start out with a general question of the type of task: how can we evaluate the repetition test from the point of view of the requirements it imposes on the patient? It is a well-known and plausible fact that acting out situations, or sentence-picture matching, or similar tasks require the patient to understand, semantically interpret the given sentence. In contrast, syntactic grammaticality judgement tasks primarily demand a first-pass parse (Linebarger (1990)) of the structure, at least it does not require preparing any kind of interpretation (Linebarger, Schwartz and Saffran (1983), Schwartz, Linebarger, Saffran and Pate (1987)). It appears that the repetition task is more similar to the latter type (i.e. to the judgement of syntactic errors), inasmuch as it is, strictly speaking, *sufficient* (and of course also necessary) for its successful completion to analyse the *syntactic* structure; on the other hand, it is also true that the contingent further semantic processing (which is to follow syntactic parsing most of the time) may influence faithful reproduction. In fact, it can aid the reproduction of the sentence: reproduction is easier if not only syntactic but also semantic representation is made ready; in addition, if the syntactic structure has already passed away from the working memory, but the interpretation is still available, the parser may be able to regenerate the original syntactic structure. Of course if semantic representation has been damaged as well, the patient may choose to observe the conceptual content of the utterance over the syntactic structure, which may result in a

response that is conceptually or pragmatically essentially faithful, or even equivalent from the point of view of description of events in actual reality, (i.e. the truth conditions of the repetition are a subset of the truth conditions of the target sentence), but which is structurally considerably simpler than the eliciting sentence. See (1a) for an illustration of this latter case. In another response, semantic faithfulness is conspicuous from the selection of lexical items - see (1b).

(1) a. E: Nem vágta a kenyeret, hanem törte.  
 not cut-past-3sg the bread-acc, but break-past-3sg  
 'He didn't cut the bread, but broke it.'

P: Törte a a kenyeret.  
 cut-past-3sg the the bread-acc  
 'He broke the...the bread.'

b. E: A híres festményt nem eladták,  
 the famous painting-acc not pref-sell-past-3pl  
 hanem elajándékozták.  
 but pref-give-past-3pl-away  
 'The famous painting was not sold, but was given away.'

P: ...ták igen. Híres festményt nem aka  
 ...-past-3pl yes famous painting-acc not (nons.fr.)  
 nem pénzzé tették hanem hanem eleajánkékozták.  
 not money-abl make-past-3pl but but pf-sell-past-3pl  
 '...d yes. Famous painting was not (nons.fr.)  
 not turned into money but but was given away.'

In short, we find that this type of task belongs to those strictly requiring only a syntactic (and of course phonological) parsing, though it appears that it is a transitional genre, for the influence of semantic processing on its completion cannot be excluded. This fact will be significant further down, when we examine the predictions of some competing theories concerning Hungarian, for a portion of these theories were developed mainly on the basis of data obtained from experiments investigating comprehension.

## 2 The method

Although the present paper is a case study of a single patient, it should be noted that she shows traits strikingly characteristic of

Hungarian agrammatics in general. The subject was female, age: 63, and the lesion site was back fronto-parietal. She was found to show dominantly symptoms of Broca according to the Western Aphasia Battery (WAB) (Kertész (1982), as adopted for Hungarian by Osmánné Sági Judit. Her spontaneous speech is fragmented, her comprehension is average. The bulk of data to be examined comes from a single repetition test carried out in one session with a short free, spontaneous conversation halfway through. This test involves an oral presentation of sentences which the subject is supposed to repeat one by one. Our test contained 120 such eliciting sentences. Target sentences were repeatedly presented to the patient in case of total failure of the repetition attempt, however, a cluster of such attempts were considered as only one target string. The target sentences varied both in syntactic complexity and in word order. They ranged from two constituents (in a linear sense) to multi-constituent coordinated sentences, and a portion of them contained topicalisation, focus, quantifiers (which are overtly raised in Hungarian) and negation. I attempted a comprehensive test of Hungarian simple and coordinated sentences, hence the advantage of the data set is that it is sufficiently varied to base our later observations on.

### 3 Discussion of the data

#### 3.1 General observations: explained by a capacity approach

Let us turn now to the data. I will make some general observations first, illustrated below:

- (2) a. E: János újságot olvas.  
           John newspaper-acc read-pres-3sg  
       P: János újságot olvas.
- b. E: Péter állt a téren.  
           Peter stand-past-3sg the square-on  
       P: Péter állt a téren.
- c. E: János a hirdetésekét böngészgeti.  
           John the ad-pl browse-pres-3sg  
       P: flöngészgeti flöngészgeti  
           (browse-pres-3sg - phonological error at the left edge)
- d. E: Péter odébbtolta az asztalt.  
           Peter PREF-push-past-3sg the table-ac  
           'Peter pushed the table on.'  
       P: Odébbtolta az asztalt.



slower than normal speech rate often facilitates sentence comprehension performance in aphasic patients (Lasky, Weidner and Johnson (1976), Liles and Brookshire (1975), Pashek and Brookshire (1982), Poech and Pietron (1981), Weidner and Lasky (1976).)<sup>3</sup>

It is to be pointed out that the found language-related deficiencies are clearly in need of explanation by any theory of agrammatism, all the more so, since these and akin phenomena are central and pervasive in the case of Broca. What we see, however, is that theories other than those based on the hypothesis of capacity limitation simply do not treat the matter. It is unclear, to say the least, how the purely grammar-based approaches could account for facts of the kind of (i-iv).

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<sup>3</sup>A further observation is apparently memory-management related. In some cases the previous sentence or part of it seems to 'get stuck' in the memory, as it were, i.e. it fails to get deleted and memory is not freed up to receive subsequent sentences. Thus it is the stranded material that comes forth once again:

- a. E: Nem találtam a cipómet.  
not find-past-1sg the shoe-my-acc  
'I couldn't find my shoes.'
- P: Nem találtam a cipómet.  
not find-past-1sg the shoe-my-acc  
'I couldn't find my shoes.'
- E: Nem láttad a cipómet?  
not see-past-2sg the shoe-my-acc  
'Haven't you seen my shoes?'
- P: Nem találtam a cipómet.<sup>3</sup>  
not find-past-1sg the shoe-my-acc  
'I couldn't find my shoes.'
- b. E: A vonat lassan mozgott.  
the train-nom slowly move-past-3sg  
'The train was moving slowly.'
- P: Vonat lassan mozgott.  
train-nom slowly move-past-3sg  
'Train was moving slowly.'
- E: Az autó elsuhant a ház előtt.  
the car-nom PREF-whizz-past-3sg the house in-front-of  
'The car whizzed past the house.'
- P: Elsuhan a ház előtt.  
PREF-whizz-past-3sg the house in-front-of  
'(It) whizzed past the house.'
- E: Micsoda?  
What?
- P: Akkor vonat.  
then train-nom  
'Then train.'

This type of data points to problems with memory-management, although it still awaits a precise explanation. Of course the more uniform the account is with respect to a general theory of agrammatism, the more explanatory power it has.

### 3.2 The pattern of the data

#### 3.2.1 Starting point

Having discussed observations which point to a capacity limitation, some among them to memory reduction, let us turn to a special pattern showed by the data. We will examine those neutral (unfocussed) sentences that are not coupled with responses ending up in total failure, and did not elicit repetitions of the end of the target string only (cf. (ii) above). There is a total of 55 such sentences. It is remarkable that in approximately 38% of these the word order used by the patient was different from that in the input sentence. This surprising fact suggested the idea of exploring the pattern of the alterations themselves in the repetition set. This seems a novel point of view in the investigation of agrammatism.

Before entering the discussion of the transformations, we need to look at the syntactic structure of the simple Hungarian clause. We will adopt the analysis of É.Kiss (1992, 1994, 1996), which we outline below.

#### 3.2.2 The structure of the Hungarian clause

We will outline only the skeleton, as it were, of the Hungarian simple clause, as it is sufficient for our purposes. The empirical observation of the linear order of constituents in a simple sentence in (4a) is captured through the basic structure in (4b) (É.Kiss (1992: 89)):

- (4) a.  $XP^*_{topic} XP^*_{univ.quant.} XP_{focus} V XP^*$   
b.  $[S XP^*_{topic} [VP XP^*_{univ.quant.} [VP XP_{focus} [V' V XP^*]]]]^4$

The nucleus of the Hungarian clause is a bare VP. Under the adopted analysis, the structure of the VP is flat, i.e. all arguments and adjuncts of the verb are sisters of the verb, which is left-peripheral in the phrase. Now, the verb may be preceded by a focused phrase, whose semantic function is identification and exclusion, or often merely identification. It is inferable from (4a,b) that the focus site is a unique position in the clause. To the left of the VP, there can appear one or more universal quantifiers. To the left of this quantifier position is the topic

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<sup>4</sup>S is replaced by TP (Tense Phrase) in É.Kiss (1994), but this is irrelevant for our purposes.

field. As is indicated by the star, the topic position is again recursive: multiple topic constructions are allowed. The VP in this system is the predicate: potential topics are predicated of the VP. The same linear order is derived in the framework of É.Kiss (1996), which is formulated in terms of functional projections, embracing ideas put forward by Brody (1990).

(5) [TopP\* XP\*<sub>topic</sub> [QP\* XP\*<sub>univ.quant.</sub> [FP XP<sub>focus</sub> [VP V XP\*]]]]

Crucially for our purposes, all pre-verbal phrases are raised out of their VP-internal positions, where they bind a trace.

### 3.2.3 Word order alterations in the patient's responses: the topic field

Let us return now to the matter of word order in the responses of the subject. In the majority (more than 90%) of the changed word order cases, alteration concerns the topic position. This is a large proportion, and even more so given that the unchanged order instances (the 62%) were almost exclusively structurally simple sentences (at most of a complexity of a verb plus two phrases) and in about 14% of them there was no topic to be tampered with. 63% of those changed word order sentences where a topic position was interfered with involved extra topicalisation. (6) and (7) illustrate the case:

(6) E: ... mi van a tévébe?

what be-pres-3sg the TV-in

[<sub>FP</sub> mi<sub>k</sub> van<sub>i</sub> [<sub>VP</sub> t<sub>i</sub> t<sub>k</sub> a tévébe]]

'what's on TV?'

P: ... Tébe mi van?

T-on what be-pres-3sg

[<sub>TopP</sub> tébe<sub>i</sub> [<sub>FP</sub> mi<sub>k</sub> van<sub>i</sub> [t<sub>i</sub> t<sub>k</sub> t<sub>i</sub> ]]]

'what's on T?'

(7) E: A levelet megírta Péter.

the letter-acc pref-write-past P.

[<sub>TopP</sub> a levelet<sub>i</sub> [<sub>PredP</sub> megírta Péter t<sub>i</sub> ]]

'Peter wrote the letter.'

P: Péter a levelet megírta.

[<sub>TopP</sub> Péter<sub>j</sub> [<sub>TopP</sub> a levelet<sub>i</sub> [<sub>PredP</sub> megírta t<sub>i</sub> t<sub>j</sub> ]]]

'Peter wrote the letter.'

[PredP ... DP ...] → [TopP DP<sub>i</sub> [PredP ... t<sub>i</sub> ...]]

26% involved de-topicalisation, i.e. a constituent in a topic position of the target sentence was placed back to a VP-internal location. (8) represents this type of response:

- (8) E: Péter levelet írt.  
P. letter-acc write-past-3sg  
[TopP Péter<sub>i</sub> [PredP levelet írt t<sub>i</sub> ]]  
'Peter wrote a letter.'
- P: Levelet írt a Péter.  
letter-acc write-past-3sg the P.  
[PredP levelet írt a Péter ]  
'Peter wrote a letter.'

[TopP DP<sub>i</sub> [PredP ... t<sub>i</sub> ...]] → [PredP ... DP ...]

In the remaining 11%, a different constituent was topicalised instead of the original topic in the test sentence. (9) is an instance of this type:

- (9) E: A virágot megöntözte János.  
the flower-acc water-past-3sg J.  
[TopP a virágot<sub>i</sub> [PredP megöntözte t<sub>i</sub> János ]]  
'John watered the flower.'
- P: János bevkeze za a+ János megöntözi  
J. (nonsense fragments) the J. water-pres-3sg  
ke a virágot.  
(nonsense fragment) the flower-acc  
[TopP János<sub>i</sub> [PredP megöntözi (ke) a virágot t<sub>i</sub> ]]  
'John (nonsense fr-s) is watering (nons. fr.) the flower.'

[TopP DP<sub>i</sub> [PredP ... t<sub>i</sub> DP<sub>k</sub> ...]] → [TopP DP<sub>k</sub> [PredP... DP<sub>i</sub> t<sub>k</sub> ...]]

These data are in fact remarkably surprising in view of the most well-known theories of aphasia - though this very fact is not to be regarded as curious, given that these theories were based primarily on western European, more or less fixed word order languages, in which phenomena of this kind are rather uncommon (though not impossible). What is surprising about the data can be formulated in different terms in different theoretical frameworks (we will discuss this issue further down), however, it is empirically straightforward: the operation of topicalisation or

the lack of this operation exhibits something like free alternation.

### 3.3 Further word order alternations: operators

In order to be able to provide an explanation for this pattern, it seems worth examining other, though related, data. For, it is not exceptional for the operation of focusing to be cancelled. (10) contains a case in point:

- (10) E: Nem A KÉP mozgott,  
not the picture move-past-3sg,  
hanem A VÍZ hullámozott.  
but the water ripple-past-3sg  
[<sub>NEGP</sub> nem [<sub>FP</sub> a kép<sub>i</sub> mozgott<sub>j</sub> [<sub>VP</sub> t<sub>j</sub> t<sub>i</sub> ] ]  
hanem [<sub>FP</sub> a víz<sub>k</sub> hullámozott<sub>l</sub> [<sub>VP</sub> t<sub>l</sub> t<sub>k</sub> ] ]  
'It was not the picture that was moving,  
but it was the water that rippled.'
- P: ...lámozott. Hullámozott a víz  
...(rip)ple-past-3sg ripple-past-3sg the water  
a a mikor mikor a kép mozgott.  
the the when when the picture move-past-3sg  
[<sub>VP</sub> hullámozott a víz ... [<sub>TOPP</sub> a kép [<sub>VP</sub> mozgott ] ] ]  
'...pled. The water rippled  
the the when when the picture was moving.'

In this example as well as in other places negation gets omitted, or a different element is negated in the response. This happens in (11) and (12) below:

- (11) E: Kirándultunk vasárnap,  
go-past-2pl-for-an-outing Sunday,  
nem fociztunk.  
not play-past-2pl-soccer  
[<sub>VP</sub> kirándultunk *pro* vasárnap] [<sub>NEGP</sub> nem [<sub>VP</sub> fociztunk *pro* ] ]  
'We went for an outing on Sunday, and didn't play soccer.'
- P: Fociztunk és kirándultunk.  
play-past-2pl-soccer and go-past-2pl-for-an-outing  
[<sub>VP</sub> fociztunk ] és [<sub>VP</sub> kirándultunk ]  
'We played soccer and went for an outing.'

- (12) E: A moziban nem Péterrel beszélgettem.  
 the cinema not P.-with talk-past-1sg  
 [a moziban [<sub>NegP</sub> nem [<sub>FP</sub> Péterrel<sub>j</sub> beszélgettem<sub>i</sub>  
 [<sub>VP</sub> t<sub>i</sub> t<sub>j</sub> ]]]]  
 'It's not Peter who I talked to in the cinema.'
- P: Péterrel nem pö Péterrel nem beszélgettem.  
 P.-with not (nons.fr.) P.-with not talk-past-1sg  
 [<sub>TopP</sub> Péterrel<sub>i</sub> [<sub>NegP</sub> nem [<sub>VP</sub> beszélgettem t<sub>i</sub> ]]]  
 'I didn't talk to Peter.'

It also happens that the response to an input question is a declarative. In Hungarian this can be marked by the intonation pattern, without any overt syntactic alteration. See (13) below:

- (13) E: Ki mondta, hogy késő van?  
 who say-past-3sg that late be-pres-3sg  
 'Who said it's late?'
- P: Ki mondta, hogy késő van.  
 'Who said it's late.'

### 3.4 A first discussion of the data

Now the above distortions are left without any apparent and straightforward account by current theories of Broca. In order to work out possible explanations, the question that offers itself concerns what the common feature(s) may be in these types of data. The answer to be given to this question will ultimately determine the resolution of the problem. The first possibility is to claim that in all the above cases it was an operator feature that was affected: erased, associated with another constituent, or in the case of extra topicalisation, added to the structure. We have argued above against admitting independent (grammatical) deficiencies to our theory. Thus, we should try to avoid making this claim an extra stipulation, instead it would serve our purposes best to relate the problem with operator features to the independently necessary capacity limitation. To this end, and particularly in view of the deletion of operator features from the structures, we could propose that operators represent special burden for the memory capacity. It is problematic however that (i) operator features are often not erased, (ii) they get associated with a different constituent, (iii) and it also occurs, as we have seen, that they can get added to the structure. In addition, in this latter case it never occurs that the added operator feature

should trigger a movement into a non-sentence-initial position, e.g. into a second position behind a topic or adverb. Thus, it seems that this path is not viable, at least in this formulation.

There is a further, even more puzzling conceptual problem for this attempt. It seems quite clear that although topic is often termed an operator, it is not strictly speaking a semantic operator at all. To show this it is enough to point out that the order of topicalised phrases in the topic field is irrelevant for computing the logico-semantic structure of a sentence; while in a sentence like *Minden fiú két lányt észrevett* 'Every boy noticed two girls.' the first quantifier (*minden fiú*) takes scope over the lower one (*két lányt*), and the sentence has the only interpretation 'For every boy there are two girls that he noticed,' but not 'There are two girls that every boy noticed.' This seriously weakens the footing of the approach under consideration, as the operators in question do not seem to constitute a semantically natural class.

An alternative approach is that in the cases in question movement applies, or would apply. (Interrogatives turned into declaratives apparently constitute exceptions here. However, we can argue that the question interpretation is only not reflected in the phonological form, but is syntactically and semantically realised as well, only covertly.) Movement is more or less considered a source of difficulty for the patients in all theories, though the actual reasons vary. However, once again, we face the problem of moving a different element instead of the original one (topicalisation, negation), and that of extra topic raising. Clearly, we encounter the same difficulties if the issue is formulated in terms of syntactic complexity.

Though, characteristically of the field of aphasic research, data do not provide direct evidence, the inadequacy of these approaches seems apparent. Few points appear to be clear, among them the fact that the accomplished modifications are subject to principles restricting the operation of the parser: the patient favoured grammatical, particularly, syntactic principles and the thematic interpretation over the changes she made.

Before presenting our explanation of the observed pattern, let us examine current leading theories of agrammatism from the point of view of their (implied) account of these phenomena and potential problems they face when turned to a language such as Hungarian.

#### **4 Conflicting current theories with the data and with Hungarian**

This section will scrutinise the most prominent approaches to agrammatism from basically two perspectives: (i) conflicting them with the structure of Hungarian, and (ii) examining if they are able to provide an explanation to our empirical findings above. However, we will not restrain ourselves from pointing out some more general theoretical considerations. Only the very basics of each approach will be outlined, but that will suffice for our purposes here.

##### **4.1 Deficient grammar approach**

###### **4.1.1 The Mapping Hypothesis**

We will begin our discussion with the Mapping Hypothesis (Linebarger, Schwartz and Saffran (1983), Schwartz, Linebarger, Saffran & Pate (1987), Linebarger (1989), Linebarger (1990), Linebarger (1995)). This theory was originally developed on the basis of the observation of the dissociation of agrammatic speakers' ability to make grammaticality judgements and their ability to use semantic interpretation in test situations. For, in 1980, Schwartz, Saffran and Marin showed that patients of Broca perform at chance when asked to match pictures with reversible passive and locative sentences; while Linebarger, Schwartz and Saffran (1983) demonstrated that the ability of grammaticality judgement of the same subjects that were tested in the 1980 experiment was relatively well preserved. To account for this significant contrast, the authors suggested two viable hypotheses. One option was termed the trade-off hypothesis, which held that there is a certain reduction in computational resources in agrammatism, which syntactic and semantic processing share. This entails that the more syntactic processing a task requires the less resources will be available for semantic calculation, and vice versa. As resources are diminished in Broca, exceeding the capacity limit is detrimental. This hypothesis is able to capture the dissociation between the preservation of grammaticality judgement in a great many cases and the loss of the ability to comprehend the same sentence types. This is because resources may be sufficient for grammaticality judgement, which only necessitates syntactic processing, but not for comprehension, which requires syntactic and semantic computation. The alternative assumption was called the Mapping Hypothesis. In essence,



according to this view, it is agrammatics' mapping of syntactic positions onto thematic roles which is deficient. As grammaticality judgement, in contrast with sentence-picture matching (comprehension test), does not require such mapping, the opposition between the performances in the two tasks is explained.

Then in a subsequent paper Schwartz, Linebarger, Saffran and Pate (1987) went on to discard one of these assumptions, the trade-off hypothesis<sup>5</sup>, which left the residing alternative, the Mapping Hypothesis. In the same study, the authors showed that in (some) moved argument sentences comprehension is more impaired than in sentences without argument movement, which fact they related to the (thematic) non-transparency or transparency of the sentences.

Later (Linebarger 1989, 1990) the theory was modified to embrace facts like the incorrect grammaticality judgement tendencies with sentences involving erroneous reflexives, tag questions or *wh*-phrases in relative clauses, for instance. Linebarger's claim is that in all these cases, as well as in the case of assigning thematic roles, what is impaired is the exploitation of coindexation in the syntactic structure for purposes of semantic interpretation. Linebarger (1995: 85) suggests that interpreting syntactic arguments as certain semantic arguments of the predicate (i.e. assigning thematic roles) 'involves linking elements in the two structures, the S-structure and theta grid.' Now there seems to be some confusion here. For, the theta grid is a lexical concept: this stores information about the argument structure of a lexical predicate in the lexicon, and

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<sup>5</sup>Schwartz, Linebarger, Saffran and Pate (1987) carried out their study of judgements of semantic anomaly using normal and lexically padded sentences. They rejected the trade-off hypothesis, because they obtained no significant effect of syntactic complexity on correctness of judgement. Kolk and Weijts (1995) repeated part of their experiment, with a different result: they found a significant effect, especially with padding by center embedded clauses. However, it is important to point out that Schwartz et al.'s results are in fact not necessarily problematic for every version of the trade-off hypothesis. Some of current capacity theories may well comply with Schwartz et al.'s finding. For, it can be maintained, as I said above, that the parser can work correctly within the limits of its reduction in computational resources, and conceivably, padded sentences were still within those limits in respect of the needs of a grammaticality judgement task. However, it is not unfeasible to construct a trade-off theory which could fully accommodate, what's more: predict, the assumedly missing syntactic complexity effect. For, a long (padded) sentence does not necessarily impose higher requirements on the working memory of the parser in every possible model in which the parser is deficient. This is possible because in padded cases the capacity taken up at a time by the elements and structure to be stored for short term (computation) is not by all means greater than in short sentences. This idea can be traced in Abney and Johnson (1995) (whose theory is not in fact a model of agrammatism) in simple and mechanical terms. We cannot go into details here, but refer the reader to their work.

is fed to the computational system along with the predicate itself. Note again that this is only information about the properties of the lexical item, in fact part of the lexical element itself. Interpretation of the thematic relation between syntactic arguments and syntactic predicates takes place at LF (Logical Form) in Government and Binding theory, and has nothing to do with the theta grid. According to some analyses, the structural position of the arguments in the hierarchical VP is dependent on the rank of their thematic role in the thematic hierarchy, i.e. VP structure is predictable from the thematic roles and *vica versa*, without any further information provided.

As in case of *in-situ* arguments there is no coindexation, there should be no impairment of semantic interpretation of thematic roles - under the new formulation of the deficiency. However, in case of moved arguments there is coindexation of the argument and its trace at S-structure. The impaired semantic processing of this coindexation results in an inability to interpret moved arguments thematically. However, in all variants of the theory there is a linear order principle, or rather heuristics, which helps comprehension. This is the above-mentioned transparency, or canonical mapping. This explains that not in all argument movement patterns, only in non-transparent ones, does comprehension break down.

Now this theory is clearly challenged by significant puzzles. First, as we have seen above, Hungarian has a non-configurational VP, and arguments can land in pre-verbal operator positions in any order (under certain restrictions). Under such circumstances it is difficult to see how transparency versus non-transparency can be interpreted. It seems that Linebarger's prediction for Hungarian is that transparency cannot aid interpretation, that is, it should be considerably difficult to interpret a sentence which involves movement, i.e. coindexation. Another entailment of the theory is that if all arguments stay *in situ* behind the verb and there is no other syntactic coindexation either, then comprehension (as well as syntactic processing) should be faultless. In fact neither of these predictions is warranted by a bulk of unpublished Hungarian data (Zoltán Bánréti, personal communication) as well as my own clinical experience with Hungarian aphasics.

There are two more theoretical shortcomings this theory strongly appears to suffer from. One concerns the fundamental claim, namely that patients cannot exploit semantic consequences of syntactic coindexation. If there is no *a posteriori* difference between this position and one according to which coindexation is

erased (or any other synonymic expression could be used here expressing unavailability) at the semantic interface level, LF; i.e. if there is no *empirical* way to distinguish the hypothesis which says 'coindexation exists, it is only unexploitable' and the one which says 'coindexation itself is not available/erased', then in an equivalent formulation, Linebarger's theory maintains that coindexation is present at S-structure, but is erased at LF, the interface level with the cognitive systems. Now this view is presented with at least two main puzzles. One is that given that indices are erased at LF, principles governing some aspects of coindexation operating at LF will be too strong in terms of their consequences. ECP and Binding Theory are two cases in point: they would syntactically exclude many more structures than desirable.<sup>6</sup> For illustration, consider any structure which standardly involves a trace. Now ECP is a condition on traces (non-pronominal empty categories), it severely restricts the appearance of such empty elements. But if coindexation is unavailable, then besides the problem of interpretation, there is a fatal violation of ECP in configurations where antecedent-government would need to apply, since antecedent-government is a relation between *coindexed* elements. In case of binding, it is easy to see that Principle A could never be satisfied by an anaphoric element, and Principles B and C would apply totally vacuously: there would be no structure they could potentially exclude, for every element would be unbound, given the lack of indices. This leads us to conclude that we must content ourselves with the *theory-internal* reason for believing that indices exist at LF, they are only invisible to the cognitive performance systems interpreting the interface representation. But this means that indices (which were originally employed with a clear view to interpretative cognitive sphere) are only relevant to the abstract system of grammar, but not to the performance systems. However, the serious conceptual problem here is that anything in the grammar is visible to scientific investigation only as far as it is relevant to grammar-external systems of the mind/brain. Now we have arrived at an antagonistic picture where on the one hand we cannot have evidence for the existence of indices in the grammar of Broca, but on the other

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<sup>6</sup>Both ECP and BT are assumed to be principles operating at LF. In fact, some ECP effects have actually been used as diagnostics for the existence of the level of LF. As for Binding Theory, LF reconstruction effects have long been observed in the literature (e.g. Aoun and Li (1989), Brody (1993)), and Chomsky (1993) argues extensively in favour of a BT which applies solely at LF.

hand we are forced not to abandon indices for purely theory-internal reasons.

The other difficulty for the index-unavailability view is produced by the recent development in the Government and Binding tradition, namely the Minimalist Program (Chomsky 1993, 1994, 1995b). For, if this theory of syntax is correct, e.g. binding no longer needs indices to apply at all: it will simply become an interpretative principle (Chomsky 1995a: 211). Then the picture of agrammatics' state of the language faculty cannot seriously be maintained, given the shift towards abandoning the use of indices in the theory.

A further problem with Linebarger's theory is a conceptual one. Namely, the implication that the judgement of the grammaticality of coindexed pronouns, anaphors, or question tags, pro-forms (e.g. as in *...and so does John*), etc. is a matter for interpretation, that is, a *semantic* exploitation of coindexation is required. Now this view is completely off standard assumptions, for making grammaticality judgements about structures involving such coindexed elements can be done purely on a syntactic basis. This is because all coindexed elements must share some of their features: traces share all their features with their antecedents (except for phonological ones), anaphors, pronouns, question tags, etc. share their grammatical features, for example person, number, gender or tense. Clearly, these are all purely syntactic features, and accordingly mismatches are syntactic violations. This is most conspicuous in the case of grammatical gender (e.g. in a language such as German), which cannot be interpreted by semantics in any way. But if such agreement is of a syntactic nature, then it is entirely mysterious under Linebarger's line of argumentation why their grammaticality judgement is impaired.

A study by Haarman and Kolk (1994) is also relevant here. The authors demonstrated in an *on-line* word monitoring test that Broca's aphasics are sensitive to ungrammatical agreement in certain environments. Crucially, this *on-line* word monitoring task did not involve semantic processing, only a fast syntactic analysis. This piece of evidence goes against Linebarger's assumption that it is *post-syntactic* exploitation of indexation which is damaged.

It is apparent that the Mapping Hypothesis has serious theoretical flaws, and it also runs into problems in case of Hungarian. Now let us look at this theory from the perspective of our empirical findings. In fact, our data turn out to be rather unexpected under Linebarger's framework. For we spotted various

types of alterations of the syntactic structure where coindexation is heavily involved, and without any apparent reason, or in some cases expressly going against the predictions Linebarger makes. We saw a set of responses involving extra movement to topic position. Now these examples are surprising because extra movement means extra coindexation which the patient cannot semantically exploit. Another pattern is the case of changed topic, which is once again difficult to explain given that it entails the same amount of coindexation in the structure. Why does the subject actively alter the input sentence in 74% of the cases where a topic was affected to create an equally, or in 63% of the instances, more complicated structure than the target string?

#### 4.1.2 The Trace-deletion accounts

We will move on to the next family of theories, the Trace-deletion account (Grodzinsky (1986), Grodzinsky (1990), revised Trace-deletion Hypothesis: Hickok (1992), Hickok, Canseco-Gonzales and Zurif (1993)). The crucial assumption in this framework is that the deficiency lies with the syntactic structure itself: traces are argued to be absent from the syntactic representation. Now this claim in itself can be exposed to severe criticism for the load of theoretical ramifications it entails. First, it is surprising that the grammatical system of patients is capable of creating chains containing traces, but does not tolerate traces themselves.

Second, it is difficult to see what makes traces a natural class, i.e. available as a distinct type of elements to the syntax. (This is in fact a problem for the standard ECP too, which holds of traces only. See Suranyi (1997) for some related discussion.) For traces are in fact non-pronominal empty categories, which is not really a natural class: the natural class in BT terms is pronominal categories, elements with the feature [+pronominal]. This is even more apparent under a copy theory of movement (Chomsky 1993, 1995b, Pesetsky 1996). Traces are merely phonologically different from overt elements. However, if we claimed that the system fails to license such phonologically empty elements, then we would immediately face the problem of PRO and pro: elements still tolerable for the patients' grammar.

Once again, problems arise with respect to syntactic principles applying to traces. We mentioned the preserved ECP and Binding Theory, both applying at LF, in the previous section. Binding Theory on the one hand may lose some of its coverage, and on the

other hand it may rule out more structures as ungrammatical than in healthy grammars due to the lack of traces. For illustration of the former case, consider NP-traces. By Principle A they should be bound in their Governing Category (GC). Now if they are not bound in their GC, no violation arises for aphasics, there being no (NP-)traces in the structure at all. This means that agrammatics should tolerate such BT violations, in contrast with people with a healthy grammar. An example for the latter case, i.e. when Binding Theory rules out structures unnecessarily, would be the following. Consider a raising structure such as *John seems to be pleased with himself*. Now if no traces are present in the lower clause, then Principle A gets violated by the reflexive, moreover the reflexive cannot be interpreted. However, we know that raising structures are easy for comprehension and for grammaticality judgement<sup>7</sup>: many several suggested linear order strategies rely on this fact, among others. As for ECP, it appears that in Broca it applies vacuously, i.e. without any effect, no traces being available for it to be taken care of. This means that ECP violations are predicted to be unnoticed by patients in judgement tasks. In fact neither of these two predictions seem tenable in the face of aphasics' performance.

A further shortcoming is that this model of agrammatism is far too rigid: it is not adjustable to cover degrees of impairment over individuals or over the healing process. The element trace is either permitted or is not, no other options being available. The Trace Deletion accounts once again face the problem of predicting that a sentence with only unmoved elements should prove perfectly easy for patients, contrary to data from Hungarian and also to reports of impaired performance with sentence types not containing traces at all.<sup>8</sup>

Another puzzle is produced by Grodzinsky's (1986, 1990) Default Principle, which is essentially based on the prototypical thematic role assigned to phrases appearing in subject position. In a passive sentence like *The girl was harassed by the boy* the agent theta role gets assigned to two noun phrases: one via the standard mechanism to the DP in the *by*-phrase, and the other one to *the girl* in subject position by the Default Principle. Thus a conflict is created, and correctly so, because patients have been shown to resort to guessing in the comprehension of such sentences. Over and above difficulties with the Default Principle noted by Kolk

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<sup>7</sup>In the relevant sense, at least reflexives are not more difficult to judge in a simple sentence where BT Principle A is satisfied, than in a raising structure like above.

<sup>8</sup>Some of these data come from Linebarger's studies (1989, 1990), mentioned beforehand (see section 4.1.1).

and Weijts (1996, Hungarian presents it with the same puzzle as in the case of Linebarger's theory. Namely, in Hungarian virtually any phrase can move out of the VP and these fronted phrases may appear pre-verbally in a number of orders. Significantly, there seems to be strong evidence that Hungarian does not have a subject position at all (É.Kiss 1992, 1994), there is a reiterable topic position made available by Hungarian syntax instead. Although there is a slight degree of variation in the acceptability of sentences with topics of different theta roles, this does not affect grammaticality at all:

- (14) a. Jánost elütötte a vonat  
 J.-acc(PAT) over-run-3sg the train  
 'John was hit by the train'
- b. Péterrel szeretek kirándulni menni  
 P.-with(INS) love-1sg hike-inf go-inf  
 'I love going hiking with Peter'
- c. A könyvet TEGNAP olvastam ki  
 the book-acc(THEME) yesterday read out  
 'It was yesterday that I finished reading the book'

This means that no Default Principle can apply in Hungarian. This may well undermine Grodzinsky's theory, where the Default Principle is indispensable to derive the desired effects.

Now under the assumptions of the Revised Trace Deletion theory (Hickok (1992), Hickok, Canseco-Gonzales and Zurif (1993)), the Default Principle is not needed. Instead, a simple heuristics is supposed to apply which in case of one movement chain is able to recreate the lost dependency. Now this approach consists of the assumption of the deletion of traces from the structure and that of the VP-internal subject hypothesis (e.g. Sportiche (1988), Koopman and Sportiche (1991)). Under this hypothesis the subject originates internal to the VP and raises to a VP-external position at SpellOut (at least in English). Now if there is another movement besides the extraction of the subject, then we have two deleted traces, in which case the heuristics referred to above cannot apply. This makes correct predictions about double movement constructions: these prove difficult in comprehension tasks. However, as we have mentioned already, Hungarian VP has an essentially flat structure according to É.Kiss (1992, 1994), which cuts the ground even from under the Revised version of the Trace

Deletion hypothesis. It seems this group of theories do not square very well with the structure of the Hungarian sentence.

Let us turn our attention to the empirical facts we found. As movement to topic position creates extra deleted traces, it is unexpected that such extra movement should occur so heavily. Also, changed topic responses are totally unmotivated by the system. It appears that much of what we uncovered is left unexplained under the either variant of the Trace Deletion hypothesis.

#### 4.1.3 The coindexation hypothesis

The coindexation hypothesis is in fact an akin influential theory of Broca (Maurer, Fromkin and Cornell (1993)), which holds that the so-called Coindexation Condition, which would ensure correct coindexation of movement or non-movement chain links is inoperative in aphasics' syntax. This forces patients to entertain all the possible coindexations in a given structure. An extra assumption is that aphasics actively avoid deviant semantic interpretations. One more thing to be added to this set of hypotheses is that the subject is generated VP-internally. Thus in a sentence like *the girl that the boy was smiling at was fat* we have two available coindexation patterns:

- (15) a. the girl<sub>i</sub> that the boy<sub>j</sub> was t<sub>j</sub> smiling at t<sub>i</sub> was fat
- b. the girl<sub>i</sub> that the boy<sub>j</sub> was t<sub>i</sub> smiling at t<sub>j</sub> was fat

(15a) is the correct coindexation and (15b) is the wrong pattern: (15b) entails that it is the girl who was smiling at the boy. Other indexations would result in uninterpretability, therefore are ruled out. These two coindexation patterns give rise in this type of sentences to the ambiguity observed in comprehension tasks. Now in subject relatives the same heuristics is at work, discarding all other indexations except for (16):

- (16) the girl<sub>i</sub> that t<sub>i</sub> is t<sub>i</sub> smiling at the boy is fat

So this correctly predicts that object relatives are difficult to interpret, while subject relatives are relatively easy; or more generally a single movement does not significantly influence comprehension performance, while two or more movements present more difficult tasks.

As the lack of the coindexation condition potentially gives rise to ambiguity only, there is no interference with



grammaticality, consequently the preservation of grammaticality judgement in Broca is correctly predicted. This means that when a sentence like \**John hit* is given up for grammaticality judgement, the patient straightforwardly rejects it for reasons of uninterpretability. In case of a simple active sentence, or a subject relative, there is only one available coindexation, as we have shown above, and since apart from the coindexation condition all of the grammar is preserved, patients make correct grammaticality judgements again. Grammaticality judgement is not unimpaired in all cases though. As we have referred to it above, coindexed pronouns, anaphors, question tags, pro-forms, etc. have been demonstrated to be difficult judgement tasks. This falls out neatly from the theory, for all these types involve agreement going hand in hand with coindexation. But provided a sentence does not contain the appropriate agreement - and if besides proper coindexations improper ones are also generated - then if the patient happens to select the improper coindexation, the agreement condition on the coindexed elements is inoperable (no relevant coindexed elements being involved in the structure), therefore no ungrammaticality is discernible. This means in short that impaired judgement of incorrect agreement in these sentence types is predicted by the theory. This part of the system works neatly, and even apparent objections of preserved sensitivity to subject-verb agreement (Haarmann and Kolk (1994)) can be warded off, since subject-verb agreement does not involve coindexation of the two elements: it is a simple case of specifier-head agreement.

However, the picture is not so nice as it seems. Mauner et al. derived preserved grammaticality judgement for thematic dependencies by relying on (un)interpretability and the assumedly faultless state of the grammar apart from the coindexation condition. That is, some coindexations were excluded by patients on semantic grounds. This predicts that in case all possible coindexations are rejected for interpretational reasons, then if such a sentence is presented in a judgement task, patients will make the correct grammaticality judgement that the sentence is bad. However, there is data which suggests exactly the opposite. Bánréti (1994) observes that judgement of sentential intertwining is strongly impaired. (17a) illustrates a well-formed case of sentential intertwining, (17b) contains the ungrammatical counterpart applied in the tests.

(17) a. Mari a könyvet mondta hogy megveszi Jánosnak  
 M.-nom the book-acc say-past-3sg that buy-3sg J.-dat  
 'As for Mary, it was the book that she said  
 she would buy (it) for John.'

b. \*Mari a könyvet mondta  
 M.-nom the book-acc say-past-3sg  
 hogy a kabátot megveszi Jánosnak  
 that the coat-acc buy-3sg J.-dat  
 'As for Mary, it was the book that she said  
 she would buy the coat for John.'

In the deviant example another argument is inserted in place of the raised one. Now in such a sentence, no coindexation yields an interpretable structure, nevertheless patients show strongly impaired judgement results with the ungrammatical test sentences. Such a pattern is apparently unwarranted by Mauner et al.'s theory.

Now it also follows from this system that a logically possible coindexation can be ruled out not only on semantic, but also on syntactic grounds, i.e. by the application of some independent syntactic principle, which under Mauner et al.'s assumptions must be preserved in the grammar in Broca. This means that patients rule out semantically or syntactically ill-formed coindexations and consider only those patterns that are left. This predicts that if all possible indexations have been excluded for interpretational and syntactic reasons, then the sentence will be straightforwardly turned down by patients as ungrammatical. It turns out however that this is not true either. Bánréti (1995) reports impaired judgement with ungrammatical test sentences containing reflexive and reciprocal anaphors. (18) and (19) illustrate the two cases:

(18) a. A vezető látta önmagát a tükörben  
 the driver-nom see-past-3sg himself-acc the mirror-in  
 'The driver saw himself in the mirror.'

b. \*Önmaga látta a vezetőt a tükörben  
 himself-nom see-past-3sg the driver-acc the mirror-in  
 'Himself saw the driver in the mirror.'

(19) a. A férfi meg a nő  
 the man-nom and the woman-nom  
 beszélgetett egymással  
 talk-past-3sg each other-with  
 'The man and the woman talked to each other.'

b. \*A nő beszélgetett egymással  
 the woman-nom talk-past-3sg each other-with  
 'The woman talked to each other.'

In both of the ungrammatical cases there are two possibilities. Either the assumed antecedent is coindexed with the anaphor or it bears a different index. In (18b) in either case Principle A of the Binding Theory is violated, the anaphor not being bound. In (19a), if there is proper coindexation, then presumably the structure is uninterpretable, and if the two elements have different indices, then again Principle A gets dissatisfied. Thus, in both (18) and (19) there is no available indexation, which should drive patients to make the correct judgement, namely that these structures are ungrammatical. However, data reveals just the contrary: the judgement of the unacceptable counterparts is among the difficult tasks. This type of findings points in the direct opposite of Mauner et al.'s predictions.

In this light, data of the authors themselves become suspicious. Consider (15), repeated here with the replacement of the empty operator by an overt wh-element as (20):

(20) a. the girl<sub>i</sub> who<sub>i</sub> the boy<sub>j</sub> was t<sub>j</sub> smiling at t<sub>i</sub> was fat  
 b. the girl<sub>i</sub> who<sub>i</sub> the boy<sub>j</sub> was t<sub>i</sub> smiling at t<sub>j</sub> was fat

Now by the same token as we have argued just above, patients should be able to exclude indexations which are in violation of some preserved syntactic principle. In fact, there are at least two relevant syntactic considerations to make which would aptly rule out (20b). One is (some equivalent of) Pesetsky's Nested Dependency condition, which demands that movement chains should be nested rather than crossing (e.g. Pesetsky (1987)).<sup>9</sup> Another consideration is that the chain of *the boy* in (20b) is Case-marked at two links, which is not normally allowed for. (One formulation to rule this out is economy, Chomsky (1991, 1993, 1995b).) Or,

<sup>9</sup>Pattern (i) shows nested, (ii) shows crossing dependency:

(i) X<sub>i</sub> ... Y<sub>k</sub> ... t<sub>k</sub> ... t<sub>i</sub>  
 (ii) X<sub>i</sub> ... Y<sub>k</sub> ... t<sub>i</sub> ... t<sub>k</sub>

from another perspective, the movement chain of the *wh*-phrase *who* fails to get Case-assigned at any link, in violation of any equivalent of the Case Filter. In short, (20b) entails strong violations of assumedly preserved syntactic principles, therefore it should be rejected in comprehension tasks. This would leave (20a) only, in effect eliminating the desired ambiguity.

It appears that the coindexation hypothesis faces serious difficulties if its repercussions are followed consistently. Turning the theory to Hungarian, its prediction is that more than one phrase moved to a pre-verbal operator position is detrimental for comprehension performance, while with only one or no such raised constituent comprehension is intact. Now, neither of these two entailments are confirmed by data from comprehension tests with Hungarian aphasics (Zoltán Bánréti, personal communication). Our repetition test too features counterexamples, illustrated in (21):

(21) E: *Lassan csöpögött a csap.*

slowly drip-past-3sg the tap

'The tap was dripping slowly.'

[<sub>VP</sub> *lassan* [<sub>VP</sub> *csöpögött a csap*]]

P: *Csapo csapan csapom csap na. Csappan.*

(nonsense words phonologically related to *csap* 'tap')

There are no coindexations in the structure, repetition still breaks down, curiously.

Much of our findings, as with previously discussed theories, are again difficult to motivate under the coindexation hypothesis. It is not easy to see why extra topicalisation is so frequent, given that it creates extra coindexation. It is true that it does not occur in our corpus that the extra movement creates two coindexations, which would be categorically unexpected under Mauner et al.'s system, but in fact target sentences were such that this configuration could possibly arise in only 4 responses out of the total of 120 eliciting tasks. Further research is needed to investigate this possibility. However, it is still curious that without any apparent motivation in the theory, patients create extra movement chains, or occasionally (in 11% of those responses where the topic field was modified) a different phrase is moved to topic position.

We have demonstrated that none of the theories that assume some aspect of the grammar to be deficient in Broca cope very well with the observations we made. Moreover, they all have difficulty in

treating a language like Hungarian, which has a different structure to languages investigated thus far. Also, these approaches have some serious theoretical flaws, surfacing as incorrect predictions for empirical facts.

As we have said, these theories seem to concentrate heavily on a small set of data, and lack a straightforward explanation of facts such as in (i) to (iv) above, which point to some kind of capacity limitation. Recall that these approaches propose that the deficiency lies with some aspect of grammar. Hence, the only solution to describe such capacity-related phenomena in these frameworks would seem to be to state that besides the supposed grammatical deficit there exists an independent performance deficit. (In fact, it appears that something very close to this is what theoreticians belonging to this group actually resort to, at least at the level of implications.) It is an inescapable fact, however, that given that we are forced to assume a performance limitation anyway, it is a more *minimal*, and hence more favourable theory which is able to deduce all facts of agrammatism from this sole fundamental hypothesis, and does not need to make other independent basic assumptions. This consideration points to an unacknowledged, nevertheless extremely significant theoretical advantage of the performance frameworks.

#### 4.1.4 Functional structure theories

Proposals made by Friedman and Grodzinsky (1997) and Hagiwara (1995) may also be considered as belonging to the grammar-based approaches, although they have implicit implications which would classify them among capacity theories. It is due to this paradoxical situation that we discuss them as being at the periphery of competence frameworks. The authors, building on a recent model of functional structure, claim that the difficulty level of a sentence is contingent on the functional structure it involves. For, they show that the higher a functional projection is located in the hierarchical functional structure, the more problematic its processing becomes for agrammatics. Now an important note here concerns our finding that there is a marked tendency to change word order of the input string in the responses creating extra topic phrases (TP). TPs are positioned at the left-periphery of the sentence, being hierarchically higher than Agr<sub>3</sub>P (corresponding to IP in earlier theories of clause structure). Now the proportion of extra topicalisation operation in the responses

is definitely contrary to the predictions of this type of framework.

## 4.2 Capacity reduction theories

### 4.2.1 Working memory capacity

We are turning now to the capacity limitation approaches. There are a number of versions within this group as well. According to Just and Carpenter (1992), Carpenter, Miyake and Just (1994, 1995) the limitation lies in the working memory. This theory is an instantiation of the trade-off hypothesis (Linebarger, Schwartz and Saffran (1983)), which holds that in agrammatism there is a reduction in computational resources, which syntactic and semantic processing share at the expense of one another.

This framework is able to capture the damaging effect of argument movement on comprehension by assuming it to be a computational load factor, not an uncommon assumption (cf. e.g. Caplan and Hildebrandt (1988), Frazier and Friederici (1991), Haarman and Kolk (1991)). However, things may not be as simple as that. Consider for example (15) and (16) above. The object relative (15) proved significantly more difficult to interpret than the subject relative (16), but the question is whether the difference in movement chains in the two sentences is correspondingly significant: (15) contains only one more coindexed element than (16), for (15) contains 4 such elements, while (16) contains 3.<sup>10</sup>

Once again, this theory faces the same problem with tag questions, coindexed pronouns, anaphors and pro-forms as Linebarger's revised approach: it needs to be accepted that such constructions require semantic processing, and then by the trade-off hypothesis syntactic plus semantic processing can exceed computational resources. However, we have argued that this assumption is completely unwarranted as far as syntactic theory is concerned (cf. section 4.1.1), thus under this approach we have no valid explanation for the impaired judgement of such sentence types.

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<sup>10</sup>This includes the invisible relative operator in SpecCP - in fact the same would be true with overt wh-phrases in SpecCP. The head noun *girl* is not considered here, as its coindexation is one of predication - nevertheless it would render the difference between the number of coindexed elements relatively even more minimal (5 and 4) if we counted the head of the relative as well.

Significantly, this approach, in contrast with all the theories discussed so far, is capable of accounting for syntactic complexity effects described in the literature (Grossmann and Haberman (1982), Gorrell and Tuller (1989), Haarmann and Kolk (1991), Haarmann and Kolk (1994), Kolk and Weijts (1996).

As for Hungarian, proponents of the theory would predict that the more preposing movement a sentence involves (other variables being unchanged) the more difficult it will prove for aphasics to comprehend. To my knowledge, the only relatable piece of research in the literature on Hungarian is in Bánréti (1996), who finds in a grammaticality judgement task that when all three arguments are fronted to topic position subjects are insensitive to grammaticality violations on the leftmost constituent. In the present context this can be explained by the extent of the computational load the three movement chains impose on the parser. There is no published research into Hungarian at present which could possibly be contrasted with Carpenter, Miyake and Just's claims.

Turning to our findings in the repetition test, again it seems curious that extra movement should occur so heavily, given that it is supposed to increase computational burden. Changed topic sentences are without any apparent explanation as well.

#### **4.2.2 Parsing work space**

##### **4.2.2.1 A model**

Caplan and his colleagues have extensively argued that the limitation underlying agrammatic performance is related specifically to the parsing process, i.e. the syntactic computation (Caplan, Baker and Dehaut (1985), Caplan and Hildebrandt (1988), Rochon, Waters and Caplan (1994)). Now this enables the theory to readily account for the difficulty of the comprehension of moved argument sentences: as movement chains lead to a greater demand on the parsing work space, processing of such sentences may result in work space overflow. As the sentence could not be properly processed syntactically, comprehension will also be impaired. However, it would incorrectly follow that the same sentences should be difficult judgement tasks, which is not necessarily true. Caplan and Hildebrandt (1988) ward this off by resorting to non-syntactic knowledge of aphasics: e.g. if there are more theta roles to be assigned than available DPs, then the sentence is ungrammatical. Yet, as Kolk and Weijts (1996) point

out, there are a substantial number of cases where even this consideration fails to apply (cf. Linebarger (1989)).

Once again, this framework is potentially able to account for the observed syntactic complexity effect.

Recall the judgement data from Hungarian mentioned in the previous section (4.2.2). This piece of observation is neatly explained by this syntactic working space limitation approach: all we need to say is that the three movements presented the parser with too much computational load. It is interesting to ask, however - though we do not know the answer - whether patients in this judgement task actually successfully comprehended the test sentences with three fronted arguments. If so, then this would argue against the working memory capacity limitation view, because in this theory if comprehension is unproblematic, then this means that syntactic processing was successful as well. This is because comprehension builds on results of syntactic computation, and shares resources with it. Now if three fronted argument sentences were comprehended by patients, then syntactic processing must have been successful too. But judgement data obviously show exactly the opposite. This short discussion indicates that there are empirical ways to differentiate the working memory capacity view and Caplan et al.'s approach.

Again, results of our repetition test pose the same problems for this theory as for the previous one (cf. section 4.2.1).

#### **4.2.2.2 Parsing strategies**

Abney and Johnson (1991) give an explicit and detailed analysis of various parsing strategies, and confronted them with the finding that center-embedding proves difficult to comprehend (e.g. Chomsky and Miller (1963), Caplan and Hildebrandt (1988: 256)). They maintain in accord with standard assumptions that center-embedding is likely to induce stack overflow, i.e. it requires more computational memory than is available. The authors argue that it is the so-called *left-corner* strategy which is able to simulate relative easiness of left- and right-branching structures compared to the difficult to parse center-embedded structures.

Importantly, their theory is not one of aphasia, but it could easily be adapted to yield a competitive and interesting capacity approach. However a too direct adaptation would not do: although this model correctly captures the difference in performance between left/right-branching and center-embedded structures (i.e. some aspect of the syntactic complexity effect), it fails to



predict a number of facts in its present form. In fact, it leaves unexplained most of the observations discussed above (among them argument movement, other coindexed structures, Bánréti's 'all 3 arguments precede the verb' condition) as it is specially designed to account for center-embedding only. Furthermore, it is unable to deal with the found manipulations with the input string in the responses in our repetition task.

#### 4.2.3 Temporal limitations

##### 4.2.3.1 Slowed down syntactic processing

###### 4.2.3.1.1 'Slowed-down lexical activation only' hypothesis

A group of theories assume some kind of temporal deficiency to be at play in Broca. According to Zurif, Swinney, Prather, Solomon and Bushell (1993) it is lexical activation that is slowed down in agrammatism, which in turn disrupts syntactic processing. They can potentially explain impaired comprehension with some moved argument sentences by assuming, as they show in their priming task, that patients are unable to reactivate the moved constituent in trace positions. However, it remains to be asked why only *some* moved argument sentences pose difficulty, but not others? Further, they offer no ready explanation for damaged judgement performance in case of coindexed anaphors, pronouns, pro-forms and question tags. Given that judgement is an *off-line* task, reactivation, although slow, will eventually be reached. Another problematic issue with pro-forms and question tags is that they involve closed class elements, which are commonly associated with fast, automatic availability or at least are accessed from a different module or generated differently in the system (as opposed to open class items) (Garrett (1975, 1980) Bradley (1978), Bradley et al. (1980), Stremberger (1984, 1985), Saffran (1985), Saffran and Martin (1988), Zuriff, Swinney and Garrett (1990), Bánréti (1995), Cornell (1995), Kolk (1995), Biassou et al. (1997)). Thus taking them on a par with open class elements with slowed down activation would be somewhat against standard assumptions (held by some of the authors themselves).

The approach does not readily explain the syntactic complexity effect, because delay is a function of *lexical* activation not the complexity of the structure.

For simple moved argument sentences in Hungarian the prediction is preserved judgement, as there is time in the off-line judgement

task for elements to be reactivated in sentence-final (VP-internal) trace positions. Again, a bulk of unpublished Hungarian research does not confirm this prediction. As far as published research is concerned, by the same token the finding we have referred to above - namely that when in Hungarian all three arguments are raised to topic position, sensitivity to grammaticality violations on the first argument is significantly reduced - is curious enough, since there is time for reactivation to take place, and if there is no other deficiency, judgement should again be unimpaired. Other conditions in the same off-line judgement task are also unexplained in the same light: Bánrėti's (1995) 'pro-subject', 'sentential intertwining', 'VP-anaphora', 'Gapping', 'agreement between a relative pronoun and its head', 'aspect', 'selectional restrictions', 'unfocusable sentence adverbial in focus' conditions are among the hard tasks, all unaccounted for by 'slowed-down lexical (re-)activation only' theory.<sup>11</sup>

Turning to data derived from our repetition test, it is once again difficult to reason in this approach why extra movement, or changed topics are recurrent. It is true that given that repetition is again an off-line task, i.e. there is time for the reactivation for the moved element, however no motivation whatsoever is detectable for this striking pattern in the responses.

#### 4.2.3.1.2 Delay in early structuring

Friederici and Frazier (1992) propose that in Broca there is a certain temporal delay in the process of what they term as early structuring, referred to in other works as first-pass parse. Now this short delay may be detrimental, because structuring of information aids short term retention (Miller (1957)), and the lack of such structuring for 200-250 ms can result in a decay of the input string from memory.

Now this seems a very simple theory of Broca, but it may be just too simplistic to capture facts. First, as pointed out by Kolk and Weijs (1996), grammaticality judgement is predicted to be as seriously impaired as comprehension, contrary to fact. Second, one is not able to differentiate input strings on the basis of their syntactic complexity in any sense of the term: before early structuring takes place, input is only an unanalysed string; if it is long it (or some part of it) may be argued to

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<sup>11</sup>We cannot give examples here; see Bánrėti's (1995) paper for the details.

pass away from memory more easily (though this does not directly follow from Friederici and Frazier's basic assumption of a delay), but its internal complexity is simply invisible for the parser. Thus, moved argument sentences, and their various subtypes cannot be isolated either, etc. Facts of Hungarian discussed above once again have no clear explanation.

The reason for the alternations of the syntactic structure in our repetition test is also rather obscure. If the input string is eventually structured and parsed, then why does the patient need to adjust the structure in the repetition?

#### **4.2.3.2 Slowed down syntactic processing / fast decay**

##### **4.2.3.2.1 Synchron**

Haarman and Kolk (1991) devised a computer simulation model of Broca's aphasia, named SYNCHRON. Their crucial assumption is that computational synchrony is required for the proper build-up of a syntactic node: for a node to be created (going in a bottom-up direction) all its daughter nodes have to be simultaneously available in memory, i.e. should minimally have a critical activation level (Kolk (1995)). This synchrony is unimpaired in normals, though very complex structures may be disrupting. There are two factors either of which can be damaging to simultaneity in the structure: one is slowed down syntactic computation, which results in the delay of retrieval of syntactic elements; the other is fast decay of syntactic information. A stipulation is that either one or the other applies, it cannot be the case that both deficiencies are present at the same time.

Now this picture can account for impaired comprehension versus (partially) preserved grammaticality judgement by supposing that comprehension necessitates a longer availability of nodes in memory than judgement. The effect of argument movement is explained by the assumption that the moved element and the trace should be simultaneously active at the point when thematic role assignment is checked (i.e. at LF). Analogously, other types of coindexations impose the same requirement. Although the essentials of the argument are clear, not much of the details has been worked out. Moreover, the prediction is that all operations/conditions on dependency chains that apply at LF would be as seriously impaired as theta role assignment, as nodes need to be simultaneously in memory for successful satisfaction of principles. In fact, nothing is said about this entailment of the theory. An alternative

formulation of the treatment of the types of tasks which require semantic processing would be to make a distinction in the following terms: the watershed is between syntactic operations in the broad sense (including LF) on the one hand, and semantic interpretation by cognitive performance systems on the other. Thus here we differentiate between the central competence system (syntax) and one of the performance systems (the cognitive/conceptual system) which interprets the output of the competence system.<sup>12</sup> This way the above complication can be avoided.

However, even under this new formulation, we have the same problem with coindexed anaphors, question tags, pro-forms, etc. (cf. Linebarger (1989, 1990)), as in Linebarger's theory (see section 4.1.1). Namely, these conditions involve essentially syntactic violations, which are predicted to be easier than judgement tasks requiring semantic processing in the present theory. To still give an account for why they are relatively difficult to judge, we shall look at data presented by Bánrėti (1994, 1995, 1996).

In a series of judgement tests with six Broca's aphasics focusing on a wide variety of conditions, a more or less clear division of the conditions was derived. Easy tasks included 'anaphoric agreement in person and number', 'case endings' and 'V-anaphora' conditions. It is to be noted here that out of these, the easiness of the 'V-anaphora' condition is somewhat of a surprise, given on the one hand standard results in the literature with the same structures (cf. Linebarger 1989, 1990), and on the other a rather similar condition, which came out as a difficult one in the tests in the same study ('VP-anaphora', Bánrėti (1995: 27, 1996)). Difficult tasks included 'agreement between a relative pronoun and its head', 'agreement of reciprocal anaphora', 'all 3 arguments precede the verb', 'anaphora + case hierarchy', 'aspect', 'gapping', 'pro-subject', 'selectional restrictions', 'sentential intertwining', 'unfocusable sentence-adverbial in focus', and 'VP-anaphora'. (We will not illustrate these conditions here, the reader is referred to the papers themselves.) Out of the difficult tasks, 'agreement of reciprocal anaphora', 'all 3 arguments precede the verb' and 'unfocusable sentence-adverbial in focus' belong to the class of *systematically*

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<sup>12</sup>If this picture is correct, then Caplan and Hildebrandt's (1988) observation that patients can easily detect the absence/excess of thematic elements could be translated into our terms as a violation of the *syntactic* principle of the Theta Criterion, applying at LF.

*misjudged* sentence types, the others constituting the *guessing* tasks.

We propose the following explanation for the obtained pattern. Easy tasks involve purely local syntactic violations, which in Haarman and Kolk (1991) and Kolk's (1995) model are correctly predicted to require low effort from the parser, because they require activity of syntactic information only during syntactic processing, and the requirement of synchrony is again simple to meet, relations in question being strictly local. Let us illustrate 'anaphoric agreement in person and number' to show that even this condition involves strictly local relations:

- (22) \*A gyerek látta magadat a tükörben.  
the child-nom see-past-3sg yourself-acc the mirror-in  
'\*The child saw yourself in the mirror.'

Clearly, there is a mismatch between agreement features of the verb and its sister, the reflexive pronoun. The other sentence type, labelled 'argument + case ending' also involves strictly local syntactic relations.

- (23) a. \*A gyerek ül a szék.  
the child-nom sit-pres-3sg the chair  
'\*The child is sitting the chair.'  
b. \*A papára kölcsönadott a fiú egy könyvet.  
the daddy-on lend-past-3sg the boy a book-acc  
'\*The boy lent a book onto daddy.'

(23a) features unfulfilled syntactic selection within V', i.e. an offending dissatisfaction of the verb's syntactic selectional requirements imposed on its sister argument. Type (23b) is strictly local along the same lines if the patient can successfully 'reactivate' the moved argument in the sister-to-V trace position.

Tasks that resulted in guessing are those that involved either (i) some non-local syntactic violation, or (ii) a purely semantic offence<sup>13</sup> (but not both of the two). (i), is predicted to trigger

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<sup>13</sup>'Gapping', 'aspect' and 'selectional restrictions' are the tasks requiring semantic processing (the rest of the *guessing* class feature non-local syntactic violations). 'Gapping' is listed here because in this condition it is not the syntactic rules of gapping that are not obeyed, but there is a *semantic* deviance in the ungrammatical sentences. Consider (i):

- (i) \*Mari látta a kutyát, Péter meg a kutyát.  
M.-nom see-past-3sg the dog-acc P.-nom MEG the dog-acc

difficulty due to the requirement of synchrony; (ii) is predicted to cause problems for patients due to the necessity of longer availability of syntactic information in memory.

The last group of conditions, which triggered systematic misjudgement are those that necessitated *both* a synchrony between two syntactically distant elements and a longer availability for semantic processing, which jointly rendered patients insensitive to violations in these sentences. One type in this group is difficult to judge for different reasons: it demands synchrony between a topicalised phrase and its trace in a configuration where this is the leftmost element in the sentence and there are two more arguments in topic position to the left of the VP. This configuration renders it difficult for the fronted leftmost element and its trace to be available in memory simultaneously. 'Unfocusable sentence-adverbial in focus' belongs to this set because we assume that the focus position is a functional specifier which is only a landing site for movement from below. Given this, the sentence adverbial can only be base generated in adjoined position to VP, and raised from there to [Spec, FP]. Independently, sentence adverbials can be generated in this position:

- (24) [FP PÉTERT akarja [VP valószínűleg [VP a közönség]]].  
P.-acc want-pres-3pl probably the audience  
'It is Peter who the audience probably wants.'

Thus, this condition too requires that two positions be simultaneously available and that they be still available during semantic processing.

Recall that we are making this excursion to obtain an alternative account for question-tags, pro-forms, etc. which seemed to slip out of our coverage, because, as we have argued in section 4.1.1, they involve already syntactically detectable mismatches. While this is true, these sentence types are difficult (similarly to class (i) of the *guessing* group of Bánréti (1995, 1996)) because of some *non-local* syntactic violation, which is correctly predicted to be difficult by the existing model of Haarman and Kolk (1991) and Kolk (1995), on the grounds of the

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'\*Mary saw the dog, and Peter the dog.'

In this sentence there is a conjunction of two clauses with contrastive topic. Now it is precisely this semantic motive of contrast which is absent, giving rise to unacceptability. This violation is revealed only during semantic processing.

synchrony requirement. Thus we use this model in a different way from the authors themselves to derive these results, because, if the relevant argumentation in section 4.1.1 is correct, their account fails.

It should be noted that a SYNCHRON-type model strongly predicts the existence of a syntactic complexity effect.

Turning now to predictions of the theory for Hungarian, we have already seen that we are able to correctly capture the effect that if there are elements moved into a pre-verbal topic position, the sentence becomes more difficult. Indeed, although the same violation was present in the 'argument + case ending' and the 'all 3 arguments precede the verb' conditions (case-ending violations in both conditions), but in the first maximally one element was extracted, whereas in the second three phrases landed to the left of the verb: the result was 100% correct judgement in the first condition, and systematic misjudgement in the second. It can be plausibly argued that the first and second moved nominal phrases in 'all 3 arguments precede the verb' were more separated from their trace positions than in case of the 'argument + case ending' sentences (where only one DP was fronted), which broke down synchrony, thus leading to poor performance on the condition.

As the theory does not make any claims about the order of pre- or post-verbal elements, it correctly implies that their order will make no difference in the tests. Recall that both the Mapping Hypothesis and the Trace Deletion hypothesis made incorrect predictions at this point.

However, our findings in the repetition test are rather curious in the face of this theory as well. For changed topic and extra topicalisation sentences are without any available motivation in the model, just as with previous theories. Further, de-topicalisation is without an account too: since the input sentence was processed correctly, and given that the theory makes no distinction between reception and production, there is no obvious reason why the same structure could not be produced in the response.

It appears that this approach has many positive achievements compared to previous theories, nonetheless in its present form it cannot account for the pattern found in our repetition test.

#### **4.2.3.2.2 Genchron**

Cornell (1995) devised a grammatically more explicit computer model for agrammatic comprehension, named Genchron, which we will

briefly discuss. This model is based essentially on the same assumptions as Haarman and Kolk's (1991) program, namely the slowed down activation or fast syntactic decay hypothesis; however, the model was able to simulate Broca's patients' performance with one setting, which is meant to emulate fast decay of syntactic categories. This setting outputs possibly fragmented syntactic representations along the lines of Mauner, Fromkin and Cornell (1993), which according to Cornell predicts possibly fragmented comprehension. In case of fragmented parsing, Cornell's software produces a list of parsed subtrees, which (in contrast with Haarman and Kolk's theory) may help comprehension: so fragments do not necessarily mean completely damaged comprehension.

This model is clearly capable of capturing moved argument effects, as is demonstrated in the paper. It is potentially also able to simulate performance on question-tags, pro-forms, wh-phrase-relative head, etc. Syntactic complexity effects are straightforwardly captured.

Predictions for Hungarian and problems with our analysis in the repetition test are apparently identical with Synchron's.

A common merit of most of the capacity reduction approaches is that - at least implicitly - they are gradable, i.e. there is some variable or other in the model which is adjustable, simulating different degrees of severity of Broca. (This possibility is worked out in most detail in case of SYNCHRON.) Such an option for flexibility is unavailable under the grammatical deficiency hypotheses.

We have shown capacity reduction theories to be favourable on various grounds: they avoid the theoretical complications grammar-based theories often face, as well as problems caused by resorting to linear order heuristic principles; they can account for the complexity effect; and they are gradable. However, not even the slowed-down computation/ fast decay models, which we found to be the most appealing, can account for the alternations observed in the repetition test.

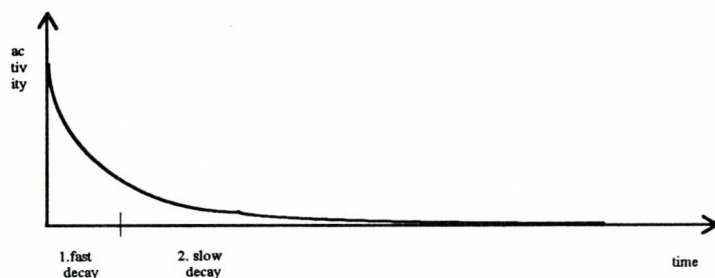
## 5 The proposal

We will go on to provide an explanation for the paradigm of findings discussed in section 3, assuming a fast decay of syntactic information from memory. Our crucial assumption will be that Broca is related to a specific pattern of fast decay: a *fast-*



slowing down decline. This pattern, as the term suggests, involves a very fast initial decline in syntactic activation level followed by a slowing rate of decay, of course in a continuum. The figure below illustrates the point:

(25)



This pattern predicts that when the patient has to reproduce a syntactic structure, it is most expedient to reproduce the constituent first which is still in phase 1 of the decline, i.e. before its activity rapidly falls below the critical level. This is apparently the last constituent to be heard. It seems an effective strategy to reproduce the last constituent first, because its availability is ensured by its high activation level, whereas the accessibility of previous constituents is less probable<sup>14</sup>, because their activation level is already in the contingent phase (phase 2) and their availability is now reducing at a slow pace, whereas the activation level of the last input constituent is dropping sharply (phase 1).

Indeed, out of the sentences which were modified in their topic fields, in the overwhelming majority (there being only 3 exceptions) the patient recited the last constituent first (see the illustrations cited in section 3), as we predicted. The three basic patterns in these reproductions, namely extra topicalisation, changed topic and de-topicalisation, can be represented as in (26) below:

- (26) a. ... V DP → DP ... V  
 b. DP<sub>topic</sub> ... V DP → DP ... V DP<sub>ex-topic</sub>  
 c. DP<sub>topic</sub>\* VP → [<sub>new-VP</sub> ex-VP DP<sub>ex-topic</sub>\*]<sup>15</sup>

<sup>14</sup>In fact, availability with respect to activation level may be expressed in terms of probability of a successful accessing, clearly a continuum. Even though this formulation is not in line with current connectionist assumptions (with the central concept of an activation threshold), it may be explored as an alternative.

<sup>15</sup>The constituent undergoing linear fronting is underlined, \* stands for 'one or more phrases'.

What happens in these cases is that the patient *linearly* fronts the last constituent, and then inserts it and the rest of the elements into a structure. In (26b) the post-verbal DP is moved to the left, then the remaining constituents are built in the structure, just as we have said. The question might be asked in connection with (26c) why is it that with some input sentences it is only a DP from within the VP that is extracted, while in other sentences it is the whole VP? Now a plausible answer is the structural simplicity of the fronted VPs: in all these cases of VP-fronting the VP was constituted by a V head without a phrasal argument.

Support for this view comes, among others, from unsuccessful repetitions. In the majority of these cases, the patient did not apply the strategy just described. (27) illustrates this:

- (27) E: Még ha nyer a lottón,  
 even if win-pres-3sg the lottery-on  
 Ödön akkor sem ad kölcsön.  
 Ö. then not-even lend-pres-3sg  
 'Even if he wins in the lottery,  
 Ödön doesn't lend (money to anyone).'
- P: Ha Ödön izét akkor akkor nyerek  
 if Ö. what's-it-acc then then win-pres-1sg  
 a lottón lottón izét izét  
 the lottery-on lottery-on what's-it-acc what's-it-acc  
 nem ké nem kap nem kap kölcsönt  
 not as(k) not get-pres-3sg not get-pres-3sg loan-acc  
 'If Ödön what's-it then then I win in the lottery lottery  
 what's-it what's-it not doesn't as(k) doesn't get  
 doesn't get any loan.'

In most of the remaining failed repetitions, the last constituent is fronted but the rest of the input structure is already faded in memory. (28) is an excellent illustration for this:

- (28) a.  
 E: Nem VASÁRNAP kirándultunk, hanem SZOMBATON.  
 not Sunday-on go-hiking-past-1pl but Saturday-on  
 'We went hiking not ON SUNDAY, but ON SATURDAY.'
- P: Szombaton ko szem szom szombat. Nem. Hogy volt?  
 Saturday-on XX Sot Sat Saturday No How be-past-3sg  
 'On Saturday XX Sot Sat Saturday. No. How did it go?'

E: Mégegyszer?  
Once-more  
Nem VASÁRNAP kirándultunk, hanem SZOMBATON.  
not Sunday-on go-hiking-past-1pl but Saturday-on  
'Once more? We went hiking not ON SUNDAY, but ON SATURDAY.'

P: Szombaton, szombaton, vasárnap az az é je  
Saturday-on Saturday-on Sunday-on the the X XX  
'On Saturday on Saturday on Sunday the the X XX'

E: És ha így mondanám?  
and if this-way say-pres-cond-1sg  
SZOMBATON kirándultunk, és nem VASÁRNAP.  
Saturday-on go-hiking-past-1pl and not Sunday-on  
'And if I said it this way?  
we went hiking not ON SATURDAY, but ON SUNDAY.'

P: Vasárnap, vasárnap.  
Sunday-on Sunday-on  
Szombaton ja igen akkor pi és  
Saturday-on oh yes then XX and  
akkor a akkor a szomszéd na.  
then the then the neighbour well  
'On Sunday on Sunday. On Saturday oh yes  
then XX and then the then the neighbour well.'

E: SZOMBATON kirándultunk, és nem VASÁRNAP.  
Saturday-on go-hiking-past-1pl and not Sunday-on  
'We went hiking ON SATURDAY, and not ON SUNDAY.'

P: ...tunk és vasárnap nem vasás vasárnap nem.  
...-past-1pl and Sunday-on not Suns Sunday-on not  
'-king and on Sunday we didn't Suns on Sunday we didn't.'

b.

E: Kivel és hol találkozol?  
with-who and where meet-pres-2sg  
'Who do you have an appointment with and where?'

P: Hogy hol találkozunk?  
that where meet-pres-1pl  
'that where do we have an appointment?'

E: Ühüm. Elejére nem emlékszik?  
'Aha. Don't you remember the beginning?'

P: Nem.  
'No.'

c.

E: Sokat dolgozik, de keveset keres.  
much-acc work-pres-3sg but little-acc earn-pres-3sg  
'He works much but he earns little.'

P: Keveset keres.  
little-acc earn-pres-3sg  
'He earns little.'

E: És mi volt az eleje? Emlékszik rá?  
'And what was the beginning? Do you remember?'

P: Ez a ... nem tudom.  
'This ... I don't know.'

Further, it is striking how frequently it occurs in the repetition of a clausal coordination that the second (short) clause comes first in the response:

(29) E: Esett az eső,  
fall-past-3sg the rain-nom  
ezért becsuktam az ablakot.  
so close-past-1sg the window-acc  
'It was raining, so I closed the window.'  
P: Becsuktam az ablakot  
close-past-1sg the window-acc  
esett a esett a eső  
fall-past-3sg the fall-past-3sg the rain-nom  
'I closed the window it was it was raining.'

This is now also explained by the fast-normal decline hypothesis.

Moreover, we are providing an account for a property of the plus topicalisation cases that has not been mentioned yet. For it virtually never occurs<sup>16</sup> that the extra topicalisation lands in a non-sentence-initial position (say behind another topic), which otherwise would be a curious fact, assuming a left-to-right structure building in the course of reproduction.<sup>17</sup>

Thus, to reiterate what we have said, we are entertaining a picture of the parser in Broca where syntactic information is handled along the lines of a compensatory strategy which preposes the linearly last constituent, which is the most prominent in memory, and then structure is constructed out of this and the remaining elements. Of course - and this is of great significance

<sup>16</sup>There is only a single exception to this.

<sup>17</sup>In case of alternations in linear order where the sentence was focussed the same regularity holds: fronting only happens to a sentence-initial position.

- all this is confined by grammar: the output structure is perfectly grammatical, and in topic-alteration cases, thematically and truth-conditionally equivalent with the target sentence.

Thus the parser makes modifications to the input string within the confines of grammar, but independently of grammar. Moreover, changed topic instances clearly mean no simplification of the structure in terms of syntax, and extra topicalisation would expressly be a case of heightened computational burden from the point of view of syntactic complexity because of the more complex structure. These considerations point to the fact that the parser, although it fully respects rules of grammar (in the broad sense), has operational principles independent of the grammar: what is more complex for the grammar may be less burden for the parser, as we have seen.

There is a further fact which supports this important finding. Note that above we referred to fronting in (26) as linear. We did so because in (26c) there is no constituent which could be highlighted as being moved from one position to another: the string dominated by the VP is *linearly* fronted; then the remaining material is built into the created structure, as usual. This points to the possibility that at some level in the processing functions of the parser, it is not (only) hierarchical structure, but (also) linear order that is relevant. This in fact should not be astonishing: speech is inevitably linear. However, we must emphasise that even though the parser may at some level carry out its operations and calculations relying on linearity, in its output it can (or in fact must) produce hierarchical structures licensed by the grammar.<sup>18</sup> Now we are entertaining a picture of the competence system which suggests that it is not especially designed for use, in fact it seems an inorganic system embedded in the organic environment of the performance systems specialised to communicate with it.<sup>19</sup>

## 6 Conclusion

Let us briefly summarise what we have found in this study. Empirical data from a repetition test with a Hungarian Broca's aphasic featured frequent modifications of the input string in the responses. Narrowing down our analysis to neutral sentences, we

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<sup>18</sup>Alternatively, data revealed and analysed here may point precisely to a non-hierarchical structure in Hungarian, or perhaps in language in general. Indeed there exist some theories of grammar that entertain non-hierarchical structures.

<sup>19</sup>This is close to ideas pursued in Chomsky (1995).

showed that there are a great number of extra topicalisations, and de-topicalisations and changed topic sentences are also recurring. We demonstrated that, in fact none of the current theories of agrammatism is capable of providing an account for the observation of this pattern.

We argued for our preference of capacity reduction approaches, and we worked in the framework of the fast decay hypothesis, which we previously showed to be the most favourable theory among capacity reduction frameworks. We narrowed the central hypothesis down to an initially fast then normal rate of decline of syntactic information. We based our explanation for our findings on this assumption, and demonstrated that given that the grammar of Hungarian allows for the above syntactic modifications without a significant alteration of the semantics of the sentence, the strategy of the human parser is to adjust the structure to approach a better chance of successful repetition.

In these terms then we argued that difficulty for the parser is not always proportional to mere syntactic complexity, as is often assumed, but is determined by independent factors as well: a grammatically more complex structure may be easier for the parser, as we have seen. We suggested that although it fully respects rules of grammar in its output, the human parser has operational principles of its own.

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