

SENTENCE PARSING IN APHASIA

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Abstract: Agrammatic Broca's aphasics can correctly judge the grammaticality of certain sentences while they are unable to produce them. We tested a total of six Hungarian Broca's aphasics. Our grammaticality judgement test covered some relevant features of Hungarian syntax and lexicon. There were three interesting cases: (A) Easy tasks: acceptable sentences were judged 100% as good, unacceptable counterparts were judged 100% as bad; (B) Guessing: where judgements were essentially random and chaotic from a statistical point of view (C) Systematic misjudgements: where acceptable sentences were judged as good with 100%, but unacceptable counterparts were judged as good with 100 % or at least close to 100%. The distribution of judgements support a time-based approach to a parser. The plausibility of an account based on asynchrony between syntactic and lexical processes is motivated.

Keywords: sentence processing, parser, syntactic and lexical processing, activation and synchronization of structure building elements, first pass parse, open class and closed class items

1. THE PROBLEM

Agrammatic Broca's aphasics can correctly judge the grammaticality of certain sentences, (Linebarger, 1995), while they are unable to produce them correctly. This has been interpreted in various ways. I intend to present some samples of Hungarian data that support a time-based approach to sentence processing.

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1.1. Some notes on a time based parser

I take notion of parser as a component of a performance model. I assume that the parser is a kind of Short-Term-Memory automaton which becomes specialized in processing of categories and features involved in grammatical representation of sentences. Under this view parser is a device which transfers information between grammatical representation and message level representation. At the message level the "what-is-to-be-said" is represented. The parser as a whole is adapted to its limited capacity. According to Kolk (1995) paper, complex message structures are "fine-tuned" to creative linguistic competence. This fine-tuning is related to the size of temporal window produced by parser for syntactic computation and syntacto-lexical integration (during a given time period).

1.2. Some notes on Hungarian

Hungarian is a more or less free phrase-order language. (Bánréti, 1994, É.Kiss-Kiefer,1994). Syntactic functions and/or thematic roles are expressed by attaching case suffixes to NPs. The possible subcategorization by verbs involves at least 17 cases expressed by surface case ending forms. Suffixes of a finite verb express number and person of subject and definiteness of direct object. Another set of suffixes indicates tense and mood.

2. SUBJECTS AND PROCEDURES

All subjects had had a cerebral vascular accident (CVA) in the left hemisphere. Patients were diagnosed as agrammatic Broca's aphasics on the basis of performance profiles on the Western Aphasia Battery (WAB) (Kertesz 1982) and in further clinical evaluations by speech-language pathologists and neurologists. All subjects were right handed. Subjects:
Age: 47, sex: female, lesion site: left fronto-temporal.
Age: 37, sex: male, lesion site: left fronto-parietal.
Age: 59, sex: male, lesion site: left insula and middle temporal gyrus.
Age: 54, sex: male, lesion site: left middle cerebral artery distribution.
Age: 47, sex: male, lesion site: left fronto-temporal.
Age: 52, sex: male, lesion site: left insula with extension into the left parietal region.
We tested a total of six Hungarian Broca's aphasics. Patients were required to judge tape-recorded sentences. The instruction was: "please tell me whether this sentence is correct or incorrect?". „As you feel, and no explanation is required". Grammatical and ungrammatical items all figured in minimal pairs in the test. Each minimal pair stood for a particular structural category. Members of a minimal pair were separated by intervening items. Six patients were given the test five times. Sentence patterns were filled with different (though equally frequent) words in each test but we did not change the sentence structures themselves. At the end we had 6x5 = 30 sets of grammaticality judgements.

3. THE MAIN EXPERIMENTAL RESULTS

Some conditions were easy and some hard. The hard conditions break into two main groups: systematic misjudgements and guessing. Table 1 shows the distribution of judgements according to particular sentence structures.

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Table 1: Patients' responses

Task	Grammatical sentences Judgement: Correct	Wrong	Ungrammatical sentences Judgement: Correct	Wrong
EASY TASKS:				
Case endings in the sentence	30	0	30	0
V-anaphora	30	0	30	0
Anaphoric agreement in person and number	30	0	30	0
HARD TASKS: SYSTEMATIC MISJUDGEMENTS				
Unfocussable sentence adverbial in focus	30	0	3	27
All 3 arguments precede the verb	30	0	2	28
Agreement of reciprocal anaphora	30	0	3	27
HARD TASKS: GUESSING				
Relative pronoun and its head	28	2	18	12
pro-Subject	16	14	17	13
VP-anaphora	20	10	14	16
Gapping	11	19	15	15
Sentential intertwining	13	17	9	21
Anaphora + case	11	19	14	16
Aspect	18	12	14	16

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An analysis of variance for correct judgements: (using BMDP statistical software).**(i)** effect of the sentence-type for correct judgements was significant ($F(13, 65) = 48.93$, $p < 0.05$), **(ii)** effect of grammaticality for correct judgements was significant ($F(1, 5) = 90.57$, $p < 0.05$) and **(iii)** effect of the interaction of sentence type and grammaticality was significant for correct judgements ($F(13, 65) = 47.42$, $p < 0.05$).

A posthoc statistical analysis of variance for correct judgements for type (Easy), (Systematic Misjudgements) and (Guessing): **(i)** effect of type E/Sy/G for correct judgement was significant ($F(2, 10) = 165.46$, $p < 0.05$), **(ii)** effect of grammaticality for correct judgement was significant ($F(1, 5) = 355.01$, $p < 0.05$), and **(iii)** interaction of type E/Sy/G and grammaticality was significant ($F(2, 10) = 221.24$, $p < 0.05$).

3.1. Examples for easy tasks

In easy conditions patients' judgements were correct for grammatical and ungrammatical sentences, alike.

Case endings in the sentence:
The acceptable version contains a grammatical configuration of surface case endings assigned by Verb to its arguments, and agreement of verbal suffixes expressing person and number of Subject and Object. The ungrammatical versions involved errors with surface case endings attached to NPs and errors with person-number suffixes of a finite Verb. In these items only one argument NP preceded the verb, the others followed it in the surface string.

Examples:

(1) a. A papá-**nak** kölcsönad**ott** a fiú egy könyv-**et** .
the father-**dat** lend- **past/3sg** the boy-**nom** a book-**acc**
'The boy lent a book to the father.'

b. * A papá-***ra** kölcsönad**ott** a fiú egy könyv-**et** .
the father-***on** lend-**past/3sg** the boy-**nom** a book-**acc**

(2) a. Róbert nézi a könyvet.
Robert-**nom** look-**3.sg**/present/def the book-**acc**
'Robert looks at the book'

b. * Te nézi a könyvet.
You-**nom** look-**3.sg**/present/def the book-**acc**

(3) a. A gyerek-**et** elküld-**te** a bolt-**ba** a mama.
the child-**acc** send-**past/3sg** the shop-**to** the mother-**nom**
'The mother sent the child to the shop.'

b. * A gyerek elküld-**te** a bolt-**ba** a mama.
the child-**nom** send-**past/3sg** the shop-to the mother-**nom**

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Anaphoric agreement in person and number: an example
Judgements are required for agreement in person and number between anaphora (himself-type) and its antecedent (content NP).

Example:
(4) a. A gyerek látta magá-**t** a tükörben.
the child-nom see-past/**3sg/def** self-**3sg/acc** the mirror-in
'The child saw himself in the mirror.'

b. * A gyerek látta maga-**d-at** a tükörben.
the child-nom see-past/**3sg/def** self-**2sg/acc** the mirror-in
'The child saw yourself in the mirror.'

V-anaphora: copying only bare V
Another example for easy conditions is task V-anaphora , that required the judgement of the category of Verb itself, whether it is an attribute predicate or an action verb.

Example:
(5) a. János magas volt és Mari is.
John tall was and Mary too
'John was tall and Mary too.'

b. * János magas volt és ezt csinálta Mari is.
John tall was and this-acc did Mary too
*'John was tall and so did Mary.'

3.2. Examples for systematic misjudgements

The hard conditions break into two main groups. The first one is the group of systematic misjudgements. In this case, acceptable sentences were judged as good with 100%, but unacceptable counterparts were judged as good with close to 100%. These tasks contain errors which cannot be detected with the help of surface case frame of the verb.

Unfocussable sentence adverbial in focus:
In these tasks the surface case ending frame is the same in the grammatical and ungrammatical sentences, alike. In Hungarian there is a distinct syntactic position for the focused constituent, accompanied by heavy stress, before the Verb. *Perhaps*-type sentence adverbial can occur in several syntactic positions, except the position of Hungarian focus. *Perhaps*-type adverbial is an unfocussable category in Hungarian syntax. If this adverbial is put into syntactic position of Hungarian focus, the sentence will be ungrammatical. Patients, however, accepted this unfocussable category in the syntactic position of focus.

Example:
Perhaps-type of unfocussable adverbials is put into the syntactic position of Hungarian focus in front of the verb. Capitals and " stand for the focus position and heavy stress.
(6) a. János talán elkésett.
'John perhaps came late.'

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b. * János "TALÁN késett el.
It is PERHAPS that John came late.

All 3 arguments precede the verb:
Other example for systematic misjudgements is task All 3 arguments precede the verb.. This condition involved errors with surface case endings. It is well known: the Verb assigns the surface case frame attached to NPs. Because, in these conditions, verb was the last syntactic constituent in surface string, the correctness of case endings assigned to NP's may be assessed without any knowledge of verb or, once verb becomes known the entire string can be recalled and case endings verified. Under these conditions patients failed to detect errors with surface case endings.

Examples:
Judgements of case endings and agreement of person and number suffixes between NPs and Verb are required. All 3 NPs precede the Verb.

(7) a. A gyerek-**et** a bolt-**ba** a mama elküld-**te**.
the child-**acc** the shop-**to** the mother-**nom** send-**past/3sg**
'The mother sent the child to the shop.'

b. * A gyerekrõl a bolt-**ba** a mama elküld-**te**.
the child-**about** the shop-to the mother-**nom** send-**past/3sg**

(8) a. A papá-**nak** a fiú egy könyv-**et** kölcsönad**ott**.
the father-**dat** the boy-**nom** a book-**acc** lend-**past/3sg**
'The boy lent a book to the father.'

b. * A papá-*__**ra**__ a fiú- egy könyv-**et** kölcsönad**ott**.
the father-***on** the boy-**nom** a book-**acc** lend-**past/3sg**

3.3. Other examples for Systematic misjudgements materials showed by Table1 (not discussed in details)

Agreement of reciprocal anaphora:
Judgements of the dependency between (each other type) reciprocal anaphora and its antecedent NP with or without co-ordinate structure. (The reciprocal requires plural or co-ordinate NP antecedent. The NP and the reciprocal are not adjacent.)

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

b. * A nô beszélgetett egymással.
the woman-nom talk-past/3sg each other-with

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3.4. Examples for Guessing

The second main group of hard conditions is Guessing : Judgements were random or chaotic. With a subtype of these tasks patients were required to judge syntactic dependencies which involved two clauses, two different verbs and dependencies between arguments of these two verbs (tasks of VP- anaphora, Gapping, Sentential intertwining, pro-Subject).

pro-Subject
In the example below the Subject is the Hungarian equivalent of ***my mother***. According to the grammatical rules of Hungarian, the overt lexical item of Subject from the first clause, can **not** be repeated in overt form in subject position of the second (subordinate) clause. A phonologically empty pronoun must be found in the position of the repeated Subject. (indicated by ***pro***). If this position is filled with the repeated Subject in overt lexical form, the whole sentence becomes ungrammatical.

Example:
pro is found in the position of repeated Subject. Judgements are required for *pro* and overt lexical material in the syntactic position of the repeated Subject:

(10) a. Anyukám azt gondolta, hogy megkapta az állást.
'My mother thought that [pro] had got the job.'
i i

b. * Anyukám azt gondolta, hogy Anyukám megkapta az állást.
* 'My mother thought that my mother had got the job.'
i i

Aspect
A different example for type Guessing is task Aspect. In the grammatical version of example below, the verb in itself denotes progressive aspect. This is compatible with the 'duration' meaning of a time adverbial in the sentence (Hungarian equivalent of ***for two days***). The ungrammatical version contains a verbal prefix which has [perfective] feature, indicating perfective aspect. This verbal prefix is Hungarian ***EL***. And there is a time adverbial with duration meaning -- ***(for two days)*** -- in the sentence, again. *[Perfective]* feature and *[duration]* feature are incompatible with each other, therefore the sentence will be ungrammatical. Patients failed to detect this feature clash.

Example:
Judgements are required for compatibility of aspect of verb and time adverbial.
(11) a. Két napon át készítette az ebédet.
for two days (she) was making the dinner-acc.
'She was making dinner for two days.'

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

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3.5 Other examples for Guessing materials showed by Table 1 (not discussed in details)

Agreement between a relative pronoun and its head:
Judgements of ... **the pot that....** versus ...* **the pot who:**
(12 a. Erzsi letette az edényt, amely nehéz volt.
Liz down put the pot-acc that heavy was.
'Liz put down the pot that was heavy.'

b. * Erzsi letette az edényt, ki nehéz volt.
Liz down put the pot-acc who heavy was.

VP anaphora:
Judgements of choice between structures like so did Liz and such was Liz.
(13 a. Péter festette a kaput és ezt csinálta Erzsi is.
Peter painted the gate-acc and this-acc did Liz too.
'Peter painted the gate and so did Liz.'

b.* Péter festette a kaput és ilyen volt Erzsi is.
Peter painted the gate-acc and such was Liz too.

Gapping:
Judgements of syntactic and lexical environment of gapped verb: if there are contrast relations between content of NPs in environment of gapped verb and NPs in environment of overt verb:
(14)a. János látott egy kutyát és Péter [ ] egy macskát.
John saw a dog-acc and Peter [ ] a cat-acc
John saw a dog and Peter a cat.'

b.* János látott egy kutyát és Péter [ ] egy kutyát.
John saw a dog-acc and Peter [ ] a dog-acc

Sentential intertwining:
Judgements are required for lexical material in the syntactic position of a trace of moved NP. The constituent THE BOOK was moved from the subordinate clause into the main clause. Its trace is marked by (trace). Capitals and " stand for heavy stress-bearing Focus position)
(15) a. Mari a KÖNYVET mondta, hogy megveszi Jánosnak.
Mary the book-acc said that (she) buys John-dat
'As for Mary, it was the book that she said she would buy (trace) for John.'
i **i**

b. * Mari a KÖNYVET mondta hogy a kabátot megveszi Jánosnak.
Mary the book-acc said that the coat-acc (she)buys John-dat.
* 'As for Mary, it was the book that she said she would buy * the coat for John.'

Anaphora + Case:
Judgements are required for case assignments to anaphora and its antecedent. Word order is free, the case assignment, however, is bound. Antecedent must be marked with a zero suffix

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for nominative and anaphora must be marked with accusative case ending. Therefore *NP-nom* and *himself-acc* are grammatical but the *NP-acc* and himself-nom are not grammatical.

(16) a. A vezetô látta önmagá-**t** a tükörben.
the driver-**nom** see-past/3sg/def self-3sg/**acc** the mirror-in
'The driver saw himself in the mirror.'

b. * a vezetô-**t** önmaga látta a tükörben.
the driver-**acc** self-**3sg/nom** see-past/3sg/def the mirror-in
* 'Himself saw the driver in the mirror'.

4. A POST-HOC ANALYSIS OF DATA

How can parser and grammatical representation of a sentence interact with each other? I suppose that patients' performance in judgements depends 1/ on the capacity of the impaired parser, and 2/ on the type of grammatical error hidden in the grammatical representation of sentence. I accept the hypothesis of a distinct first stage of sentence parsing that is called first-pass parse or initial structure building operations.

4.1. Judgements in easy conditions can be based on initial structure building operations and the first-pass parse can protect information which was analysed

The first pass parse is supposed to be a more or less phrase structure parse, sensitive only to the basic features of syntactic categories of input. Initial structure building operations process only the scheme or "gestalt" of sentence. Grammatical errors involved in our easy conditions were related to basic features of syntactic categories. Therefore judgements in easy conditions can be based on dependencies that are computed during first-pass parse, when initial structure building operations take place. According to easy tasks in our test, the crucial relations are the following: the local dependencies between the category of verb and its subcategorization frame, its surface case ending frame and tense and mood inflections.

Processes can be effected in stepwise checks on surface inflectional endings: "what it is seeking to match what in their basic features". Parser is orientated by sets of structural expectations. These dependencies are carried along as **alterations** of the **internal state** of the parser, therefore this information can be protected from temporal or memory deficit, provided that first-pass parse works. The specific semantic/pragmatic features are not available to the first pass parse.

4.2. Systematic misjudgements can be related to erasure of specific features during processing and to slowing down of parser

Some syntactic information which is not encoded in the internal state of parser, after first pass parse, is unprotected. Unprotected information decays more rapidly in aphasics than in normals. This can cause the erasure of the specific features of syntactic categories (like category of *unfocussable adverbial*) and the underspecification of features of closed class categories (like *reciprocal anaphora* or *case endings*). The erasure of specific features of

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syntactic categories and closed class categories result in an incomplete processing of sentence structure (Cornell, 1995). The grammaticality judgements can be based on partial processing. In systematic misjudgements patients made a partial analysis and were unable to detect the feature clash lurking there, when the critical features were not expressed by surface forms, rather they were "hidden" into the properties of a syntactic category. (Features of unfocussable sentence adverbial, or features of reciprocal anaphora). This can lead to a strong Yes-bias type of poor performance.

With task *All 3 arguments precede the verb,* grammatical errors were related to the configuration of case endings. Patients' performance, however, deteriorated to Yes-bias. The relevant data for judgements are relations between specific category of verb which is the last constituent and a NP which is the first constituent. The correctness of case ending attached to the first NP can be judged after the verb has processed. In other words, the correct judgement of the first NP requires the Verb and its subcategorization frame as a starting point. When the verb becomes known the entire NP string preceded the verb must be recalled and the case ending attached to first NP can be verified. In this condition patient's performance reflected the slowing down of the parser: because Verb was in the last position of the surface string, the slow parser was too late to receive its starting point: the category of Verb and its surface case ending frame. The reason why patients neglected the configuration of case endings is the lack of the safe starting point in due time. Patients' incorrect judgements reflect the fact that NPs, one by one, were correct in themselves, if they were considered independently of Verb. Patients may follow a strategy likc this. It is remarkable: patients' performance was 100 % correct in easy tasks *Case endings in the sentence* at which Verb was not the last but the second constituent in surface string.

4.3. Guessing responses reflect a sketchy and unfinished analysis of stimuli because of desynchronization of parsing modules

With Guessing conditions, subjects not only failed to detect ungrammatical features of stimulus, but also mysanalyzed fully grammatical sentences. How is it possible?
To judge these tasks, syntactic and lexical processes should have been integrated. In compound sentences, patients should have judged whether syntactic positions (like Subject, Hungarian Focus or a position of a trace of moved constituent) **and** their content word fillers were associated with each other grammatically or were not (tasks *pro-Subject, Sentential intertwining, Gapping, VP-anaphora*). Or, patients should have judged whether features of a closed class item were compatible with features of a content word when they were in distinct syntactic positions (tasks *Aspect* and *Anaphora + case*).

Impairments on accessibility of closed class morphemes create syntactic difficulties. The results in our grammaticality judgement tests are compatible with findings in Haarmann and Kolk (1994) and Kolk (1995): agrammatic aphasia may show either slow activation or fast decay but not both at the same time. The normal activation goes at the expense of fast decay and, vice versa, normal decay goes at the expense of slow activation. Applying this theory to our data we find the following. Specific features of syntactic subcategories and closed class morphemes can be activated at a normal rate, but then they decay very fast, too early form working memory; or they can be retained at a normal rate, at expense of slow activation into working memory. In the fast decay case other specific lexical information had not been

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activated yet, when needed. In the slow activation case other specific lexical information in working memory is already gone when needed.

The fast decay or slow activation of grammatical features and subfeatures causes a desynchronization in the building of syntactic structure. Syntactic slots are opened up too late or too early for content word filler; specific lexical information in working memory had not been activated yet or is already gone when needed. Therefore patients are not able to complete the analysis of stimuli, processing operations result in a merely sketchy and unfinished structure. Patients were aware of their unfinished analysis, they often made comments on it. This could lead to guessing responses on complex, non-local relations.

4.4. Summary of post-hoc analysis:

Patients were able to use of initial structure building operations involved in first pass parse for correct judgements of easy tasks. In normals first pass parse must be tightly synchronized with a second major parsing module which extracts detailed and specific features of category of arguments and predicate. But fast decay or slow activation of specific, unprotected information in working memory can cause desynchronization between processing modules. The consequences are: systematic misjudgements **or** guessing responses, depending on the type of grammatical error and the complexity of sentence to be judged.

5. A HYPOTHESIS ON THE STRUCTURE OF PARSER

Suppose the following structure-building operations. The parser produces a structural frame for all possible sentences. This syntactic frame contains categorized slots. When the configuration of surface case endings assigned by category of Verb to its complements and the configuration of other closed class items are in their active phase in working memory, they define and open up syntactic slots for content word filler. Content-words would be generated by lexicon and would be inserted into their slots in the syntactic frame.

Because, closed class items have to be integrated with their categorized slots in the syntactic frame, and open class (content) words have to be inserted into their categorized slots in the syntactic frame as well, these two kinds of integration require synchronization, synchronized activation of structure building elements in working memory for language. The slow activation or fast decay of closed class items leads to a desynchronization between syntactic slots opened up by closed class items **and** active phase of content word fillers.

We defined parser as an automaton which becomes specialized in processing of categories and features involved in grammatical representation of sentences. Under this view parser is a device which transfers information between grammatical representation and message level representation. Parser computes grammatical representations of sentences and transforms them into message level representation (at which the „what is to be said" is represented). The category and feature system is hierarchical in grammatical representation. It has various levels of sub- and sub-sub categories, from the bare category to the individual lexical item and from the closed class category to the fully specific features of that closed class item.

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Then, it is the question of capacity and synchronization how far down the hierarchy in grammatical representation, the parser goes on its search for information. The distribution of judgements into correct and incorrect judgements reflects the limitations on the **interaction** between impaired parser and grammatical representation containing a hierarchy of categories and their features..

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