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Edited by
Wayles Browne,
Miloje Despić,
Naomi Enzinna,
Simone Harmath-de Lemos,
Robin Karlin,
Draga Zec

**Serbian-speaking Broca's Aphasics:
Some Problems for Theories of Aphasia**[*]

Darinka Anđelković
University of Belgrade, RS

Helen Goodluck
University of York, UK

Maja Savić
University of Belgrade, RS

Danijela Stojanović
Government of Canada, CA

Mile Vuković
University of Belgrade, RS

1 Introduction

Damage to the left frontal lobe of the brain (Broca's area) results in a pattern in which speech is non-fluent, with omission of both bound and free grammatical morphemes. The early profile of Broca's aphasics was one in which comprehension of speech was relatively unimpaired, in contrast to individuals with damage to other areas of the brain. However, literature since the 1980s has revealed deficits in comprehension, with a

concomitant range of explanations. In this paper, we report two experiments that challenge hypotheses concerning the successes and failures Broca's patients experience.

The first hypothesis concerns the use of case marking. Serbian uses case marking to distinguish the role of noun phrases. In our first experiment, testing the comprehension of questions, we found selective deficits that indicate that case marking is to some degree impaired in Serbian-speaking Broca's patients. This runs counter to the claim of Kljajevic (2012), who asserted on the basis of a study of Croatian that case marking leads to superior performance in Croatian-speaking Broca's patients, as opposed to English-speaking patients. In this experiment, we also observe a difficulty in comprehending D(iscourse)-linked phrases (such as *koji tigra* 'which tiger'), a finding similar to those in experiments with English- and German-speaking patients (Salis and Edwards 2008, Neuhaus and Penke 2008).

The second hypothesis we tested concerned the source of the problems in comprehending D-linked phrases. Avrutin (2000, analysing data from Hickok and Avrutin, 1993, 1996) suggested that the deficits in Broca's patients were the result of a lack of ability to compute binding chains – i.e. chains formed by pronominal linkage, opposed to movement. Serbian offers an excellent opportunity to test this hypothesis, since some questions can be formed by either a mechanism of wh-movement or by a mechanism of pronominal binding. We found that Serbian-speaking Broca's patients do not exhibit greater difficulty with questions formed by pronominal binding, contrary to the hypothesis that Binding chains are impaired in Broca's patients. We concur with Avrutin (2000), however, that Broca's patients may have particular difficulty with integrating discourse-related information into the parse.

2 Experiment 1
2.1 Background
English-speaking Broca's patients have been tested on the question types in (1-4).

(1)   Who followed the tiger? (Subject question, non-D-linked question phrase)

(2)   Which lion followed the tiger? (Subject question, D-linked question phrase)

(3)   Who did the tiger follow? (Object question, non-D-linked question phrase)
(4)   Which lion did the tiger follow? (Object question, D-linked question phrase)

Hickok and Avrutin (1995, 1996) studied two Broca's patients; the experimenter acted out a scenario, and the patient's task was to point to the correct animal in answer to the question. Hickok and Avrutin found that the question types in (1-3) resulted in an above chance performance, whereas performance on the question type in (4) was at chance. Avrutin's (2000) explanation is that a plus Discourse-linked (+DL) phrase is subject to a non-movement (i.e. a binding) analysis, and that binding chains are impaired in Broca's aphasia.[1] The success with question type (2) and poor performance with question type (4) results from use of a strategy whereby the first NP is assigned the role of agent/subject (Grodzinsky, 1990). In sentence (2), it results in correct performance, but in (4) there is a conflict: the first NP *which lion* is assigned agent by the strategy, but the second NP *the tiger* is also agent via direct assignment of theta-roles from the verb. The aphasic patient is thus forced to guess which NP is the subject, and the performance is at chance.

A number of subsequent studies show results that are more complex than those found by Hickok and Avrutin. Thompson, Tait, Ballard and Fix (1999) and Salis and Edwards (2008) found that only some subjects followed the pattern of above chance performance on (1-3) and chance on (4). In a study of German, Neuhaus and Penke (2008) also found that only a subset of aphasic persons followed that pattern.

In a study of Croatian, Kljajević (2012) found that no subject followed the pattern reported by Hickok and Avrutin. She tested three Broca's patients and three mixed non-fluent patients, one mixed fluent and one anomic patient (a reduced set is also reported in Kljajević and Murasugi, 2010). The same procedure was used as in the previous studies. Of the patients tested, only two of the mixed non-fluent patients showed a deficit, with better comprehension of object extraction than of

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[1] The motivation for proposing a binding analysis (Cinque 1990, Rizzi 1990) is the amelioration of island constraints when the question phrase is D-linked. See Saah and Goodluck (1995) and Goodluck, Saah and Tsiwah (2015) for cross-linguistic support for this hypothesis.

subject extraction (the inverse of the subject-object asymmetry found for languages such as English). Kljajević claims that case marking permits Croatian-speaking Broca'a patients to circumvent the difficulty that English speakers have with questions such as (1-4). The finding that object questions are easier than subject questions for two patients (contrary to the pattern in English) is attributed to the greater saliency of object case marking.

The fact that German is a language with case marking causes concern for Kljajević' proposal (Neuhaus and Penke, 2008), as does the fact that the number of subjects in Kljajević study is small. Furthermore, only three of patients were Broca's aphasics. We report in this section that follows a study of Serbian, which shares the case system with Croatian, with the same seven cases and the same endings for them (Brown and Alt, 2004).

2.2 Participants
The subjects were 20 aphasic patients, comprising 8 male and 12 female, 47-70 years old. Most of them (18) were diagnosed as Broca's and two were diagnosed as mixed non-fluent, by means of an adaptation of the Boston Diagnostic Aphasia Examination (BDAE, Goodglass, Kaplan and Baressi, 2001).[2] Ten unimpaired persons were also tested; performance was near perfect (involving one error by one person).

2.3 Materials and Procedure
The materials consisted of sentence types (5-8).

(5) Ko_i je t_i pratio   tigra? (Subject question, -DL)
        Who_{NOM} aux   followed $tiger_{ACC}$
        'Who followed the tiger?'
(6)   Koji lav_i je t_i pratio   tigra? (Subject question, +DL)
        Which $lion_{NOM}$ aux followed $tiger_{ACC}$
        'Which lion followed the tiger?'
(7) $Koga_i$ je tigar   pratio t_i? (Object question, DL)
        Who_{ACC} aux $tiger_{NOM}$ follow
        'Who did the tiger follow?'

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[2] The scores on the adaptation of the BDAE are available on request.

(8)   Kojeg lava$_i$ je   tigar   pratio t$_i$? (Object question, +DL)
       Which lion$_{ACC}$ aux tiger$_{NOM}$ follow
       'Which lion did the tiger follow?'

Each participant responded to eight tokens of each question type, arranged in four blocks of two tokens of each type. The task was the same as Hickok and Avrutin (1996), other than that the materials were video recorded. The video provided the context for each question, showing an animal of type x performing an action on an animal of type y, and the animal of type y then performing the same action on another animal of type x. This type of context is suitable for all four questions in (1-4/5-8). The participant had to point to the animal that s/he thought was the answer to the question. Five different action verbs were used (*pratiti* 'follow', *češati* 'scratch', *gurnuti* 'push', *juriti* 'chase', *šutnuti* 'kick'). There were 12 pairs of identical animals. Gender (masculine, feminine) of the nouns (animals) was used in equal proportions. In two of the four blocks the action proceeded from right to left and in the other two the action proceeded from right to left.

2.4 Results
The performance of individual participants is given in Table 1. We excluded those who scored above chance on all four conditions (6, 7, or 8/8 correct [subjects KM, DjG, DA and VD]). The remaining 16 participants can be analysed as falling into the following patterns of responses:[3]

A. Generalized subject problem (the pattern found also by Kljajević, 2012): both subject conditions are more difficult than object questions (n=2, MLJ and AM)
B. Generalized object problem: both object conditions are more difficult than subject questions (n=1, GM)
C. D-linking problematic:
   a) both subject and object D-linked questions are more difficult than non-D-linked questions (n=3, KZ, SN and CLj)

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[3] This division into groups was based on a minimum difference of two between the scores that defined the groups.

b) D-linked subject questions are the most difficult condition (n=2, ZP and MK)

c) D-linked object questions are the most difficult condition, as found by Hickok & Avrutin, (1995, 1996) (n=2, DM and LD)

D. Non-D-linked object questions are the most difficult condition (n = 5, SJ, BS, ZZ, JS and LDj).

E. Both subject question types and object D-linked questions are below chance (n = 1, CB).

Participant	Subject –DL	Subject +DL	Object –DL	Object +DL	Pattern
DM	7	7	7	5	Cc
KM	8	8	8	6	
DjG	8	7	8	8	
SJ	8	7	0	8	D
CB	5	4	7	5	E
DA	7	8	8	6	
BS	8	8	4	8	D
ZZ	8	8	3	7	D
VD	8	8	6	6	
JS	8	6	4	6	D
MLJ	4	2	8	8	A
KZ	6	4	6	4	Ca
ZP	7	5	7	7	Cb
SN	8	4	6	4	Ca
AM	2	3	8	7	A
GM	8	8	5	5	B
LDj	8	8	5	6	D
CLj	8	5	8	2	Ca
LD	7	7	6	4	Cc
MK	8	5	8	8	Cb

Table 1: Raw scores - Experiment 1

Table 2 shows that patterns A, Ca, Cb and Cc combined, and D significantly discriminate between the question types:

	N of partic.	Subj. -DL	Subj. +DL	Obj. -DL	Obj. +DL	Chi Square	df [4]	P
A	2	6	5	16	15	9.524	1	0.002
C	7	51	37	48	34	4.612	1	0.04
D	5	40	37	16	35	11.063	3	0.02

Table 2: Total correct responses - participants with shared patterns

2.5 Discussion of Experiment 1

Our larger sample of aphasic subjects (with more homogenous disorders) calls into question the generality of Kljajević' findings. First, it is not the case that all Serbian-speaking Broca's patients perform above chance on all question types. Second, two participants had more difficulty with subject questions than with object questions, as Kljajević also found for two participants with mixed non-fluent aphasia. However, only one of these two in the present study was classified as mixed, non-fluent patient; the other was a Broca's patient. Third, we also found one participant who had (non-significantly) more trouble with object than with subject questions (Pattern B) and five subjects (Pattern D) showed lowest performance with non-D-linked object questions, suggesting a deficit in processing object case marking.

In addition, we also found that D-linking is a problem: subjects with Patterns Ca, Cb and Cc have more difficulty with one or both D-linked conditions. Thus we found a more general problem than the difficulty with D-linked object questions found by Hickok and Avrutin (1995, 1996).

3 Experiment 2

3.1 Background

The discussion above does not help solve the question of what the deficit that Broca's patients have. In this section, we address the proposal of

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[4] df = 1 (degree of freedom) when a comparison was made between two conditions and two others (in the case of pattern A, the two subject conditions vs. the two object conditions; and in the case of pattern C, the two –DL conditions vs. the two +DL conditions). df = 3 when all four conditions are treated separately in the analysis (pattern D).

Avrutin (2000): that Broca's patients may have trouble computing Binding Chains, leading (in combination with a strategy whereby the first NP is treated as agent) to a particular difficulty with +DL object questions. Although the patterns found in Experiment 1 cannot be accounted for by this single explanation, nonetheless some individuals, such as those tested by Hickok and Avrutin and others in the subsequent studies, may have difficulty with Binding Chains.

    Serbian offers the possibility to test this explanation, since it has questions formed by pronominal binding. *Koga* questions such as those (5-8) are formed by movement, as evidenced by sensitivity to island constraints. For example, a *koga* question cannot penetrate an indirect question, as shown the ungrammaticality of (9),

(9)   *$Koga_i$ će   Jelena   pitati   kada   će   posetiti t_i?
        Who_{ACC} will   Jelana   ask   when   will   visit
        'Who will Jelena ask when she/they will visit?'

In (9), the question word is moved from object position of the embedded clause. (9) is not made better if a resumptive pronoun (*ga*) is added to the embedded sentence.[5]

    However, there is a type of question in Serbian which permits reference into an embedded question. (10), with the preposition *za* preceding *koga,* contrasts with the ungrammatical (9),

(10)   Za $koga_i$ će   Jelena pitati kada   će ga_i posetiti?
        For whom will   Jelena ask   when   will   him   visit

The resumptive pronoun *ga*, coreferential with the question phrase, is obligatory in (10). In the analysis of Goodluck and Stojanović (1996), *za koga* questions use pronominal coreference between the *za koga* phrase and the resumptive pronoun, i.e. a binding chain.[6] The pronominal

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[5] The reading of example (9) as ungrammatical entails that *pitati* does not take a direct object. If *koga* is moved from the object position of *pitati,* (9) can be construed as grammatical with *ga*, since *koga*/t can then be bound to the pronoun. In the materials in (11) below, the possibility of co-reference between *koga* and *ga* is excluded by the content of the story.

[6] The derivation Goodluck and Stojanović give is more complex. *Za koga* is selected for by the main verb, and moves from the Spec CP of the embedded clause; it is then co-indexed with the resumptive pronoun, which has itself been moved from object

binding relation between *za koga* and the pronoun in the subordinate clause opens the way for obviation of the island effect created by an embedded question.

3.2 Participants
The participants were the same twenty aphasic patients tested in Experiment 1. A group of 17 unimpaired adults were also tested, to ensure that participants made a distinction between the sentence types in the experiment under the testing conditions described below (which were somewhat different from a previous study of children and unimpaired adults by Goodluck et al. 1996).

3.3 Materials and Procedure
Participants were asked questions following a short story. The questions used either *koga* or *za koga* to target an object position (for which the correct response was the matrix object in the case of *koga* and the embedded object in the case of *za koga*). An example is given in (11):

(11)   *Zoran i   Vesna razgovaraju o tome šta   će   raditi na leto*.
       Zoran and Vesna talk   about what will do   in
       summer
       'Zoran and Vesna are talking about what will they will do in the summer'

       Zoran hoće da idu kod dede   na selo.
       Zoran want to go to grandad in village
       'Zoran wants to go to grandad's in the village'

       Zoran kaže: "Pitacu tatu kada ćemo posetiti dedu"
       Zoran say   ask   dad when will   visit   granddad
       'Zoran says: "I'll ask dad when we will visit granddad" '

       Ovo je njihova kuća na selu.
       Here is their   house in country
       'Here is their house in the country.'

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position to pre-auxiliary position (see Goodluck and Stojanović 1996, p. 292-5; fn. 8 gives syntactic justification for this analysis).

Koga question:
> *Koga će Zoran pitati kada će   ga posetiti*?
> Who will Zoran ask   when will him visit
> 'Who will Zoran ask when he/they will visit him'

Correct interpretation: For which person x will Zoran ask x
when he/they will visit y.
Correct answer: *tatu* (dad)

Za koga question:
> *Za koga   će   Zoran pitati kada će   ga   posetiti*?
> 'Za' who will Zoran ask   when will him visit.

Correct interpretation: For which person x will Zoran ask y
when he/they will visit x.
Correct answer: *dedu* (granddad)

There were twelve stories, six with an embedded question with the question word *kada* ('when'), and six with *da li* ('if'). Only one main verb was used (*pitati* 'ask'), because the range of verbs that can take *za koga* is very limited and difficult to incorporate in the question response task. Both the *koga* and *za koga* questions were asked for each context story; in half the stories the *koga* question was asked first, and in the other half the *za koga* question was asked first. Two questionnaires were used, so that half the participants responded to an individual story with the *koga* question presented first and half with the *za koga* question first. The participants listened to the stories, which were accompanied by pictures in a booklet. The last picture was 'neutral' with respect to the correct answer (for example, for the story in 11, it was a picture of a house). The experimenter turned the pages of the booklet as she read the story, and presented the question together with the last picture.

3.4 Results
The unimpaired participants showed a categorical distinction between *koga* and *za koga* questions*,* 96% correct for *koga* and 95% correct for *za koga*. Although the level of performance was lower, the aphasic participants also showed a clear cut distinction, with 83% correct for *koga* and 85% correct for *za koga.* The participants who had problems with D-linking (Patterns Ca, Cb and Cc) scored 81% correct for *koga* and 75% correct for *za koga* questions. Neither the difference for all

participants or those who experienced difficulty with D-linking is significant.

3.5 Discussion of Experiment 2
Experiment 2 argues against an explanation that appeals to binding chains for the fact that some aphasic patients find questions involving +D-linked phrases difficult. Aphasic speakers are as adept at processing *za koga* questions as they are at processing *koga* questions, and yet *za koga* questions are formed by a pronominal binding mechanism.

4 General Discussion
The particular pattern of D-linked object questions being more difficult that other questions has not been borne out in Experiment 1 or in other earlier studies, except for a minority of participants (see section 2). However, there *is* evidence that D-linking in general may increase the difficulty that Broca's patients have. This may be taken as a reflection of difficulty in processing discourse information, rather than of computing Binding Chains per se, a hypothesis that Experiment 2 argues to be incorrect. Goodluck (1990) and Avrutin (2000) both argue that a range of data from child language studies leads to the conclusion that the integration of discourse information challenges child learners.[7] Our Experiment 1 and earlier studies provide evidence that this may be true of some aphasic patients also.

This study has also found one previously little documented pattern of data. In particular, we found in Experiment 1 greater difficulty for subject (as opposed to object) questions for two of our participants; as noted in section 2.1, that pattern was also found for two mixed non-fluent patients studied by Kljajević (2012). Only one of our participants was classified as mixed non-fluent, the other was classified as a Broca's patient. The source of this pattern remains an open question. Is it due to the greater salience of some instances of case marking, as suggested by Kljajević? Or does the greater ease of object vs. subject questions (or its opposite pattern) derive from differing attentional focus on different

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[7] We are as yet at an early stage in understanding the precise nature of D-linking effects. Work by Goodluck (2005) and Donkers et al. (2013), on child and adult subjects respectively, suggests that it is not the syntax of D-linking per se that leads to greater difficulty with +DL phrases, but rather their semantic content.

portions of the sentences? In order to support the attentional focus hypothesis, we need an independent measure of attention to portions of the stimulus, which must await further research. This hypothesis has the advantage in principle of covering a wider range of patterns in the data: if a correlation is found between attentional focus and particular response patterns, it may in part support an explanation of patterns A vs. B and also Cb vs. Cc in Experiment 1.

A more general moral from this study is that there is the danger of relying on studies of a small number of aphasic patients. As Salis and Edwards (2008, p.389) note "the differences between Avrutin's group [=Hickok and Avrutin 1995 and Thompson et al. 1999] and our group show how small samples can generate contradictory data".

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dandjelk@f.bg.ac.rs
helen.goodluck@york.ac.uk
smaya@eunet.rs
danijela.stojanovic@cic.gc.ca
mvukovic.dr@gmail.com