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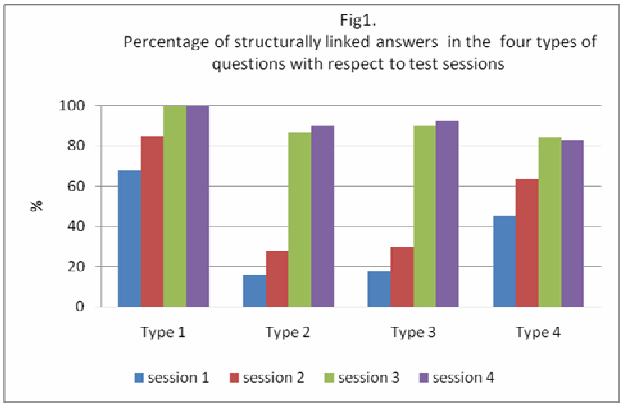
Recursion and recovery from aphasia
(case study)

Introduction: There is no universally accepted definition of recursion in linguistics. It is a topic of considerable debate whether recursivity is a syntactic phenomenon, defined as embedding a phrase/sentence within other phrase/sentence, or it is originated in semantics or pragmatics. In this longitudinal study we analyzed the recovery of embedded structures in an individual with agrammatic Broca's aphasia, who suffered from a cerebral infarct in frontotemporal area of the left hemisphere. An elicited sentence production task was repeatedly recorded in four test sessions during the 12 months following the onset of disease.

Test materials: Photographs representing simple situations were presented to the patient and questions were asked about them. There were 4 types of questions:
Type 1: *What is X doing in the picture*?
Type 2: *What does X hate/like/want....every afternoon/in her office, etc*?
Type 3: *What can be the most entertaining/unpleasant/urgent things for X to do*?
Type 4: *What can X say/think/remind Y of/ ask Y to do,* etc?

Grammatical answers were categorized according to whether (i) they were structurally linked to the questions, or (ii) were not structurally linked to the questions.

Results: Figure 1. shows the percentage of structurally linked answers to the four types of questions in four different sessions. As can be seen on Figure 1, the performance of the patient improved on Type 4 questions requiring a recursive embedded clause answer more than on Type 2 or Type 3 questions. This results contradicts the expectation that building a recursive structure is more difficult than building a non-recursive one.



It is a common observation that aphasic patients often produce short phrases or sentences (so called 'speech automatisms' Lebrun 1986, Code 1991, Wallesch & Blanken 2000). These speech automatisms are situation-specific (used only in certain situation but not in others), they concern emotional aspects of communication *('I want! How nice!*), and they show clear relationship to the verbal habits, previous experiences and interest of the aphasic patients (Pena-Casanova et al. 2002).

In our tests, the answers to Type 4 questions are supposed to involve formal structural recursion (complex sentences containing a matrix and subordinate clause), but the patient in our study frequently produced so called 'discourse statements" instead. These utterances have some of the characteristics of the 'speech automatisms': they are emotionally charged, often expressing intention, amazement, warning or command (1a-b).
(1) a. intention: picture: A girl doesn't want to give a bar of chocolate to a boy.

question: What could the girl be saying to the boy?
answer: *Az enyém a csoki! 'The chocolate is mine!'*

b. amazement: picture: A man praises the boy for his drawing.
question: What could the father be thinking of the boy?
answer: *Nagyon ügyes voltál! '*Very well done*'*

c. warning: picture: A man prohibits smoking to a girl.
question: What is the father warning his daughter about?
answer: *Ne gyújts cigit! Ne gyúltsál! '*Don't light a cigarette! Don't light it!*'*

d. command: picture: A man asks the receptionist for his key
question: What may the man be saying to the receptionist?
answer: *Kulcs, kulcsot a szobámba! '*Key (-nom)! Key(-acc) for my room! '

These 'discourse statements' *directly* represent the mental state one of the person in the picture, so they can be considered as a statements with 'theory of mind" type embeddings which mainly involve semantic-pragmatic operations of right hemisphere. Most interestingly, the percentage of syntactic embeddings increased and the frequency of 'theory mind' type direct embeddings decreased at third and fourth test sessions. These results indicate that together with and increased use of formal linguistic devices (complementizer, change of modality of verb, etc) the role of right hemisphere decreased, resulting in less semantic-pragmatic type embeddings.

We were also interested to see how improvement in syntactic ability influences the syntactic complexity of the answers with respect to Type 2 and Type 3 questions.
Results show that improvement in the availability of syntactic structure can be characterised by two stages. In the first stage of recovery, the patient produced more answers that were not structurally linked to the question, and most of the structurally linked answers were one-word utterances. They involved bare verb stems in the answers to Type1 questions, and bare infinitives to Type2 and Type3 questions. The second stage of recovery can be characterised by increased syntactic complexity: (*i*) most answers involved nominative and/or accusative noun phrases (2a), (*ii*) the patient produced adjectival phrases involving infinitives as arguments (2b), *(iii)* embedded sentences involving subjunctives or inflected infinitives also appeared (2c-d), .

(2) a. *A lány megmossa az arcát. '*The girl washes her face*'*

b. *Neki a legjobb biciklizni. '*Riding a bicycle is the most pleasant for him'

c. *Neki a legfontosabb, hogy nőjenek a virágok. '*Growing flowers are the most important for him'

d. *Neki a legfárasztóbb, hogy festenie kell. '*Having to paint is the most tiring for him'

As it can be seen, the patient strives not only to produce all arguments of a predicate, but also to agree syntactically dependent constituents within and between sentences. We can draw a tentative conclusion that agreement within and between sentences might be an overarching, influential 'principle' to produce complex structure (syntactic embedding) at this stage of recovery from aphasia.

Conclusion: Results from this patient suggest that formal syntactic recursion may be selectively impaired in individuals with agrammatic Broca's aphasia and semantic recursivity may remain selectively intact. The results provide arguments supporting the claim that, along with formal-structural recursivity, the semantics of a language can also be seen as a source of recursion. At full recovery from aphasia, the patient can produce both syntactic and semantic-pragmatic recursion just as non-aphasic individuals.