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Possible Deficits in an Agreement Mapping System and their Relationship to Human Deficits in Aphasia

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Abstract

Drienkó (2004a,b) describes a linguistic model based on generalised agreement properties of linguistic elements. Being a computational system, the model consists of various computational components, whose modification may result in suboptimal or defective functioning of the whole system. In this paper we examine how deficits of the major components of the model can relate to a representative collection of human errors made by aphasic patients.

1. The model

Let us begin with summing up the basic characteristics of the agreement framework as outlined in Drienkó (2004a,b).

The operation of the language faculty is considered to be a mapping from input elements to patterns. Patterns are configurational representations of linguistic input. Besides being configurational, patters also incorporate agreement constraints. An agreement constraint requires the identity (agreement) of a feature of some input elements mapped on the same pattern. Input elements are represented as simple attribute-value structures (AVS) consisting of a finite number of attribute-value pairs.

Known input elements are a finite set KEL. Elements in KEL are AVSs whose attribute values are fully specified, i.e. each attribute has a value. Unknown input elements, i.e. AVSs with unspecified attribute values, constitute a nonfinite set UEL.

Input elements can be mapped on patterns recursively (as determined by the pattern in question). For recursive mapping it is necessary for an agreement system to incorporate various agreement strategies so that agreement checking can be done in various ways, as required by any given pattern. Formally, a strategy can be represented as a two dimensional arrangement (matrix) of known input elements.

The connection between attributes and their values is established by the mapping process. Algorithm VALA (a(X)) returns values for attribute X of input element 'a' by either

(1)
1. looking up the value for elements in KEL (known elements),

or

a. selecting values that yield successful mapping for elements in UEL (unknown elements)

Point 2. in (1) represents a reconstruction mechanism which is capable of returning an attribute value for an input element that has no value specified for the stated attribute. Reconstruction plays a crucial role in our model.

The mapping process can be linear, or random access. Linear mapping means that input elements are mapped on a pattern in the same order as they are presented to the system. In the case of random access, mapping order can be different from the order in the input.

2. Possible deficits in the mapping system

In this section we survey how various components of our model can be faulty, and what results the corresponding suboptimal functioning may bring about concerning the overall behaviour of the system.

Defect I: input elements

Since input elements are feature structures in our model, breakdown of input elements means the loss (change) of attribute values. However, the loss of attribute values can be of various degrees, the two extremes being the loss of only one feature, and the losing of all features. In any case, input elements with lost attribute values will increase the need for reconstruction. This can lead to a general slow down in the system. The more values are lost of the more input elements, the more intensively reconstruction will be needed. Since reconstruction involves mapping on patterns other than the optimal one, the increased role of reconstruction then implies an increase in the degree of ungrammaticality.

Defect II: Patterns

Patterns, in the agreement model, can be defective basically in the following ways:

- Modification (=change, loss, or emergence) of representational elements
- Modification of agreement constraints
- Loss of the whole pattern

Modifications in patterns will, in general, entail ungrammaticality. If a representational element is changed or lost (or several representational elements are changed or lost) in a pattern, or new representational elements emerge, then it becomes a perfectly different pattern corresponding – most probably, if we assume that such changes are effected by extralinguistic factors – to ungrammatical utterances. The same is true for changes in agreement constraints. The speed of grammatical processing in the case of such changes may be comparable to normal functioning. The loss of agreement constraints, and also the loss of whole patterns, on the other hand, will decrease the size of the search space, thus faster processing can be predicted than usual. Of course, the loss of patterns, or constraints potentially increases ungrammaticality.[1]

Defect III: VALA(a(X))

Misfunctioning with respect to attribute value retrieval results in erroneous mapping on representational elements and a haphazard fulfillment of agreement constraints if VALA(a(X)) associates wrong features with input elements. Such erroneous

[1] Fast and ungrammatical, nonsense speech is a characteristic of Wernicke's aphasia

associations are another source of ungrammaticality, while processing speed may remain similar to normal.[2]

The loss of VALA(a(X)) means a very serious problem. Since it is also the basis for the reconstruction mechanism which can be resorted to in the case of other deficits, the absence of VALA(a(X)) is practically equivalent with a general breakdown.

Defect IV: The mapping engine

If the system is equipped with facilities for both types of mapping, linear and random access, a possible source of deficit lies in the application of the wrong type. This can lead to ungrammaticality, and to change in processing time, but not necessarily in every case. For instance, an input sequence can be mapped on the same pattern both linearly and in random access way requiring approximately the same amount of time. However, in the general case, linear mapping allows only one – the correct - mapping, while random access may involve several patterns including possibly the correct one, but possibly also including unwanted mappings. Naturally, mapping on several patterns takes more time.

Since it is also the main mapping module's task to keep track of input elements, a possible source of error in the system is if the input sequence is organized in a way that new elements can be added to it (e.g. mixing with previously processed elements), or not every input element is considered (e.g only every second element is processed).

It would be more interesting to characterize the combined effects of the above deficits. For our present purposes, however, it suffices to conclude that deficits:

- may or may not cause a slowdown in processing time,
- usually co-occur with ungrammaticality,
- can be, to various degrees, compensated by reconstruction

[2] Providing the deficit of VALA(a(X)) does not itself involve a slowdown.

The above conclusions are compatible with current research in neurolinguistics.[3] There are various kinds of aphasia characterized along the dimensions 'speed of speech', and 'ungrammaticality'. The notion 'compensation strategies' is also well-established.

A further dimension of defective behaviour could be obtained by considering defects as being dependent on time. Deficits can be temporary, or there can be more or fewer deficits as time goes by. Temporary deficits in human linguistic capacities may cooccur with tiredness, drunkenness, passing illnesses, etc. Increasing or decreasing degree of linguistic defects can be paralleled by evolving of a disease or recovery from it, respectively. However, we do not include these types of time dependencies in this work.

In the next sections we attempt to interpret various kinds of linguistic errors made by aphasics in terms of Defects I-IV, possible deficits in the Agreement Mapping System model.

3. Aphasic deficit types

3.1 PHONOLOGICAL/PHONETIC ERRORS

Phonological patterns can be thought of in much the same way as e.g. syntactic patterns. Representational elements here represent, of course, phonological material: individual phonemes, phonetic features, etc. Phonological patterns may also have their explicit agreement constraints consistent with phonological theory. Input elements are phonemes or sounds as represented by phonetic attribute value structures. (2) shows an example of a phonetic representational element.

(2)

PHFORM	o
CAT	vow
ROUND	yes
HIGH	no

[3] See e.g. Banreti (1999) for an overview.

Blumstein (1995) divides phonological deficits in aphasia into the following types:

(3)
- Phoneme substitution errors
- Environmental errors: metathesis, assimilation
- Simplification errors
- Phoneme insertion errors

Below we examine how the error types listed in (3) can relate to Defects I-IV described in the previous section.

3.1.1 Phoneme substitution errors

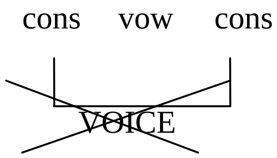
Defective performance here is due to substituting other phonemes for the correct ones. E.g.

(4) DOP instead of TOP

This kind of error can be a consequence of Defects I- III in an agreement mapping system. Deficit I could mean that the VOICE feature for the input element representing the sound 't' is lost and reconstruction assigns it *VOICE=yes*, equating it with the phoneme 'd'. Of course, this kind of reconstruction is only possible if a pattern for 'dop' exists. Alternatively, we can say that mapping is done onto the pattern for 'top' but reconstruction erroneously assigns *VOICE=no* to the input element representing 'd', facilitating, thus, mapping 'd' instead of 't'.

Deficit III could yield the same result. In that case the *VOICE=no* feature would exist for 't', but somehow *VALA(t(VOICE)) = yes* could be brought about due to a misfunctioning of VALA(a(X)), licensing the mapping of 't' on 'dop'. Alternatively, *VALA(d(VOICE)) = no* could result in the mapping of 'd' on the pattern for 'top'.

It can also be the case that the modification of a pattern allows the unwanted mapping. (Defect II). This can be exemplified by (5). If the agreement constraint blocking mapping of consonants with different VOICE values is lost then 'dop' becomes a legal sequence for (5).

(5)


3.1.2 Environmental errors: metathesis, assimilation

There can be two types of assimilation errors, according to the two possible directions of assimilation. It can take place in a backward or a forward way. The former is exemplified by

(6) TRÉTA instead of KRÉTA (chalk, Crete)
Backward assimilation

while the latter by

(7) KRÉKA instead of KRÉTA.
Forward assimilation

One line of thought, taking only note of the 'k'='t' identification, would lead to the above arguments for the case of (4), representable as 't'='d' (Deficits I-III.).

Taking Defect IV into consideration, may yield a possibly more insightful analogue. It can be possible, that the main module of the mapping algorithm considers some elements several times, and it can also ignore elements. In the case of (6) it considers 't' twice, and ignores 'k', whereas in the case of (7) there are two 'k's and 't' is left out. Note that combinations 'kteta', 'krera', 'krete', and 'krata' are similarly conceivable. Defect IV can model assimilations (6) and (7) if patterns licensing 'treta' and 'kreka', respectively, exist.[4]

Metathesis means interchanging two phonemes:

(8) KAPTUM instead of PAKTUM (pact)

The most plausible parallel of this kind of error is perhaps Defect IV. If random access mapping is also facilitated in the system, then for each pattern it should be unambiguous which way of mapping the pattern gives preference to. Reasonably, a phonetic pattern for a word should require mapping echoing the temporal order of the elements (phonemes) of the word. If random access mapping can anyhow still have a go, then, without further restrictions, any of the *n!* combinations of *n* phonemes can be expected to be mappable on the pattern licensing 'paktum'.[5]

3.1.3 Simplification errors

Simplification means that certain elements (phonemes, syllables) are left out. For instance

(9) GÉPFRUT instead of GRÉPFRUT (grapefruit)

One analogue can be provided by Defect IV. For some reason, the mapping algorithm ignores an input element, the one representing the first 'r' sound. Naturally, mapping can only be done on an existing pattern licensing 'gepfut'.

It can also happen that a representational element of a pattern is lost - Defect II. Then the resultant pattern may license the mapping of 'gepfrut'. Cf. (10).

(10) ~~cons~~ cons vow cons cons cons vow cons

3.1.4 Insertion errors

A superfluous element is added to the sequence of sounds:

(11) STIET instead of SIET (s/he hurries)

This can be interpreted as the inverse of the previous case. The parallelism with the defects in the mapping system is accordingly similar. Now Defect IV means that an additional input element is considered for mapping. Again, mapping requires a pattern licensing the unsolicited word - 'stiet', in the present example.

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[4] Or they can share the same pattern.

Defect II would imply that a new pattern licensing 'stiet' is formed by somehow adding a new representational element to the pattern licensing 'siet'. Cf. (12)

(12) cons vow vow cons
↑
cons

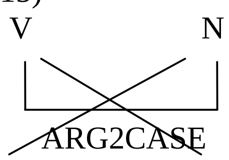
3.2. MORPHOLOGICAL ERRORS

First of all, we think of incorrect suffixation in this section, i.e. agreement in the 'classical' sense. Consider sentences (13) – (14).

(13) Segített Marinak
help-PAST-3rd -SG Mary-DAT
S/he helped Mary

(14) *Segített Marival
help-PAST-3rd -SG Mary-INSTR

The type of error in (14) was observed, e.g., in Drienkó (2001) while examining the performance of a Hungarian Broca's aphasic. A straightforward analogy with Defect II arises if we consider the agreement of the ARG2CASE attribute responsible for the proper grammatical case of the noun, as required by its subcategorizing verb. If the agreement constraint is lost, nouns with other grammatical cases can be mapped on the pattern. Cf. (15).

(15)


It can also be possible, Defect I, that the ARG2CASE feature for 'marival' is lost and reconstruction assigns it the dative case.

[5] It is, of course, reasonable not to expect vowels to be mapped on consonantal representational elements, and vice versa. So the allowable combinations would rather be *c!* × *v!*, where *c* is the

Defect III would mean that, correctly, *ARG2CASE = instr* for 'marival', yet the malfunctioning of the value assigning function yields *VALA (marival(ARG2CASE)) = dat*, making thus mapping possible.

Note the parallelism between our present topic, and the discussion in section 3.1.1 of phoneme substitution errors. Then it was possible to map 'd' on a representational element requiring 't' due to incorrect assignment of *VOICE= no* for 'd'. (Defects I or III) In the present example it is possible to map 'marival' instead of 'marinak' owing to an incorrect assignment of *ARG2CASE= dat* to 'marival'.

As far as Defect II is concerned, (5) and (15) suggest the analogy.

3.3 SYNTACTIC ERRORS

In connection with relative clauses Grodzinsky (2000) reports that sentences of type

(16) The girl who pushed the boy was tall

are understood above chance level by aphasics, while sentences like

(17) The girl who the boy pushed was tall

are interpreted randomly. Let us concentrate on the embedded clauses

(18) who pushed the boy
(19) who the boy pushed

One way to differentiate the two clauses is to rely on word order. The word order in (18) is S(ubject) V(erb) O(bject), in (19) OSV. Thus Grodzinsky's data suggest that clauses with OSV order are harder to process. Bánréti's data (2001)[6] seem to support this line of thought. He examined production performance in agrammatism on three types of Hungarian sentence patterns:

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number of consonants, *v* is the number of vowels.
[6] Bánréti, Z. (2001) Egyeztetés agrammatikus afáziában: A szintaktikai fa metszése. (Agreement in Agrammatism: Intersecting the Syntactic Tree). Ms.

(20) Ti várjátok az ünnepeket
You(pl2) wait(for) the holidays

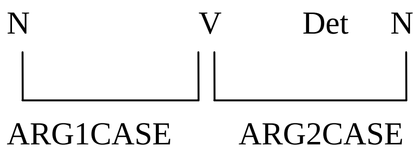
(21) Ti az ünnepeket várjátok
You(pl2) the holidays wait(for)

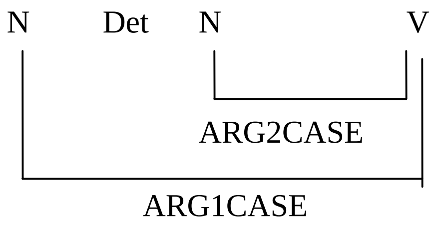
(22) Az ünnepeket ti várjátok
The holidays you(pl2) wait(for)

Bánréti found that the difficulty of the production of sentence types increases in the above order, that is, (20) represents the easiest group, while (22) is the hardest A careful look reveals that the degree of deficit may depend on word order in this case, too. (20) is an SVO pattern, (21) is SOV, and (22) is OSV. So the difference between (20) and (22) is analogous to the difference between (18) and (19). This means, on the one hand, that both Grodzinsky's perception results and Bánréti's production data may confirm that OSV sequences are more difficult to process than SVO sentences are. On the other hand, Bánréti's data suggest that there is an intermediate sequence, the SOV type. We can write our conclusion schematically as (23).

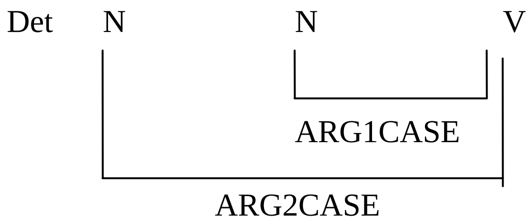
(23)
SVO SOV OSV
Easiest ------------------------->Hardest

Combination of Defect II and Defect IV may provide an analogy. Suppose the system originally has patterns (24) – (26).

(24)


(25)


(26)



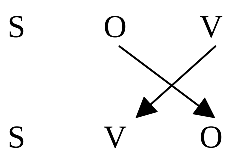
For simplicity, we write (27) - (29) for (24) - (26).

(27)	S	V	O
(28)	S	O	V
(29)	O	S	V

Now suppose that patterns (28) and (29) are lost, Defect II. If Defect IV is also present, then the system can map SOV, and OSV type sentences randomly on pattern (27) corresponding to the SVO order. Since random access mapping generally takes more time, SOV and OSV type sentences will take more time than SVO sentences, since the latter type does not require random access for being mapped on (27). If we accept that processing time is proportional to the difficulty of the task[7], then we have some insight into the nature of the difference between SVO and the other two types of sentences.

Now, what is left to show is why SOV is easier than OSV. Consider the random mapping process. When mapping SOV onto SVO there is only one 'slight' transformational step – interchanging the positions V and O. (30) shows this.

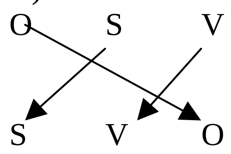
(30)



[7] We also suppose, tacitly, that the probability of ungrammatical performance increases with the difficulty of the task in the human case.

However, the mapping of OSV on SVO requires more "transformation". Actually, none of the elements in the sequence OSV occupy the position that they occupy in the SVO pattern. Cf (31)

(31)



4. Conclusions

We presented a – we believe – representative selection of aphasic deficit types and attempted to relate them to possible defects in the agreement model. Four basic Defect types in the agreement model provided a basis for interpreting aphasic data. As our results reveal, it may not be too unrealistic to indulge a hope for a possibility of approaching the characterization of human errors in a unitary way, within the framework of a single theory.

Of course, we could only point to intuitive parallelisms with our model. A more quantitative analysis would require much more (and more systematically collected) data on human errors than is currently available for research.

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