SHORT COMMUNICATIONS

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A SYNTACTIC ACCOUNT OF COMPREHENSION DEFICITS IN BROCA'S APHASIA

Broca's aphasia is still a relatively poorly understood phenomenon. The Trace Deletion Hypothesis is one of the attempts made to explain linguistically comprehension deficits observable in this disorder. The article presents the main assumptions, claims and consequences of this hypothesis, as well as criticisms it has raised in the literature. This hypothesis offers an opportunity for shedding more light on the issue of agrammatism in Broca's aphasia, and also for improving our understanding of the phenomenon of aphasia as such and, consequently, our understanding of language processing in the human mind.

Key words: Trace Deletion Hypothesis, agrammatic language, comprehension, Broca's aphasia

Introduction

The relevant literature on the subject offers various theoretical explanations of agrammatic sentence production and comprehension in Broca's aphasia. Linguistic theories show similarity in that they point to some linguistic level as the only or main source of observable language deficit patterns. Within these theories one hypothesis will be presented and discussed in this paper: the Trace Deletion Hypothesis, which seeks to account for comprehension deficits observable in Broca's aphasia, besides agrammatic language production impairment. The hypothesis was put forward by Yosef Grodzinsky and his colleagues.

The choice of this hypothesis for presentation in this paper is twofold. First, it reflects contemporary efforts to develop an adequate theory of agrammatism. Second, it is the one which has evoked much interest and is now extensively discussed in the relevant literature. The choice of this hypothesis and 'skipping' earlier theories is not intended to ignore or depreciate previous solutions. In fact, the theory to be presented here should be viewed as a more recent continuation of earlier approaches. Its recentness lies in the fact that it tries to learn from the criticism that earlier accounts have received and to overcome their flaws. In addition, it resorts to the most recent developments in linguistic theories, e.g., Pollock's (1989) analysis of split inflection or Chomsky's (1992) Minimalist Program, which provide new, more effective, tools for more adequate analyses of agrammatism. These tools were not at the disposal of earlier studies.

Still, this hypothesis, is not by far uncontroversial and is also subject to criticism of a different type. Thus, its shortcomings are also discussed in this paper.

The Trace Deletion Hypothesis (TDH)

The beginnings of the Trace Deletion Hypothesis (TDH) go back to 1976 when the then prevalent view that Broca's aphasia is associated with normal comprehension was challenged. Caramazza and Zurif (1976) found that a group of Broca's aphasics performed poorly in comprehending certain types of sentences. The authors interpreted these results as indicating that Broca's aphasia is the result of damage to syntactic processing mechanisms used both in sentence comprehension and in sentence production. According to this view, the agrammatic production of Broca's aphasics necessarily co-occurs with asyntactic comprehension because the two deficits are the result of damage to common mechanisms that are used in the two tasks (Caramazza, Capitani et al., 2001; Bahlmann, Schubotz et al., 2008).

The Trace Deletion Hypothesis is probably one of most widely discussed and controversial hypotheses. It holds that Broca's aphasics have impairments in a syntactic process known as the coindexation of traces. This impairment results from the deletion of traces from agrammatics' representation of sentence structure (Grodzinsky, 1986). It has also been argued that this problem of coindexing traces is the *only* syntactic processing problem that Broca's aphasics have (Grodzinsky, 2000a). The hypothesis was originally put forward by Grodzinsky (1986) to account for comprehension deficits observable in agrammatism, and then gradually modified (Grodzinsky, 1991, 1995a, 1995b, 2000a; Grodzinsky, Wexler et al., 1993). Most recently, the theory was refined in 2000 and it is this reformulation which will serve as the source for presenting the TDH in this work.

The TDH is relevant to the nature of normal syntactic representations and their normal processing and is based on Chomsky's model of syntax. In his syntactic theory, Chomsky (1981, 1986) postulates the existence of traces. Traces

are noun phrases (NPs) that are not uttered and are found in sentences in which an NP has to be related to a distant syntactic position to receive a thematic role, because the NP has been moved from an initial position. In Chomsky's theory, this occurs in passive sentences, sentences with relative clauses, and several other sentence types. Most of the research in aphasia regarding the coindexation of traces focuses on passive sentences, therefore the syntax of this type of sentences is briefly outlined now.

Chomsky's (1986) model postulates that passive sentences contain an abstract, unpronounced noun phrase known as a 'trace' – *t*. The trace may be thought of as something left behind after the NP movement from the initial object to the subject position (Lightfoot, 1977). In this model, passivization is achieved by moving the object NP from its initial position to the subject of the passive sentence position. However, any moved constituent leaves behind at its extraction-site an identical empty category. This empty category is known as a trace, and the moved constituent is said to be the antecedent of the trace (Radford, 1988). According to this rule, in passive sentences the category from which the object NP has moved is not deleted but is occupied by the trace, as depicted in (1):

- (1) [The girl] was hugged [t] by the boy.
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The trace inherits the grammatical properties of its antecedent. Therefore the trace serves as the object of the verb and as such receives the thematic role assigned to the object:

- (2) [The girl] was hugged [t]_{Theme} by the boy.

However, the trace is related to its antecedent (the subject of the passive sentence) and this relation is called 'coindexation'. Coindexation is expressed in the fact that the trace transmits its inherited properties to its antecedent. Among others, the trace transmits its thematic role to the subject (Radford, 1988). This arrangement is depicted in (3), where the subscript (*i*) indicates that the trace (*t*) and the subject noun are coindexed, and the arrow indicates that the thematic role assigned to the trace is transmitted to the subject NP:

- (3) [The girl]_i was hugged [t]_i by the boy.
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According to Grodzinsky (2000a), the coindexation of traces takes place in Broca's area. In support of this hypothesis, he claims that Broca's aphasics have

impairments in this process. This impairment consists in the deletion of the trace which results in the disruption of the coindexation of the trace and the subject NP (Trace Deletion Hypothesis). In consequence, such deletion prevents the subject NP from receiving the thematic role assigned to the trace.

At this point, Grodzinsky argues, when agrammatic aphasics are faced with the breakdown of the assignment of the thematic role, they start up compensatory heuristics. A frequently used heuristic assigns by default the thematic role of agent to an NP that does not have a thematic role, or to an NP before a verb. In consequence, the role of agent is assigned: (1) by the verb to the NP that serves as the object of *by*-Prepositional Phrase (PP), and (2) to the subject NP by the default heuristic strategy. This operation yields sentence structures such as the one illustrated in (4):

The same holds true of sentence types other than passives which contain traces, for example, to object-relativized sentences, such as (5):

However, sentences such as (4) and (5), with the same thematic role assigned to two NPs, are ruled out as ungrammatical from the set of possible sentence structures (Radford, 1988). Therefore, when two NPs could both be assigned the role of agent, the patient with Broca's area damaged randomly selects one as the agent in a given sentence. As a result, the comprehension of such sentences should be at a chance level, depending on the accidental assignment of the thematic role of agent to either correct or incorrect NP.

Practically, then, a deficit in coindexation of traces would lead to poor comprehension of sentences with traces and good comprehension of sentences without them. Additionally, the rate of comprehension of the sentences with traces should be at a chance level.

Thus, the pattern of performance that provides support for the TDH would allow for good comprehension of sentences with traces in the subject position, such as (6):

In this type of sentence the trace deletion takes place in Broca's aphasics as well. Thus, coindexation does not occur, nor the transmission of the thematic role from the trace to the subject NP. However, the thematic role is assigned by default, in

this case correctly, to the NP which precedes the verb. So the pattern is similar to that in passive sentences because of the changed syntactic conditions. It accidentally yields correct results, as it is illustrated in (7):

- (7) It was [the boy]_{i,Agent} who [t_i] hugged the girl.
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Therefore, an overall pattern which would favor the TDH would consist of a good comprehension of sentences with traces in the subject position, such as (8) and poor performance on sentences with traces in the object position, such as passive sentences, (9), and object-relativized sentences, (10):

- (8) It was the boy who [t] hugged the girl.
 (9) The girl was hugged [t] by the boy.
 (10) It was the girl who the boy hugged [t]. (cf. Caplan, 2002, p. 333)

Empirically, this can be examined in sentence-picture matching tasks which most frequently involve sentences with semantically reversible passive structures. In this type of task the patient hears a sentence (in either active or passive voice) and, out of two, he must select the picture that matches the meaning of the sentence. The demonstrated pictures illustrate two possible interpretations of the sentence. One is a correct depiction of the sentence (the role of agent is assigned to the subject NP); the other is a distractor picture in which the thematic roles of the participants named in the sentence are reversed (the role of agent is assigned to the NP that is the object of the preposition *by*). In accordance with the TDH, Broca's aphasics should perform poorly or, at most, at a chance level on such tests of comprehension of semantically reversible passive sentences (Berndt, Caramazza et al., 1999).

This pattern of performance certainly occurs in Broca's aphasics, and in patients with lesions in and around Broca's area, as predicted by the TDH (Grodzinsky & Finkel, 1998; Friedmann, 2000; Bickerton, 2000).

Discussion

Apart from its explanatory potential, the TDH has also turned out to pose some problems. The most common criticism has addressed the strong assumption made by the TDH with respect to the neuroanatomical localization of the deficit. Some reports demonstrated that there are Broca's aphasics who do not show the TDH performance pattern, but rather perform well on sentences such as (1) and (2). Additionally, among patients with lesions that do not affect Broca's area, there are many who *do* show the TDH performance pattern. Both these points have been the subject of considerable discussion.

The first of these points was emphasized in the paper by Berndt, Mitchum et al. (1996), which documented good performances in about one-third of Broca's aphasics on passive sentences. This paper triggered a broad discussion on the issue (Zurif, 1996; Druks & Marshall, 1996; Grodzinsky, Pinango et al., 1999; Berndt & Caramazza, 1999; Zurif & Pinango, 1999; Draï & Grodzinsky, 1999; Draï, Grodzinsky et al., 2001; Caplan, 2001). During this debate the evidence supporting the TDH was criticized both on statistical and subject selection grounds. At this point, the data appearing from this debate seem to favor the view that some of Broca's aphasics perform above chance on reversible passive sentences, contrary to the TDH.

The second claim of the TDH that has been discussed is that aphasic patients other than Broca's aphasics do not have disturbances affecting the coindexation of traces. Some reports demonstrated that the syntactic comprehension deficit explained by the TDH is not confined to Broca's aphasics: the pattern of performance that is taken as evidence of a problem in coindexing traces occurs across other aphasic syndromes (Berndt, Mitchum et al., 1996; Caplan, Waters et al., 1997). Overall, at this point in time, the evidence is consistent with the view that, among both Broca's and fluent aphasics, there are some patients that do and some that do not coindex traces. Again, these findings would seem to speak decisively against the localization claims postulated by the TDH.

Finally, the TDH claims that Broca's aphasics do not have disturbances affecting syntactic processing other than a disturbance of coindexation of traces (Grodzinsky, 2000a). This view was undermined by Caplan (2002), who showed that the literature cited by Grodzinsky is lacking in individual cases which have been studied in the full range of structures relevant to the TDH. The fact that a small number of Broca's aphasics have been shown to be able to understand some types of syntactic structures does not allow inferring that all Broca's aphasics can understand these structures. Only detailed case studies, in which individual aphasic patients have been tested in the range of structures needed to establish a deficit restricted to the coindexation of traces, can show that an aphasic patient has such a restricted deficit. Case studies in which aphasic patients have been tested on this range of structures have shown a variety of deficits (Caplan, 2002). All of the patients who have had disturbances affecting traces have also had disturbances affecting other structures, in particular, the ability to coindex other items such as pronouns, reflexives, and other empty categories postulated in Chomsky's model of syntax. No clear picture has emerged for Broca's aphasics (Caplan, 2000).

Another type of criticism put forward against the TDH concerned linguistic issues. It has been noted (Kolk & Weijts, 1996) that the default strategy, which, according to Grodzinsky (2000a), agrammatics use to assign theta roles to two competing NPs, is a weak point in the TDH. This strategy is not based on grammatical principles, but rather resorts to a linear-order rule. Since this strategy is

not grammatically principled, it is hard to see what constrains different individuals to formulate the same heuristic following brain damage. The patient may equally employ alternative heuristics.

Another objection against the default strategy was raised by Martin, Wetzel et al. (1989). Truncated passives (e.g., 'the girl was kissed') should not give rise to two incompatible role assignments, since there is only one NP, which should receive the agent role. The default strategy hypothesis therefore predicts that truncated passives will always be interpreted as actives. This does not occur, however: in the study by Martin, Wetzel et al. (1989) full passives and truncated passives elicited the same number of reversal errors. The default strategy was also criticized along similar lines by Beretta (2000).

Another linguistic criticism comes from Hickok (2000), who pointed out that there are more sentence types, apart from those accounted for by the TDH, which pose comprehension difficulties for agrammatic aphasics. These include the matrix clause of centre-embedded relatives such as (11), locative prepositions such as (12) and simple active sentences.

(11) The dog that chased the cat is brown.

(12) The dog is behind the cat. (Hickok, 2000, pp. 35-36)

According to Hickok (2000), in sentences like (11) comprehension of the thematic relation between the subject ('dog') and predicate ('is brown') is poor in agrammatic patients. The TDH cannot explain this fact, even assuming that this relation is mediated by a trace. Additionally, Hickok demonstrated that Broca's aphasics perform at chance on comprehension of sentences containing locative prepositions such as in (12). According to the TDH these should be comprehended on a par with actives. Finally, Hickok pointed out that comprehension of simple active sentences is also far from perfect. The TDH predicts that performance on passives should be variable, but makes no such predictions for actives because the correct thematic roles are assigned to both NPs.

Summing up the discussion concerning the TDH, the conclusion can be drawn that, on the basis of available evidence, the claim that Broca's area is the sole locus of coindexation of traces must be rejected. The conclusion that should be drawn on the basis of present evidence is that the coindexation of traces can also result from lesions to regions of the cortex other than Broca's area. Additionally, the fact that Broca's aphasics reveal deficits in understanding syntactic structures other than those involving the coindexation of traces sheds doubts on the claim that coindexation of traces is the core of agrammatic comprehension disorder. The TDH is further disfavored by the fact that aphasics other than Broca's have been found to reveal similar deficit patterns. Finally, linguistic objections to the theoretical concepts implemented in this theory, such as the default strategy, show the need for a modification of this account.

Conclusion

The aim of this work was to present and discuss the current state of linguistic knowledge about aphasia in the context of TDH. As could have been noticed, this knowledge is far from being satisfactory since much disagreement exists with respect to numerous issues on the subject. Nevertheless, progress in studies of aphasia is also apparent. It is reflected in recognizing the problems which have been neglected earlier, such as reaching agreement on the existence of comprehension deficits in, at least, a subgroup of agrammatic patients. Furthermore, the continuing efforts to unify the methodology of research in aphasia contribute to obtaining more reliable results. Using modern techniques of neuroimaging ensures the correct diagnosis of patients with brain lesions and, consequently, more adequately classifying them into experimental groups in research. With respect to agrammatism, progress finds its expression in the fact that the focal point of the linguistic discussion has shifted from the previous debates on the superficial (descriptive) features of agrammatism to theoretical accounts of this phenomenon.

This work has attempted to link the ongoing discussion on one of the most prominent linguistic accounts of agrammatism in Broca's aphasia – the Trace Deletion Hypothesis. The TDH holds that the loss of traces and subsequent impairment in coindexing referential constituents is the core of the comprehension deficits in agrammatism. The advantages which this account has lie mainly in their selectivity as to the components claimed to be responsible for the observable deficits and in their potential to explain a considerable range of facts. By postulating a highly restrictive impairment at the level of linguistic knowledge, this hypothesis is capable of accounting in a unified way for a vast scope of deficits revealed in agrammatic language performance. Evidence for the explanatory potential of this account has been presented in the main body of this article.

However, apart from their benefits, the Trace Deletion Hypothesis and the Trace Pruning Hypothesis have also received criticism of a different type. Let this criticism be briefly reviewed now.

The TDH was criticized first on the grounds of its neuroanatomical assumptions. The predictions it made with respect to the pattern of comprehension deficits in Broca's aphasia failed to prove specific for this disorder. The pattern of comprehension deficits involving coindexation of traces was found also in patients other than Broca's aphasics. Further, studies supporting the TDH raised objections as to their methodology – the adopted statistical procedures and criteria of patients' inclusion to the studies.

The TPH was undermined by some cross-linguistic research which demonstrated that the higher nodes of the syntactic tree *are* projected by agrammatic patients, speakers of Verb-second languages such as German or Dutch.

It should be noted, however, that all these criticisms do not demolish the TDH and TPH completely. In fact, the critical remarks motivated Grodzinsky (2000b)

to provide a substantial defence for both hypotheses. The validity of this defence is not possible to verify within the scope of this work, but the very existence of such a defence suggests that various solutions may be found to problems posed by the accounts of agrammatism presented above. Therefore, the criticisms should be viewed as a motivation for modifying the morphosyntactic theories of agrammatism rather, than rejecting them.

On the basis of the considerations presented so far, it seems that arriving at an uncontroversial linguistic account of agrammatism is still a matter of future research. Attempts made so far in this field, such as the morphosyntactic theories – the TDH and TPH, are promising and worth further investigation. If future research is to take advantage of these accounts, it should address the criticisms put forward with respect to these accounts. Therefore, the following issues can be postulated for undertaking in further research:

1. More evidence from cross-linguistic studies on language constructions critical for the assessment of the TDH and TPH should be collected;
2. If the cross-linguistic data indeed fail to conform to the predictions following from the two hypotheses, such modifications should be introduced into these theories which would allow for parametric variation among agrammatic performances in various languages;
3. Strong localization assumptions should not be made. The relations between anatomical localization of lesions and grammatical processing deficits should follow thorough observations and studies;
4. Methodological aspects of research should be addressed more explicitly. Specifically, statistical procedures applied should be unified and the criteria for inclusion of patients into research projects should be clearly defined.
5. Attempts for unifying the theories accounting for language production and language comprehension in agrammatism should be made. Such a unification ought to include both the linguistic models utilized and the search for a common explanation for the disruption of production and comprehension;
6. The linguistic accounts of agrammatism should be refined so that they do not need to resort to non-linguistic or outside-theory elements (such as the default strategy in the TDH);
7. Finally, the morphosyntactic accounts should be compared to other linguistic and psycholinguistic accounts in order to verify which of them are capable of better explaining the language disruption patterns in agrammatism.

The above suggestions offer the opportunity for shedding more light on the issue of agrammatism in Broca's aphasia, but also for improving our understanding of the phenomenon of aphasia as such and, consequently, our understanding of language processing in the human mind.

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