

What is special about Broca's area?

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Abstract: We discuss problematic theoretical and empirical issues and consider alternative explanations for Grodzinsky's hypotheses regarding receptive and expressive syntactic mechanisms in agrammatic aphasia. We also explore his claims pertaining to domain-specificity and neuroanatomical localization.

Grodzinsky has presented an impressive range of evidence from aphasia in support of the view that Broca's area and surrounding structures (hereafter referred to as "Broca's region") underlie receptive and expressive syntactic mechanisms. His endeavor to ground his hypotheses in linguistic theory is particularly valuable. Here we discuss a number of problematic theoretical and empirical issues related to his claims.

A syntactic role for Broca's region? Receptive mechanisms.

First we address theoretical issues. In the syntactic framework assumed by Grodzinsky, certain constraints apply to all traces (the Empty Category Principle), whereas others distinguish not only between X⁰- and XP-traces, but also between two types of XP traces (Chomsky 1981; 1986; Rizzi 1990). Grodzinsky's theoretical motivation for implicating Broca's region in the former dis-

tion, but not the latter, is unclear. One principled difference is that XP but not X⁰ traces are assigned thematic roles. However, Grodzinsky rejects the view that the receptive impairment concerns the mediating function of traces in thematic-role assignment (also see Grodzinsky & Finkel 1998). More generally, syntactic theory has shifted away from the concept of traces as syntactic objects in their own right or even as notational devices (Chomsky 1995a), further undermining the theoretical basis of positing a neurological deficit specific to traces.

Second, we turn to empirical issues. The arguments that Grodzinsky presents in support of the Trace Deletion Hypothesis (TDH) rely crucially on a three-way distinction between aphasics' performance at, below, or above chance. However, in a number of cases the level at which aphasics perform is not the one predicted by the TDH. English object-gap relative clauses and Japanese object scrambling are two examples. If subjects are assigned a thematic role through the mediation of a trace (the VP-Internal Subject hypothesis assumed by Grodzinsky), the grammatical assignment of an Agent role to the subject should be precluded in such structures. Thus the subject should not enter into thematic competition with the object (which should get the Agent role by the default strategy), resulting in below-chance performance and not the reported chance performance. Chinese subject-gap relatives are another example. Here, the object gets the grammatically assigned role of Theme. The subject should not compete for this role (unless the default strategy is modified so that non-first NPs get the Theme role), so the observed chance performance would be unexpected. If thematic-role assignment to objects is also trace-mediated (Chomsky 1995a), the object could not be assigned a thematic role grammatically, and should be assigned an Agent role by default, given its linear position as the first NP. This would result in below-chance performance in Chinese object-relatives. Additional sentence types problematic for the TDH are discussed by Beretta et al. (1999), Berndt and Caramazza (1999), and others.

Third, there may be alternative explanations. Grodzinsky discusses only briefly working memory and speed of processing deficits, both of which have been proposed to explain receptive agrammatism (see Kolk 1998). Both explanations warrant further examination: Broca's area has been linked strongly to working memory (Fiez et al. 1996b; Smith & Jonides 1997), and also to fast temporal processing (Fiez et al. 1995). Importantly, reports of dissociations between receptive syntax and working memory (Caplan & Waters 1999) are consistent with the view that different frontal regions may subserve different types of working memory (Smith & Jonides 1997).

Expressive mechanisms. We address theoretical issues first. Unlike the dichotomies between lexical versus functional, or Comp(lementizer)-related versus Infl(ection)-related projections, there is no clear theoretical basis to Grodzinsky's proposed categorical distinction between Tense and Agreement. Moreover, it has been argued that the relative order of Tense and Agreement is crosslinguistically parameterized (e.g., Ouhalla 1991); the order in English is posited to be opposite to that which Grodzinsky adopts for Hebrew, with Agr^S (the projection licensing subject-verb agreement) higher than Tense (Chomsky 1993). Thus, impaired Tense and intact Agreement would not be expected in both English and Hebrew, contrary to Grodzinsky's claims.

Empirical issues are also problematic. The data are not consistent with a Tense/Agreement categorical distinction. First, Tense itself can be spared in agrammatism, whereas higher projections are impaired (see Hagiwara 1995). Second, agrammatics can show a graded impairment, with increasingly worse performance at higher projections. For example, Ullman et al. (in press) report decreasing production rates of verbal inflection at increasingly higher levels in the syntactic hierarchy (see also data presented in Hagiwara 1995).

Finally, there appear to be alternative explanations. Hagiwara (1995) has proposed that agrammatics' grammar allows convergence (i.e., successful computation) at lower functional projec-

tions, because such structures are less costly from a global economy perspective (i.e., comparing different syntactic derivations; Chomsky 1993). Ullman et al. (in press) argue that graded impairments of functional projections can be explained by deficits of concatenation and/or movement. Because functional categories are assumed to be concatenated and to trigger verb movement stepwise into hierarchical structures, from lower to higher categories (Chomsky 1993), such deficits should yield a greater likelihood of successful computation of lower than higher categories.

Relation between receptive and expressive mechanisms. We have two concerns with the receptive and expressive deficits posited to underlie agrammatism: the lack of an independent factor, linguistic or neuropsychological, unifying the two, and the highly specific nature of the deficits. Impaired computation could arise from deficits of linguistic knowledge (competence) or processing (performance). Although linguistic knowledge is often thought of as highly modular (Chomsky 1981; 1995a), it is generally thought to underlie the computation of structures in both the receptive and expressive modalities (e.g., Crain & Fodor 1989). Thus if linguistic knowledge is affected, the deficit should similarly affect both modalities, contrary to Grodzinsky's claims. Indeed, greater deficits in higher than lower functional categories are found in *receptive* as well as expressive agrammatism (Hagiwara 1995). In contrast, although different *processing* mechanisms may be posited for receptive and expressive modalities, they do not normally employ highly specific components, such as a module whose only function is to construct solely those parts of the syntactic tree at and above Tense.

Is Broca's region domain-specific? It is not clear whether Grodzinsky is suggesting that all of Broca's region is dedicated to language, or whether, within this region, there exist specific structures dedicated to language. The first case is clearly false: Evidence suggests that Broca's area underlies motor functions (see Rizzolatti & Arbib 1998). The second case is also problematic. To demonstrate domain-specificity, one must show that *no* nonlanguage functions are subserved by the neural material or cognitive component in question. At the very least it should be demonstrated that those nonlanguage functions most likely to explain a set of linguistic impairments do not co-occur with those impairments. It is therefore puzzling that Grodzinsky concentrates on mathematical combinatorial skills, given that he explicitly posits that Broca's region does not subserve the "basic combinatorial capacities necessary for language processing" (Abstract).

Grodzinsky also claims that Broca's region plays a restricted role within language, subserving only the two hypothesized syntactic functions. However, Broca's aphasics are more impaired at producing, reading, and even judging regularly inflected than irregularly inflected forms (Badecker & Caramazza 1987; Marin et al. 1976; Ullman et al. 1997; in press). This morphological affixation deficit in both expression and reception cannot be explained by Grodzinsky's hypothesized syntactic dysfunctions. Finally, there is also substantial evidence that Broca's area plays a role in phonology (see Demonet et al. 1996) and in lexical search or retrieval (see Buckner & Tulving 1995).

Anatomical localization. Grodzinsky's effort to implicate Broca's region alone in the hypothesized syntactic functions is hampered by problems of patient selection. Conclusions regarding the function of Broca's region would be less problematic if patients were selected *solely* on the basis of their lesions, which should be limited to those structures. However, many of the Broca's aphasics on which Grodzinsky bases his claims also have lesions outside Broca's region, or, even worse, have no reported lesions to this region at all (e.g., Friedmann & Grodzinsky 1997; Grodzinsky 1989; Grodzinsky & Finkel 1998. For additional discussion on patient selection, see Berndt & Caramazza 1999; Grodzinsky et al. 1999.) More generally, chronic Broca's aphasia is also associated with damage to left parietal regions (Alexander 1997). Grodzinsky points out that Wernicke's aphasics' failures in syntactic comprehension are inconsistent and varied. Perhaps this variability of impairments correlates with Wernicke's aphasics'

variability in damage to inferior parietal regions (Alexander 1997). Indeed, conduction aphasia is associated with both left inferior parietal damage (Alexander 1997) and syntactic processing deficits (see Caramazza et al. 1981). It may be that left inferior parietal regions, in concert with left frontal structures, underlie grammatical processing, in a working memory role (Smith & Jonides 1997), or perhaps as a repository of grammatical knowledge.

Conclusion. We have argued that a number of Grodzinsky's specific claims are problematic, and should therefore be weakened or modified. Nevertheless, we strongly support his program relating language deficits to linguistic theory, and believe that such an approach will prove crucial to our understanding of both the neurobiology and structure of language.

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