Patterns of comprehension performance in agrammatic Broca's aphasia: A test of the Trace Deletion Hypothesis

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Abstract

We tested the core prediction of the Trace Deletion Hypothesis (TDH) of agrammatic Broca's aphasia, which contends that such patients' comprehension performance is normal for active reversible sentences but at chance level for passive reversible sentences. We analyzed the comprehension performance of 38 Italian Broca's aphasics with verified damage to Broca's area, who completed sentence-to-picture matching tasks using active and passive reversible sentences as stimuli. The results failed to confirm the predictions made by TDH: only a small minority (15%) performed at chance on passive sentences and better than chance on active sentences. Furthermore, the distribution of the 38 subjects' performance on passive sentences differed from that predicted by the TDH since many more subjects performed at better-than-chance levels than expected. We discuss the implication of these results for claims about the distribution of language processing mechanisms in the brain.
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1. Introduction

Is agrammatic Broca's aphasia associated with a specific comprehension performance profile? This question has been one of the central foci of investigation in aphasia research, at least since Caramazza and Zurif (1976) first showed that a group of Broca's aphasics performed poorly in a sentence comprehension task with semantically reversible sentences—sentences that require correct syntactic analysis for good performance. Caramazza and Zurif's observation received ample confirmation in subsequent studies (e.g., Caramazza, Berndt, Basili, & Koller, 1981; Goodglass et al., 1979; Heilman & Scholes, 1976; Schwartz, Saffran, & Marin, 1980) leading to the proposal that Broca's aphasia reflects a deficit of syntactic processing and that, therefore, Broca's area is importantly implicated in syntactic analysis (see also Caramazza & Berndt, 1978; Caramazza & Zurif, 1976). However, it has since become apparent that not all Broca's aphasics present with asyntactic comprehension (the failure to understand semantically reversible sentences; Bastiaanse, 1995; Caramazza & Hillis, 1989; Kolk, Van Grunsven, & Keyser, 1985; Laine, Niemi, Niemi, & Koivuselka-Sällinen, 1990; Miceli, Mazzucchi, Menn, & Goodglass, 1983; Nespoulous et al., 1988), and that not all subjects with asyntactic comprehension also present with agrammatic production (e.g., Caramazza & Miceli, 1991; Martin & Blossom-Stach, 1986).

The reported dissociation between agrammatic speech and asyntactic comprehension is clearly problematic for the hypothesis that both deficits are caused by damage to a common syntactic processing mechanism

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implicating Broca's area. The reaction to this state of affairs has not been uniform. Some researchers interpreted the dissociation as indicating that the complex performance of Broca's aphasics reflects the contribution of damage to neurally adjacent but functionally independent mechanisms involved in language production and comprehension (e.g., Caramazza & Berndt, 1985; Goodglass & Menn, 1985), which are often damaged together because of their neural proximity but on occasion can be affected selectively, resulting in the observed dissociations. Other researchers, while acknowledging the existence of the apparently problematic cases, did not deem those results sufficiently clearcut to abandon the view that agrammatic production and asyntactic comprehension result from a common cause and that, therefore, must be impaired or spared together (e.g., Grodzinsky, 2000; Zurif, 1996). But, what could motivate such a position?

In a recent paper, Grodzinsky, Piñango, Zurif, and Drai (1999) provided a justification for dismissing the recalcitrant results for the unitary deficit hypothesis of Broca's aphasia. They argued that those data came from single-case studies and therefore their interpretation is uncertain unless considered in the broader context of all other relevant cases of agrammatic Broca's aphasia. Specifically, they argued that the recalcitrant case reports merely represent outliers in a normally distributed pattern of results that conform with the predictions derived from their theory of agrammatic Broca's aphasia.[1] This theory attributes agrammatic patients' comprehension failure to an inability to co-index phonological traces, denoting moved constituents (the so-called Trace Deletion Hypothesis—TDH), because of damage to such traces.

According to this theory, under normal conditions understanding a passive sentence like *The boy is kissed by the girl* relies on the correct processing of phonological traces. In the example, *The boy$_i$ is kissed t_i by the girl* contains a trace (t_i) that signals the movement of the noun phrase *The boy*, corresponding to the theme role in the thematic grid of the verb, to the subject position. Intact ability to process the trace is crucial for understanding the sentence, since it provides the strongest cue for assigning the subject (hence, the theme) role to the correct noun phrase. If the trace were somehow unavailable (because of brain damage), the unambiguous assignment of thematic roles would be impossible. Under these pathological circumstances, the agent role would be assigned both to the first noun, on the basis of

order information, and to the second noun, on the basis of information about passive morphology (the—*by* phrase). Faced with such conflicting information, the agrammatic subject has little choice but to randomly assign the agent role to the first or to the second noun. However, performance on actives would be good because in these sentences linear order and hierarchical structure converge in assigning the agent role to the first noun of the sentence (the subject). Thus, this account predicts that Broca's aphasics should comprehend active, reversible sentences normally, and perform at random on passive, reversible sentences. Grodzinsky et al. (1999) further argue that their theory predicts that in agrammatic Broca's aphasics *taken as a group*, comprehension of passive reversible sentences should be at chance *on average*, but individual scores should be distributed in a gaussian curve—most subjects scoring at chance levels, and others reaching scores more or less distant from the mean, in both directions.

To support this proposal, Grodzinsky et al. (1999) produced a meta-analysis of approximately 40 published cases of agrammatic Broca's aphasia, all of whom completed testing of sentence comprehension with varying numbers of active and passive reversible sentences. The average performance of these subjects taken as a group was better than chance on reversible actives, was indistinguishable from chance on reversible passives, and was significantly more accurate for actives than for passives. The methodological approach to the analysis of comprehension performance used by Grodzinsky and collaborators has been criticized by several authors (Berndt & Caramazza, 1999; Caplan, 2001; Caramazza et al., 2001). Caramazza et al. (2001), for example, analyzed the same database used by Grodzinsky et al. but reached the opposite conclusion (see also Berndt, Mitchum, & Haendiges, 1996). They conducted an individual subject analysis of the comprehension results, and calculated for each subject the probability that the observed performance deviated to a statistically significant extent from the expected chance distribution. Their analysis showed that the profile predicted by Grodzinsky et al. (1999), that is, good performance on actives and chance performance on passives, was only one, and not even the most frequent, of the patterns of performance observed in the sample considered in the meta-analysis. Similarly heterogeneous results were obtained in a study on the comprehension of active and passive reversible sentences by Luzzatti, Toraldo, Ghirardi, Lorenzi, and Guarnaschelli (2001). The conclusion reached by Caramazza et al. (2001) was that, even if one accepted the logic of Grodzinsky et al.'s claim (but see Footnote 1), the pattern of performance of the subjects entered in the meta-analysis did not fall in a normal distribution—outliers were far too numerous, and their error distribution patterns violated the expectations of a normal distribution. This outcome is inconsistent with the view of a common

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[1] Here we leave aside the fact that this argument is specious. As we have argued elsewhere (Caramazza, Capitani, Rey, & Berndt, 2001; see also Caplan, 2001), when properly analyzed the investigation of individual cases explicitly considers the probability that the patient's performance deviates from a theoretically expected value (in this case, chance level).