Syntactic comprehension in agrammatism:

A computational model

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Abstract

In this paper we present a detailed computational model of agrammatic aphasia that is consistent with the Slow Syntax Hypothesis. In particular, our model postulates that the cause of the slowing of syntax processing is a deficit in overcoming irrelevant active lexical cues. This causes interference in retrieval of lexical and semantic information, which in turn causes a misrepresentation of semantic content. We show that the model, opportunely damaged, can simulate the impairment of patients in the understanding of psychological verbs.

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Introduction

Current hypotheses about agrammatism refer to different frameworks. Within the framework of the Government and Binding theory, Grodzinsky's Trace Deletion Hypothesis (TDH) states that agrammatism results from a damage to a specific mechanism connecting the antecedent to its trace (Grodzinsky, 2000). In opposition to the TDH, Piñango (2000) put forward the Slow Syntax Hypothesis, which drives attention on the effects of the movement of the grammatical constituents of a sentence, and focuses on a type of movement that provokes a deviation from the canonical order of thematic roles in the surface representation of the sentence. According to this view, lexical activation in agrammatic patients is slower than normal, and therefore they are unable to build the syntactic structure of the sentence quickly enough to prevent semantic linking from emerging and dominating the meaning derivation process.

A computational model

We postulated that the cause of such slowing is an inability to inhibit intrusive lexical information. We specified this hypothesis within a computational model, developed within the ACT-R architecture (Anderson et al., 2004). We had it reproduce the syntactic performance of normal participants and, then, performed a virtual damage to simulate agrammatic patients.

In our model we tried to reproduce in the most detail the parsing process, basing it on a previous ACT-R model developed by Lewis (1999). Our model automatically retrieves the syntactic category of each word processed and integrates that knowledge into a syntactic parse of the sentence. This process also involves the creation of a representation holding the semantic information that is extracted from the sentence.

The crucial step is the retrieval of a thematic grid, which triggers the assignment of roles to the encountered nouns. This retrieval is cued by the processing of specific words, which are either nouns, verbs or words denoting a passive form.

Thematic grids, like any other piece of declarative knowledge in the model, have an associated activation value that expresses their availability to retrieval and reflects the past history of the chunk itself. This base-level activation may be overcome by a contextual component, which spreads from the amount of attentional resources devoted to a specific lexical cue. This amount is ruled by a single parameter, *W*. By maintaining sustained activation of a few elements, this parameter enables working memory and goal-directed behavior (Altmann & Trafton, 2002). Given its function, this parameter is closely connected with the integrity of prefrontal cortex.

We tested our model within the simplified domain of psychological verbs. These verbs are divided in two classes, depending on whether the thematic role of Experiencer shows up as the subject (*Subject-Experiencer* verbs) or the object (*Object-Experiencer* verbs) of the sentence. In active form, verbs of the first group have a default Experiencer/Theme thematic construction, whereas the others require a Theme/Experiencer grid. As reported in Grodzinsky (2000), agrammatic patients perform well with the first ones in comprehension tests, but at chance with the seconds. However, with sentences in the passive form, the pattern is reversed, with patients performing well on the second and poorly on the first ones.

Since the default argument order is Experience/Theme, this information is more active. Contextual activation is required to overcome it and retrieve the opposite structure, as is in passive forms of ES and active forms of EO verbs. With an abnormally lower value of *W,* the contribution of contextual activation is insufficient to enhance the Theme/Experiencer grid, letting the default one compete for retrieval. This interference increases the time needed to complete it and the probability of assigning the wrong roles in the semantic representation.

Results

We test our model's syntactic comprehension in a simulated experiment. The model was first presented with a study set of 12 sentence, made of six SE verbs and six OE verbs. In each category, half of the sentences were in active, and the other half in passive form. The model was tested on a second set of other 12 sentences, made with the same materials of the first ones. As predicted by our account, in the damaged version, model's performance was at chance when the study or the test sentence was either a passive ES or an active EO sentence. An examination of model's semantic representation showed that in both cases there was a 50% chance of misrepresenting thematic roles. Results from our simulations are summarized in Figure 1. A further "test" session was presented to the model, showing that, when running as an aphasic, it can correctly recognized the meaning of a sentence only if both the study and the test items were either ES active or EO passive sentences.

Discussion

We presented a computational model that postulates agrammatism as a disorder stemming from the inability of using on-line lexical information to overcome interference amongst competing syntactic elements. This approach is consistent with the time course hypothesized within the SSH. Computer simulations showed that, in virtually damaged conditions, the model could correctly reproduce the behavior of both participants and aphasic patients.

References

Anderson, J. R., Bothell, D., Byrne, M. D., Douglass, S., Lebiere, C., & Qin, Y . (2004). An integrated theory of the mind. *Psychological Review*, *111*, 1036-1060.

Altmann, E. M. & Trafton, J. G. (2002). Memory for goals: An activation-based model. *Cognitive Science*, *26*, 39-83

Grodzinsky, Y. (2000). The neurology of syntax: language use without Broca's area. *Behavioral and Brain Sciences,* 23, 1-71.

Lewis, R. L. (1999). *Attachment without competition: A race-based model of ambiguity resolution in a limited working memory*. Presented at the CUNY Sentence Processing Conference, New York.

Piñango, M. M. (2000). Canonicity in Broca's sentence comprehension: The case of psychological verbs. In Y. Grodzinsky (Ed.), *Language and the brain: Representation and processing* (pp. 327–350). San Diego/London: Academic Press.

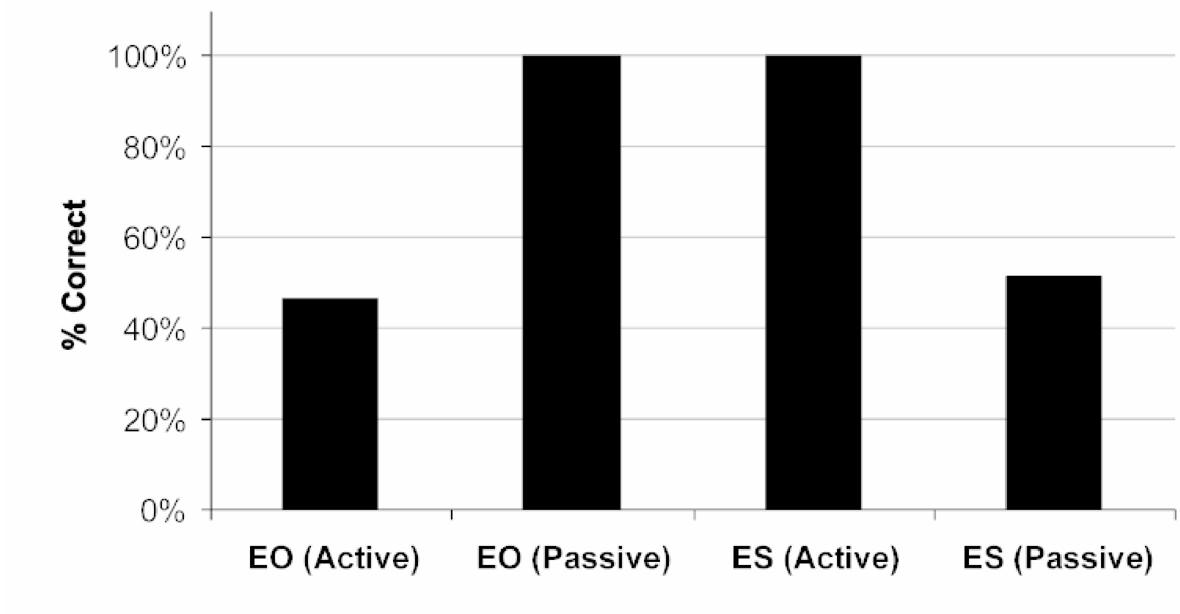

Figure 1: Mean performance of the model in the comprehension of different sentences with psychological verbs. Results are averaged over 200 simulations in the “aphasic” condition.

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