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Grammaticality judgment under non-optimal processing conditions: Deficits induced in normal participants resemble those observed in aphasic patients

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Introduction

Not all sentence types are affected equally in agrammatic aphasia. For instance, Schwartz, Saffran and Marin (1980) found that Broca's aphasic patients perform much better on semantically reversible active sentences than they do on passive structures. Some researchers have interpreted such patterns as indicative of impairments to particular grammatical representations or processes. One proposal is that agrammatic aphasic patients are selectively impaired in their ability to process structures involving traces of maximal projections (Grodzinsky & Finkel, 1998). However, such claims are challenged by the finding that, under conditions of acoustic degradation and/or increased processing load, patterns of deficits can be induced in normal participants which closely mirror those seen in agrammatic aphasia (Dick et al., 2001). This suggests that the data from agrammatic aphasia do not necessarily justify the postulation of localized neural substrates for highly specific syntactic mechanisms.

Most previous work comparing patterns of breakdown in aphasia with patterns of breakdown in normals under non-optimal processing conditions has been in the domain of sentence comprehension (e.g., Dick et al., 2001). Another domain in which similar questions can be addressed is grammaticality judgment. We have recently shown that aphasic patients tend to be impaired in grammaticality judgment across-the-board on a variety of sentence types, unlike in sentence comprehension where more complex structures are differentially affected (Wilson & Saygin, submitted). The hypothesis that domain-general factors may account for patterns of agrammatic performance thus predicts that acoustic degradation and increased processing load should impact grammaticality judgment roughly equally across all sentence types, since this is the pattern observed in agrammatic aphasia. Here we tested this hypothesis by asking normal controls to perform grammaticality judgments under optimal conditions versus three different non-optimal processing conditions. Four types of sentences were presented, crossing two factors: whether or not grammaticality depends upon a trace of a maximal projection, and whether the sentences were more or less complex.

Methods

Forty-six UCSD college students participated, and were assigned to one of the following four conditions: In condition 1 (control condition), participants were presented with sentences both visually and auditorily, and were asked to make grammaticality judgments. In all other conditions, sentences were presented only auditorily. In condition 2, sentences were acoustically degraded by compressing them to 80% of their original length and applying a low-pass filter at 1200 Hz. Condition 3 was similar but more challenging: sentences were compressed to 70% and low-pass filtered at 800 Hz. In condition 4, sentences were compressed and filtered as in condition 2, plus participants had to perform a distracting linguistic task in addition to grammaticality judgment: words and nonwords were displayed visually at a rate of 2 per second for 3.5 s during auditory sentence presentation, and participants had to read the real words aloud.

There were 24 sentences in each condition, half grammatical and half ungrammatical. Sentences were recorded in a sound-proof booth by an experienced phonologist who was instructed to avoid prosodic cues to grammaticality status. The stimuli were edited with SoundEdit 16 and presented with PsyScope.

Results

A repeated measures ANOVA comparing the performance of the four groups on the four sentence types revealed significant main effects of group [$F(3, 42) = 101.82$, $p < .0001$], and sentence type [$F(3, 126) = 10.64$, $p < .0001$]. Unsurprisingly, performance was better under optimal conditions, and better on the "easy" sentence types (Fig. 1). Crucially, the group by sentence type interaction was not significant [$F(9, 126) = 0.97$, $p = 0.46$], implying that all manipulations affected the four sentence types across-the-board, without differential effects on any particular sentence type. This is similar to across-the-board deficits seen in aphasic patients (Wilson & Saygin, submitted), whose pooled results are also depicted in Fig. 1. In fact, the condition where sentences were compressed to 70% and filtered at 800 Hz was statistically indistinguishable from the pooled results of all aphasic patients from that study. Thus this manipulation succeeded in roughly "simulating" the average performance profile of aphasic patients.

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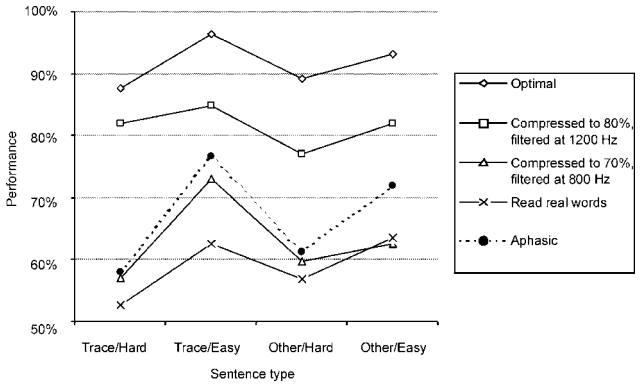

Fig. 1. Grammaticality judgment performance by group and condition.

Discussion

Breakdown of grammaticality judgment under nonoptimal processing conditions closely resembles the breakdown observed in aphasic patients. Specifically, in both cases, sentence types were affected across-the-board: differential impairments were not observed for judgments relying on traces of maximal projections, not for more difficult judgments. These results differ sharply from those obtained in sentence comprehension studies, where structures with noncanonical word order are differentially affected both in aphasia and under degraded processing conditions (Dick et al., 2001). This may follow from the fact that our grammaticality judgment task does not provide a single salient cue (e.g., canonical vs. noncanonical word order) of the sort manipulated in prior studies of sentence comprehension under non-optimal conditions. More generally, similarities between the performance of aphasic patients and the performance of normal participants under nonoptimal processing conditions, both in this study and in sentence comprehension studies, suggest that patterns of deficits observed in agrammatic aphasia may follow from damage to domain-general systems. Although it is unlikely that all aphasic deficits reflect damage to peripheral processes, claims regarding syntax-specific deficits require the discovery of patterns that differ in principled ways from those that can be obtained using peripheral stressors.

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