

Syntactic dependency resolution in Broca's aphasia

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Introduction

Research on sentence comprehension in aphasia has shown that individuals with agrammatic Broca's aphasia often exhibit a highly selective deficit in processing intra-sentential dependencies; comprehension of sentences that contain filler-gap dependencies (i.e. A'-Movement) is impaired, whereas comprehension of sentences that contain Binding relations are relatively spared. This dissociation has been attributed to the fact that there are important syntactic and processing differences between the two dependencies (Santi & Grodzinsky, 2007a, 2012). Syntactically, the antecedent of a reflexive (*John* in (1a)) is in a theta position, whereas in A'-Movement, the displaced filler (*the man*, *that*, in (1b)) is not.

- (1) a. Mary knows that John₁ loves himself₁ *Binding*
 b. Mary knows the man₁ that₁ David pinched t₁ *Movement*

One could therefore hypothesize that the dissociation should be linked to predictability, i.e. whether the dependencies can be identified at an early stage of processing based on syntactic factors. In A'-Movement, the processor encounters the filler early on and provides a warning that the reader/hearer should store the DP in memory and go hunting for a gap (predictable dependency). In Binding no such cues are available; the dependency becomes evident only when processing reaches the reflexive, which is assigned its anaphoric reference in retrospect (unpredictable dependency). The two dependencies also make different demands on Working Memory (WM). A'-Movement puts greater demands on storage processes, but Binding on retrieval processes (Santi & Grodzinsky, 2012).

The hypothesis that predictability is the key factor distinguishing A'-Movement from Binding makes the further prediction that relations mediated by leftward LF movement should behave like Binding. This prediction is supported by the finding that agrammatic patients perform normally on ambiguous doubly quantified sentences (e.g. *A woman is photographing every child*) (Saddy, 1995; Varkanitsa et al., 2012), whose inverse scope reading involves (leftward) Quantifier Raising in the LF component (May, 1977).

The present study investigates whether this asymmetry in predictability effects between overt and covert leftward movement is also manifested in the processing

of sentences with contrastive foci (CF) by Greek-speaking patients with Broca's aphasia. As shown in (2), Greek provides an appropriate minimal pair, with the CF either moved or in situ.

- (2) a. Ti GINEKA₁ filai o adras t₁ ohi to koritsi. *Moved CF*
 The WOMAN_{1ACC} is kissing the man_{NOM} t₁ not the girl.
 'The WOMAN the man is kissing, not the girl.'
- b. O andras_{NOM} filai ti GINEKA_{ACC} ohi to koritsi. *In situ CF*
 The man is kissing the WOMAN not the girl
 'The man is kissing the WOMAN, not the girl.'

Methods

Participants

Four chronic Greek-speaking patients with aphasia and four non-brain-damaged individuals participated in the study. Three patients are also agrammatic, that is, they exhibited impaired comprehension of movement-derived sentences (i.e. *wh*-questions and passives) during background testing, whereas comprehension of simple semantically reversible sentences was well preserved. Patients' WM was assessed with the digit span task and the Corsi block-tapping task (forward and backward). The agrammatic patients demonstrated WM deficits in both tasks, whereas the non-agrammatic patient performed within normal limits.

Procedure

Participants performed a picture-selection task, consisted of two experimental conditions and two filler conditions. The experimental conditions included sentences with moved object-CF and sentences with in situ object-CF. Sentences with subject-CF and simple transitives were used as fillers. Each condition included 20 semantically reversible sentences.

Results

Patients' performance on the picture selection task, presented in Table 1, revealed a dissociation between processing of sentences containing moved CF, as in (2a), and sentences containing in situ CF, as in (2b). The agrammatic patients (i.e. AG, AV, AA) performed significantly lower in the condition with displaced object-CF compared to the condition with in situ object-CF. This dissociation disappears in the case of the non-agrammatic patient (MD) who performed relatively well on both conditions. Controls performed at ceiling and, hence, their results won't be discussed here.

Discussion

These findings provide further evidence that predictability and the load it places on WM is a key factor in Broca's aphasia. An in situ CF must undergo LF movement

Table 1: Number of correct responses (/total) in the experimental conditions

	moved object-CF	in situ object-CF
AG	3/20	16/20
AV	8/20	14/20
AA	15/20	20/20
MD	19/20	20/20

to the left periphery of the clause so as to take scope over its background. As was the case with Quantifier Raising, this covert leftward movement appears spared in Broca's aphasics. Taken together, these results suggest that the problems with overt movement are WM-related.

This conclusion is further supported by the fact that all the agrammatic patients that participated in this study had lesions that include left IFG, whereas in the non-agrammatic patient left IFG was intact. Recent neuroimaging studies of non-brain-damaged individuals have shown that the presence of a syntactic dependency is not a sufficient condition for activating left Inferior Frontal Gyrus (IFG). Rather, a predictable displacement, as in movement-derived sentences, is required (Santi & Grodzinsky, 2007a, 2007b, 2012). This suggests that Broca's area hosts a 'syntactically constrained WM' (Santi & Grodzinsky, 2012: 830), that is the component of WM which is responsible for storage processes.

A currently unresolved issue is how the impaired performance on reversible passives in Broca's aphasia should be accounted for. Neuroimaging studies report activation in Broca's area, however the fact that patients' performance varies widely may suggest that the manner of Broca's area involvement is different from A'-Movement (Santi & Grodzinsky, 2012).

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