

# Production of Arguments and Adjuncts in Normal and Agrammatic Aphasic Speakers: An Eyetracking Study

Jiyeon Lee & Cynthia K. Thompson

## Introduction

Agrammatic speakers are impaired in producing verbs and sentences with complex argument structure, often omitting arguments and avoiding adjuncts (e.g., Thompson et al., 1997; Caplan et al., unpublished). This deficit has been attributed to their inability to grammatically encode a message, based on Bock & Levelt (1994)'s language production model. *However, it is unclear whether the deficit is specific to constituent assembly or arises from the earlier level of function assignment.* To investigate this question, this study examines real-time production of arguments and adjuncts, using eyetracking.

Processing an adjunct phrase, not specified by a verb, involves additional costs in both assigning its thematic role and assembling it into the sentence frame (Boland & Blodgett, 2006)

Monitoring eye movements (EM) during speech provides real-time references for when a speaker prepares what (e.g., Griffin & Bock, 2000; Griffin & Mouzou, 2004).

- EM before speech onset: difficulty deciding thematic roles and the subject
- EM during speech: difficulty ordering and lexically encoding words

**Prediction:** if the deficit is specific to constituent assembly, aphasics would show greater difficulty for adjuncts than for arguments during speech. Conversely, if the deficit is attributable to function assignment, aphasic speakers would show greater difficulty for adjuncts than for arguments prior to speech onset.

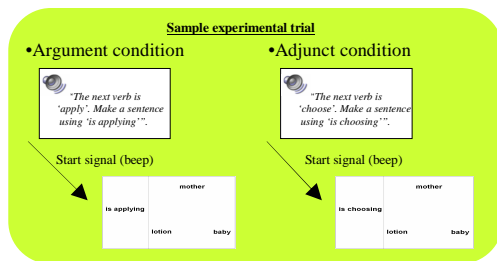
## Methods

**Participants:** 13 healthy college students (age:18-22)  
9 individuals with agrammatic Broca's aphasia (age: 35-60, WAB AQ: 61-84).

**Task:** Participants were asked to produce sentences using written words presented on a computer screen (see below), as their eye movements were tracked using ASL eyelink system. They were encouraged to include all words presented.

### Materials:

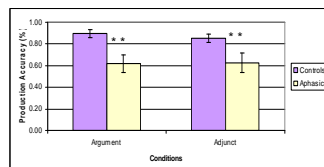
- **Verbs:** 10 non-alternating dative (M log freq = 1.84, CELEX) and 10 transitive verbs (M log freq = 1.74) for Argument (n=20) and Adjunct (n=20) condition, respectively. Each verb was used twice.
- **Nouns:** The same 40 animate and 20 inanimate nouns were used in both conditions. The role relationship of N1 & N3 was biased.  
e.g., The mother is applying the lotion to the baby. (Argument)  
N1 Verb N2 N3  
The mother is choosing the lotion for the baby. (Adjunct)  
N1 Verb N2 N3
- **Fillers:** 20 intransitive sentences (e.g., *The small rabbit is running*).



- The order of trials and the position of nouns were randomized.
- Only first attempts (N1+Verb structure, minimally) were analyzed.

## Results

**Figure 1. Production Accuracy**



\*\* =  $p$ 's < 0.001 by participants & items

**Table 1. Aphasic error analysis**

Error types	Argument	Adjunct
Missing N2 (theme)	7 (11%)	4 (6%)
Missing N3	1 (2%)	5 (8%)
Missing N2 & N3	8 (12%)	5 (8%)
Misordered N2 & N3	10 (16%)	9 (14%)
Misordered N1 & N3	18 (28%)	14 (22%)
Others	20 (31%)	27 (42%)
Total errors	64 (100%)	64 (100%)

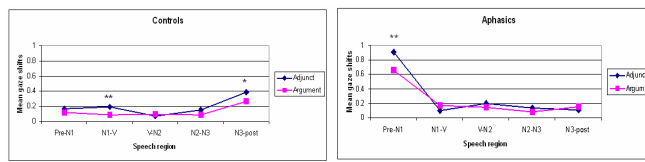
• 2 (condition) x 2 (group) ANOVA's: main effects of group only ( $F(1,40) = 24.6$ ;  $F(2,176) = 42.9$ ,  $p$ 's < 0.001).

• Although aphasics' accuracies were lower than controls, both groups produced arguments and adjuncts equally well.

• Control speakers' errors consisted of mostly non-target structures: e.g., embedded sentences (*The nanny is boiling the milk to give to the toddler.*); complex NP (*The nanny is boiling the toddler's milk.*)

### Eye Movement Data, Correct Responses Only

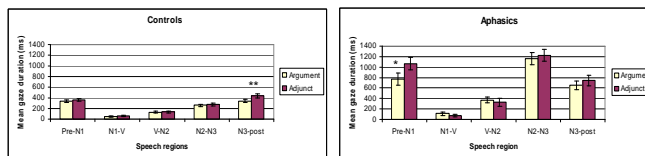
**Figure 2. Gaze shifts between the Verb and N3 by speech region**



\*\* =  $p$ 's < 0.05 by participants & items, \* =  $p$  < 0.05 by participants, one-tailed paired  $t$ -tests.

• Control speakers shifted their gazes between the Verb and N3 greater in the adjunct condition *before the verb & during N3 production*. However, the aphasic speakers showed this pattern *before speech onset*.

**Figure 3. Mean gaze durations to N3 by speech region**



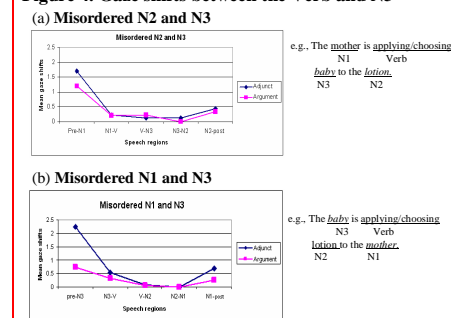
\*\* =  $p$ 's < 0.05 by participants & items, \* =  $p$  < 0.05 by participants, one-tailed paired  $t$ -tests.

• Control speakers gazed at adjunct N3s longer than argument N3s *while saying N3*, but aphasic speakers showed this pattern *before speech onset*.

## Results

### Eye Movement Data, Errors, Aphasics

**Figure 4. Gaze shifts between the Verb and N3**



• Aphasics shifted their gazes between the Verb and N3 more frequently for word order errors than for correct responses.  
• The increased gaze shifts occurred *before speech onset*.

## Discussion

• Both participant groups produced arguments and adjuncts equally well off-line, but their eye movements revealed **greater processing costs for adjuncts** as compared to arguments, consistent with previous comprehension studies (e.g., Boland & Blodgett, 2006).

- Participants showed longer gaze durations to N3 and a greater number of gaze shifts between the Verb and N3 when N3 was an adjunct as compared to when it was an argument (Figures 2 & 3).

• Importantly, **control speakers** showed increased gaze shifts and durations for sentences with adjuncts mainly *during speech* (prior to the Verb and during production of N3), whereas, **aphasic speakers** showed these patterns *before speech onset*, suggesting:

• While controls use verb information to encode adjuncts incrementally, aphasic speakers use verb information earlier, computing the adjunct (N3)'s functional role in the sentence.

• Although aphasic speakers can differentiate adjuncts from arguments, based on their preserved knowledge of verb, their ability to assign functional roles between words may be compromised.

• Preliminary error data suggest that word order errors also stem from difficulty during early stage of grammatical encoding.

## Conclusion

**Our data suggest that agrammatic speakers' deficits in sentence production arise from the level of functional processing.**