Production of Arguments and Adjuncts in Normal and Agrammatic speakers: An Eyetracking study

Abstract

Agrammatic Broca's aphasic speakers often are impaired in producing verbs and sentences with complex argument structure. In addition, deficits in production of adjunct phrases has been noted (Caplan, unpublished; Thompson et al.,1997). Based on models of normal sentence production, the former deficits have been attributed to problems at both the positional and functional level. However, these models do not address the latter. This study examined real-time production of adjuncts vs. arguments, by tracking eye movements in 13 young control and 9 agrammatic speakers. Controls showed greater difficulty for adjuncts than for arguments during production of the verb predicate structure. However, aphasic speakers showed differences prior to speech onset, suggesting an impairment in computing thematic-to-grammatical (functional) relationships between sentence constituents.

Introduction

Agrammatic aphasic speakers show greater difficulty producing verbs and sentences with complex argument structure. For instance, they show greater impairment producing sentences with a greater number of arguments compared to those with fewer (Thompson and colleagues., 1997; Kim & Thompson, 2000, 2004) and in sentences whose argument structure triggers movement operation (Bastiaanse & van Zonneveld, 2004; Lee & Thompson, 2004). The studies have localized the deficit to the level of grammatical encoding after intact lemma selection, using psycholinguistic models of sentence production (e.g., Bock & Levelt, 1994). However, it is unclear whether the deficit is at the positional level (phrase structure building) or arises from the earlier level of function assignment. To investigate this question, the current study examined real-time production of arguments and adjuncts, using eyetracking.

Adjuncts, which are lexically-unspecified by the verb, require additional processes as compared to arguments, in terms of both thematic assignment and phrase structure building (Pollard & Sag, 1994). Sentence processing research has born out this difference, showing that the lexical information of the verb is available from the earliest stage of sentence parsing until a later stage, resulting in a greater processing cost for adjuncts than for arguments (e.g., Boland & Blodgett, 2006; Schütze & Gibson, 1997).

Monitoring eye movements provides references for when a speaker prepares what during sentence production (Griffin, 2004), thus allowing stages of function assignment and positional processing to be examined. Difficulty deciding thematic roles and the subject is reflected in eye movements before speech onset, whereas eye movements during speech reflect difficulty deciding syntactic structure and the order of production of lexically encoding words (Griffin & Bock, 2000; Griffin & Mouzon, 2004). Therefore, it was predicted that if the deficit arises from the level of function assignment, aphasic speakers would show greater difficulty for adjuncts than for arguments from the very earliest stage of sentence production, i.e., before speech onset. On the other hand, if the deficit is at the positional level, greater difficulty was predicted to appear mainly during speech rather than prior to speech onset.

Methods
Participants

Thirteen control speakers (age 18-22) and 9 individuals with agrammatic Broca's aphasia (age 35 – 60) participated in this study. All had normal hearing and normal or corrected-to-normal vision. The diagnosis of agrammatic aphasia was based on the Western Aphasia Battery (AQ 69-84, Kertesz, 1982), performance on the Northwestern Assessment of Verbs and Sentences (Thompson, unpublished) and spontaneous speech. All aphasic participants were able to read single words.

Stimuli & Procedures

Ten non-alternating dative verbs (e.g., *apply*) and 10 transitive verbs (e.g., *choose*) were selected for the argument and the adjunct condition, respectively, as in (1). Each verb was used twice, resulting in 20 trials for each condition. The same set of 60 nouns (40 animate and 20 inanimate nouns) was used between conditions, rendering the same third noun (N3) as either a goal argument or a beneficiary adjunct. A set of 10 unergative sentences (e.g., *the little mouse is jumping*) and 10 unaccusative sentences (e.g., *the little bottle is rolling*) were used as fillers.

(1) The mother is *applying* the lotion *to the baby*. (Argument condition)
N1 Verb N2 N3
The mother is *choosing* the lotion *for the baby*. (Adjunct condition)
N1 Verb N2 N3

Participants were asked to construct a sentence using a set of computer-displayed written words. The position of the nouns was randomized across trials to prevent any visual bias. The role relationship between the two animate nouns (e.g., *mother, baby*) was manipulated such that only one (*mother*) was likely to become the agent. Aphasic participants were familiarized with the nouns and verbs off-line prior to the eye tracking task to ensure their ability to read and comprehend the word stimuli. Participants' speech and eye movements were recorded during the task.

Results

Production accuracies are presented in Figure 1. 2 (group) x 2 (condition) ANOVAs by participants and items revealed a main effect of group ($F1$ (1, 40) = 24.60, $p < 0.001$; $F2$ (1, 76) = 42.94, $p < 0.001$). However, there was no main effect of condition ($F1$ (1, 40) = 0.27, $p = 0.57$; $F2$ (1, 76) = 0.26, $p = 0.60$), nor an interaction between condition and group ($F1$ (1, 40) = 0.14, p =0.70; $F2$ (1, 76) = 0.53, $p = 0.47$). Although overall aphasic speakers showed lower accuracies than control speakers, both groups produced arguments and adjuncts equally well, (i.e., 90% vs. 85% for control and 62% vs. 62% for aphasic speakers).

The eye movement data showed greater processing difficulty in the adjunct compared to the argument condition, however, the differences were significant at different speech regions for the two groups. Only eye movement data from correct responses are reported here. Figure 2 shows mean gaze durations to N3's by speech region. A set of one-tailed paired t-tests showed that controls gazed at adjunct N3's significantly longer than argument N3's during N3-post region, i.e., while saying the word ($t1$ (12) = 2.12, $p < 0.05$; $t2$ (19) = 2.12, $p < 0.05$). For aphasic speakers, this difference was significant before speech onset ($t1$ (8) = 2.03, $p < 0.05$; $t2$ (19) = 1.25, $p >$ 0.05). Figure 3 shows the mean number of gaze shifts between the Verb and N3 by each speech region. The same patterns held: control speakers shifted their gazes between the Verb and N3 more frequently in the adjunct condition than in the argument condition mainly during speech, including in the N1-V region ($t1(12) = 2.06$, $p < 0.05$; $t2$ (19) = 2.13, $p < 0.05$) and N3-post region ($t1$ (12) = 1.47, p = 0.08; $t2$ (19) = 2.49, $p < 0.05$). On the other hand, this difference was significant only before speech onset for aphasic speakers (t (8) = 2.22, $p < 0.05$; $t2$ (19) = 1.76, $p < 0.05$).

Discussion

These data show that when a linguistic context (verb) sets an entity as an argument versus an adjunct, producing the adjunct requires increased processing cost, consistent with previous comprehension studies (Boland & Blodgett, 2006 and others). Importantly, control and aphasic speakers differed at stages of sentence production in which they used verb information most actively for sentence planning. Control speakers showed increased gaze durations and shifts for sentences with adjuncts mainly *during speech*, beginning prior to the production of verb (N1-V region), whereas, aphasic speakers showed differential processing *before speech onset*. Taken together, these findings suggest that while control speakers use verb information incrementally, aphasic speakers access verb information during the initial stage of sentence production, computing the adjunct (N3)'s relationship to the verb prior to production. This pattern suggests that our patients' ability to assign functional roles to lemmas was compromised. Theoretical and clinical implications of these data will be discussed.

References

Bastiaanse, R. & van Zonneveld, R. (2004). Broca's aphasia, verbs and the mental lexicon. *Brain and the Language, 90,* 198-202.

Boland, J. E. & Blodgett, A. (2006). Argument Status and PP-Attachment. *Journal of Psycholinguistics Research, 35,* 385-403.

Caplan, D., Neal, P., Goodglass, H., Shapiro, L. P., & Zurif, E. (unpublished manuscript) Effects of thematic role types and thematic role order on sentence production in aphasic patients

Griffin, Z. M. (2004) Why look? Reasons for eye movements related to language production. In J.M. Henderson & F. Ferreira (Eds.), *The Interface of Language, Vision, and Action: Eye movements and the visual world* (pp. 213-247). New York: Psychology Press.

Griffin, Z. M., & Bock, K. (2000). What the eyes say about speaking. *Psychological Science*, 11, 274-279.

Griffin, Z. M. & Mouzon, S. S. (2004). Can speakers order a sentence's arguments while saying it? Poster presented at the 17th Annual CUNY Sentence Processing Conference in College Park, Maryland.

Kertesz, A. (1982). Western Aphasia Battery. New York: Grune & Stratton.

Kim, M., & Thompson, C. K. (2000). Patterns of comprehension and production of nouns and verbs in agrammatism: Implications for lexical organization. *Brain and Language*, 74, 1-25.

Kim, M., & Thompson, C. K. (2004). Verb deficits in Alzheimer's disease and agrammatism: Implications for lexical organization. *Brain and Language*, 88, 1-20.

Lee, M. & Thompson, C. K. (2004) Agrammatic aphasic production and comprehension of unaccusative verbs in sentence contexts. *Journal of Neurolinguistics*, 17, 315-330.

Pollard, C., & Sag, I. (1994). *Head-driven phrase-structure grammar*. Chicago, IL: Chicago University Press.

Schütze, C. T. & Gibson, E. (1999). Argumenthood and English prepositional phrase attachment. *Journal of Memory and Language, 40*, 409-431.

Thompson, C. K., Lange, K. L, Sheneider, S. L., & Shapiro, L. P. (1997). Agrammatic and non-brain damaged subjects' verb and verb argument structure production. *Aphasiology*, 11, 473-470

Thompson, C. K. (unpublished). Northwestern Assessment of Verbs and Sentences.

Figure 1. Production accuracies (** = *p*'s < 0.05 by participants and items).

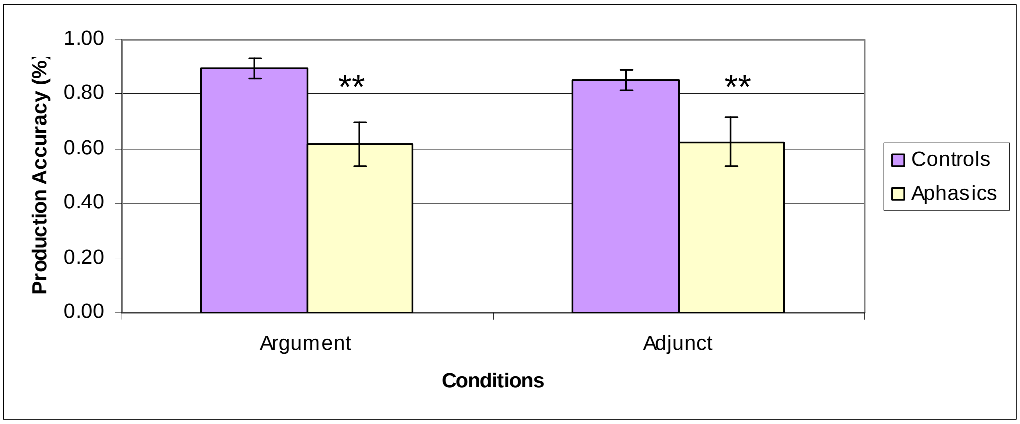
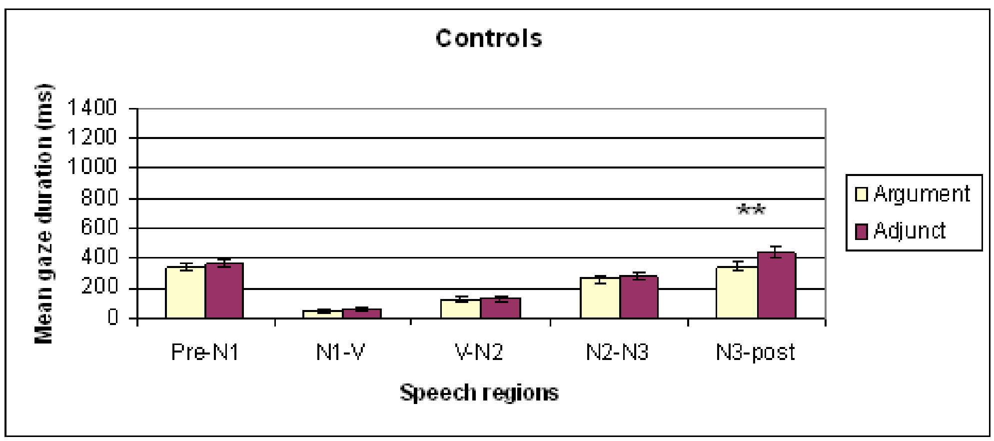


Figure 2. Mean gaze durations to N3s by each speech region (** = *p*'s < 0.05 by participants and items, * = *p* < 0.05 by participants).

(a)



(b)

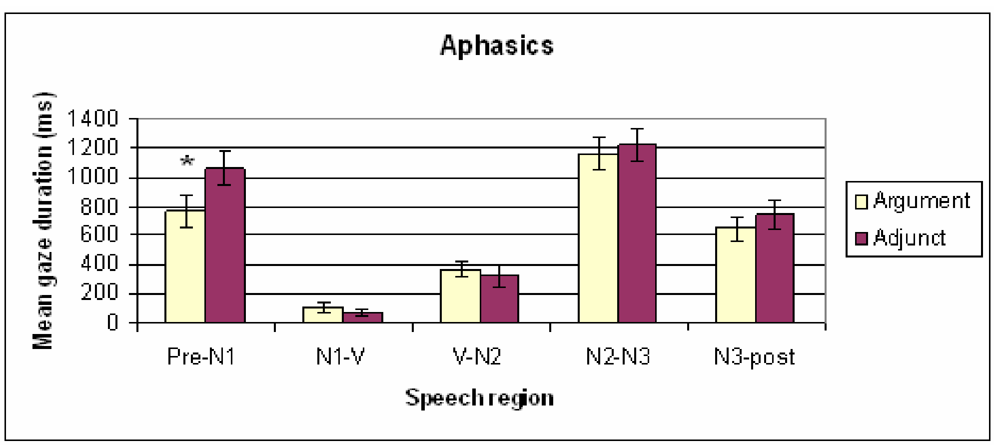
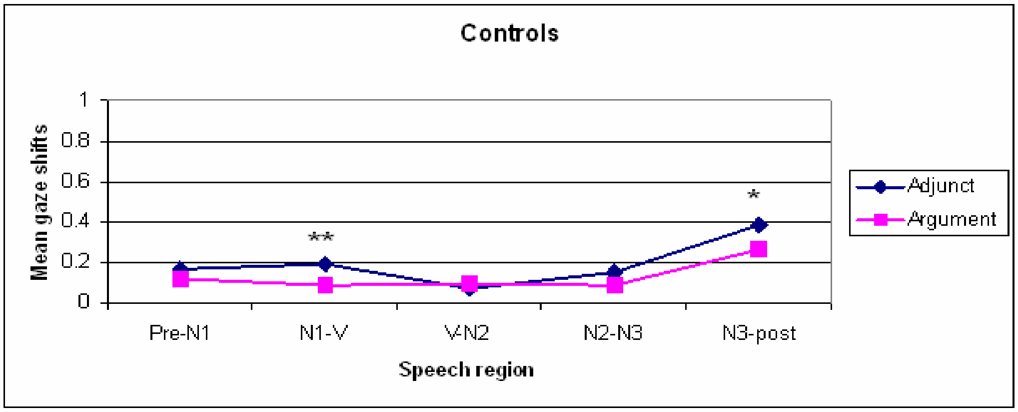


Figure 3. Mean number of gaze shifts between the Verb and N3 by speech region (** = p's < 0.05 by participants and items, * = $p < 0.05$ by items).

(a)



(b)