Effects of lexical processing deficits on agrammatic sentence comprehension: An eyetracking study

Abstract

Individuals with Broca's aphasia show lexical processing deficits, such as deficits in lexical access or lexical integration. Although studies have implicated lexical processing as areas of impairment in Broca's aphasia, few studies have looked at the effects of these deficits on sentence comprehension. We conducted a series of eyetracking experiments to test whether Broca's aphasic individuals are impaired in lexical access or lexical integration and whether such deficits affect sentence comprehension. Results showed that while lexical access and lexical integration are both impaired in Broca's aphasia, only the deficit in lexical integration affects sentence comprehension.

Background and Rationale

Individuals with Broca's aphasia exhibit difficulty comprehending syntactically complex sentences, which has been attributed to impaired working memory or deficits in processing syntactic movement (Burkhardt, Pinango, & Wong, 2003; Caplan & Waters, 1999; Grodzinsky, 1995). But recent studies using online methods have shown that lexical-level impairments may influence aphasic sentence comprehension (Love, Swinney, Walenski, & Zurif, 2008; Thompson & Choy, 2009). Despite the consensus that the lexical-semantic system is impaired in Broca's aphasia, there is debate over which lexical sub-process is affected – whether it is lexical access or lexical integration (Hagoort, 1997; Milberg, Blumstein, & Dworetzky, 1987). This study investigated whether lexical access or lexical integration is impaired in Broca's aphasia and whether these impairments influence sentence comprehension.

We conducted a series of three eyetracking experiments. Experiment 1 tested whether lexical access is delayed in Broca's aphasia. Latency of eye movements to pictures after nonlinguistic cues and words were examined. Experiment 2 tested whether a delay in lexical access affects sentence comprehension. Love et al. (2008) proposed that delayed lexical access disrupts syntactic processes, such as gap-filling, which relies on lexical access to be completed. Their results showed delayed gap-filling and lower rate of comprehension at normal rates of speech compared to slower rates for the aphasic participants. In Experiment 2, we manipulated the rate of speech for object- (OC) and subject-cleft (SC) constructions and examined eye movements and comprehension probes to assess the effects of delayed lexical access on sentence comprehension. Finally, Experiment 3 investigated whether lexical integration is impaired in Broca's aphasia and whether impaired lexical integration affects sentence comprehension. We manipulated cloze probability as studies have shown that differing levels of cloze probability require differing levels of integration (Federmeier & Kutas, 1999). We tested comprehension of high- (HC) and low-cloze (LC) sentences in object- (OR) and subject-relative (SR) constructions. Additionally, eye movements were examined during comprehension.

Methods

Participants. Nine individuals with Broca's aphasia (ages: 37-74; WAB AQs: 56.4-86.2), and nine unimpaired age-matched control participants (ages: 35-75) were tested in all three experiments. All participants were native speakers of English, and demonstrated good visual and hearing acuity. There was no reported history of neurological and psychological disorders.

Procedures. Eye movements were recorded while participants looked at a computer screen with four objects during presentation of words or stories. Stories contained 3 sentences – an introductory sentence, a critical sentence (i.e., OC, SC, OR, SR) and a comprehension probe. Latency of eye movements, proportion of fixations and accuracy on probes were analyzed.

Results

Experiment 1. No difference in eye movement latency was found between the two groups for the non-linguistic condition (Mann-Whitney Z=.493, p=.622). However, latencies were significantly slower for the aphasic group in the lexical conditions (isolation: Z=-2.676, p=.007, sentence: Z=-3.477 p=.001).

Experiment 2. Aphasic individuals showed lower accuracy on all conditions compared to age-matched controls (Slow: Z=-3.352, p=.001; Normal: Z=-3.684, p=.001; OC: Z=-3.514 p=.001; SC: Z=-3.823, p=.001). For both control and aphasic groups, a significant difference was found between sentence types (Control: Z=-2.52, p=.012; Aphasic: Z=-2.31, p=.021). On the other hand, no difference was found between the normal and slowed speech rates for either group (Control: Z=-1.542, p=.123; Aphasic: Z=.-.356, p=.722). Analysis of eye-movements showed that aphasic eye movements to nouns were delayed, showing looks to the subject (e.g., *the girl*) and object (e.g., *the boy*) later than controls. Eye movements in OC showed that both groups showed increased eye movements to the object (i.e., antecedent) after the gap in the 200ms post-offset region. The region was the same for slow and normal speech rates for both groups.

Experiment 3. Aphasic individuals showed lower accuracy on all conditions compared to controls (HC: Z=-3.526, p=.001; LC: Z=-3.514, p=.001; OR: Z=-3.143 p=.002; SR: Z=-3.698, p=.001). The control group showed no difference in accuracy between sentence types, nor between cloze conditions (Sentence: Z=-1.69, p=.09; Cloze: Z=-1.192, p=.233, Wilcoxon), whereas the aphasic group showed a difference between cloze conditions but not between sentence types (Sentence: Z=-1.40, p=.161; Cloze: Z=-2.666, p=.008). Analysis of eye-movements in OR showed increased eye movements to the object (i.e., antecedent) after the gap in the 400ms post-offset region both groups for both high and low cloze conditions. In the high cloze condition, aphasic eye movements resembled controls, showing an overall high level of looks to the object in the post-verbal regions, which was not observed in the low cloze condition.

Discussion

The results suggest that lexical access and lexical integration are impaired in Broca's aphasia as indicated by delayed eye movements to lexical items and decreased eye movements to low cloze antecedents. However, aphasic comprehension was affected only by the difference in cloze probability and not the difference in rates of speech. These results suggest that while lexical access and lexical integration are both impaired in Broca's aphasia, only the deficit in lexical integration significantly affects sentence comprehension.

References

Burkhardt, P., Pinango, M. M., & Wong, K. (2003). The role of the anterior left hemisphere in real-time sentence comprehension: evidence from split intransitivity. *Brain and Language, 86*(1), 9-22.

Caplan, D., & Waters, G. S. (1999). Verbal working memory and sentence comprehension. *Behavioral and Brain Sciences, 22*(1), 77-94; discussion 95-126.

Caramazza, A., & Zurif, E. B. (1976). Dissociation of algorithmic and heuristic processes in language comprehension: evidence from aphasia. *Brain and Language, 3*(4), 572-582.

Federmeier, K. D., & Kutas, M. (1999). A rose by any other name: Long-term memory structure and sentence processing. *Journal of Memory and Language, 41*, 469-495.

Grodzinsky, Y. (1995). A restrictive theory of agrammatic comprehension. *Brain and Language, 50*, 27-51.

Hagoort, P. (1997). Semantic Priming in Broca's Aphasics at a Short SOA: No Support for an Automatic Access Deficit,. *Brain and Language, 56*(2), 287-300.

Love, T., Swinney, D., Walenski, M., & Zurif, E. (2008). How left inferior frontal cortex participates in syntactic processing: Evidence from aphasia. *Brain Lang, 107*(3), 203-219.

Milberg, W., Blumstein, S. E., & Dworetzky, B. (1987). Processing of lexical ambiguities in aphasia. *Brain Lang, 31*(1), 138-150.

Thompson, C. K., & Choy, J. J. (2009). Pronominal resolution and gap filling in agrammatic aphasia: Evidence from eye movements. *Journal of Psycholinguistic Research*.

Thompson, C. K., Tait, M. E., Ballard, K. J., & Fix, S. C. (1999). Agrammatic aphasic subjects' comprehension of subject and object extracted wh questions. *Brain and Language, 67*, 169-187.

Figure 1. Latency of eye movements in Experiment 1.

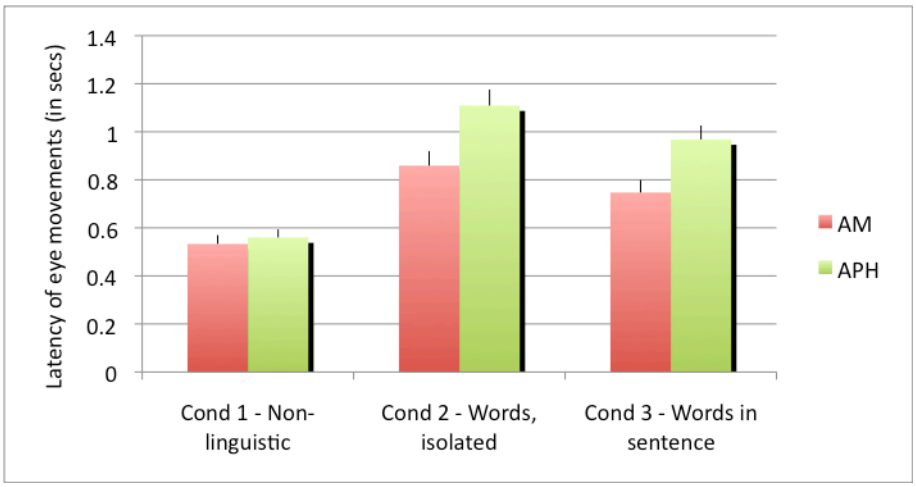

Figure 2. Accuracy on comprehension probes in Experiment 2

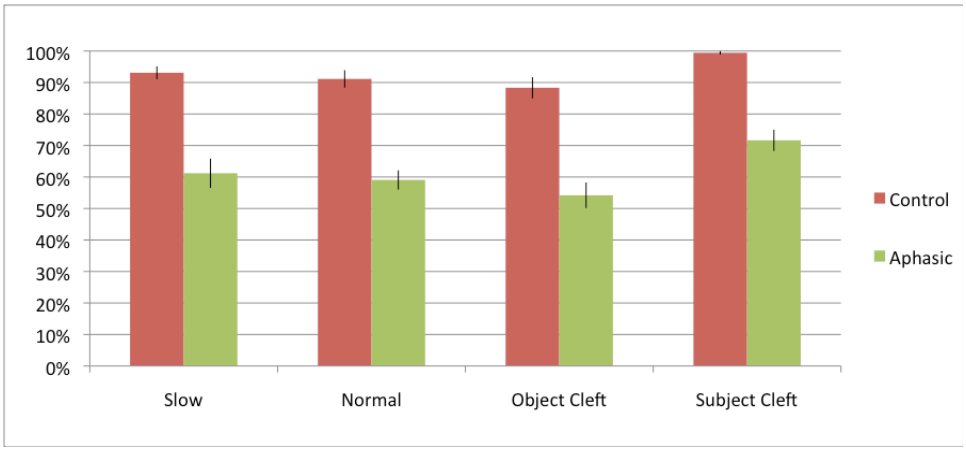

Figure 3. Proportion of fixations to the subject (Subj), object (Obj), location (Loc) and filler in sentence regions and post offset regions while listening to object cleft constructions in Experiment 2.

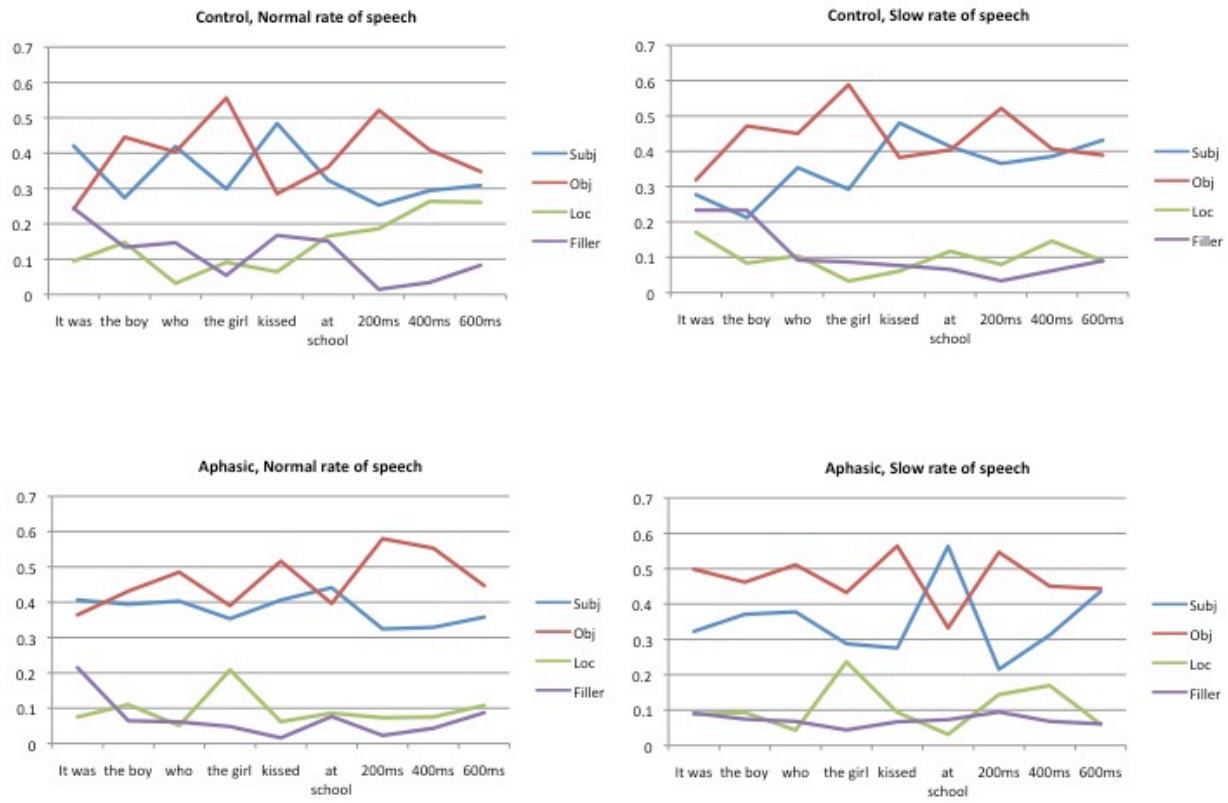

Figure 4. Accuracy on comprehension probes in Experiment 3

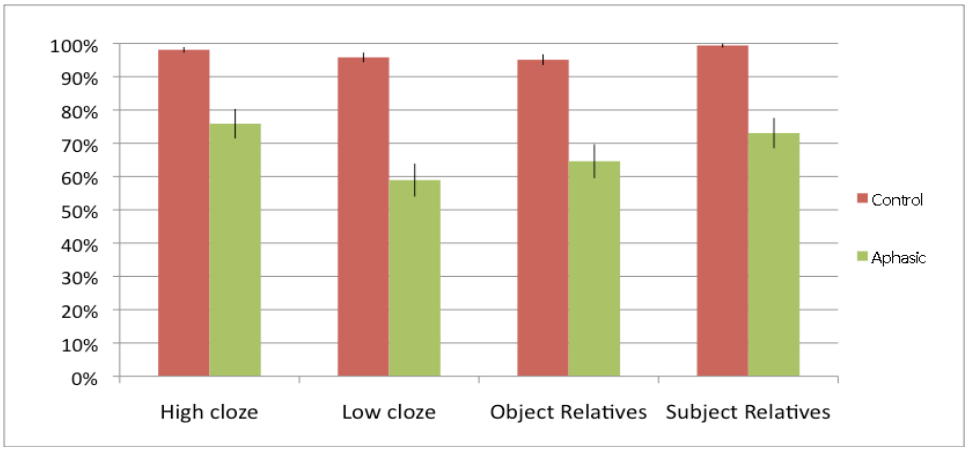

Figure 5. Proportion of fixations to the subject (Subj), object (Obj), object competitor (Comp) and filler in sentence regions and post offset regions while listening to object relative constructions in Experiment 3. Object competitors are items, if used in the object position instead of the actual item used in the object position of the high (or low) cloze sentence, would have made the sentence have low (or high) cloze probability.