Verb Argument Structure Encoding during Verb Naming and Sentence Production in Normal and Agrammatic Aphasic Speakers: An Eyetracking Study

Background and Rationale

Individuals with agrammatic Broca's aphasia have difficulty producing verbs and sentences (Menn & Obler, 1990; Miceli et al., 1984). This difficulty is associated with verb argument structure. Thompson (2003) proposed the Argument Structure Complexity Hypothesis (ASCH): verbs with more complex argument structure (as in 1 below) are more challenging to produce as compared to verbs with less complex argument structure (2) in individuals with agrammatic aphasia.

(1) The boy is *giving* the guitar to the musician. (3-argument verb)
(2) The dog is *chasing* the cat. (2-argument verb)

Increased processing difficulty with increased argument structure complexity has been found in both normal and agrammatic aphasic speakers (Ahrens & Swinney, 1995; Ahrens, 2003; Thompson et al., 1997). Cross-linguistic studies of aphasia have also shown this effect in both verb naming and sentence production tasks (English: Kim & Thompson 2000, 2004; Italian: Luzzatti et al., 2002; German: DeBleser & Kauschke, 2003). Despite these findings, it is not certain from which stage of language production the difficulties arise, i.e., deficits in generating syntactic structures for the arguments or deficits in producing the arguments themselves (word access deficits).

Monitoring eye movements during speech has been a sensitive measure to examine normal speech, revealing how speakers prepare and encode speech in real time (Griffin & Bock, 2000; Meyer et al., 1998). For example, argument structure encoding can be examined in real time as verbs and sentences are produced. The current study examined the production of two- and three-argument verbs in verb naming (VN) and sentence production (SP) conditions using eyetracking in normal and agrammatic aphasic speakers. Specifically, we looked at eye movements associated with sentence encoding as well as production of sentence constituents as participants viewed action pictures. We predicted that encoding deficits would be manifest by delayed onset of production and/or aberrant eye movement patterns, whereas word access deficits would be revealed by delayed looks to word production.

Methods

Participants. Twelve unimpaired control participants (three males) and an individual with agrammatic Broca's aphasia (male) participated in the study. The participants were native monolingual speakers of English, premorbidly right-handed, and demonstrated good visual and hearing acuity. The control participants were between 18 and 27 years of age. None of them did report history of neurological and psychological disorders prior to the study. The aphasic participant, MD, was 58 year old and 15 years post-onset at the time of testing. He acquired aphasia as a result of a thrombo-embolic stroke in the left hemisphere. He was mildly to moderately impaired, as assessed by the Western Aphasia Battery (Kertesz, 1982). The WAB AQ was 78.5 at the time of testing. His speech was agrammatic, i.e., halting and lacking grammatical morphology, and comprehension was relatively preserved.

Stimuli and Procedures. A total of 35 line-drawing action pictures (20 for two-argument verbs) (for example, see Figures 1 and 2) were used to elicit target sentences. The same pictures were used for both VN and SP conditions. Two- and three-argument verbs were roughly matched for log lemma frequency (1.561 vs. 2.099) in CELEX. While the pictures were presented on a computer monitor, the participants named the action using a single verb (e.g. *giving, chasing*) (VN) or describe the depicted scenes using a single sentence (SP). In order to minimize word retrieval difficulties, MD was familiarized with all nouns and verbs used in the pictures. Participants' eye movements were recorded by an ASL 6000 series remote eye tracker, and their speech was recorded by SoundEdit 16. In each condition, speech onset latency and eye movement patterns were measured.

<u>Results</u>

Onset latencies of MD's production were longer than those of control participants in both the VN and SP conditions (Figure 3). However, he exhibited similar patterns to controls with respect to verb types: three-argument verbs resulted in longer speech onset latencies as compared to two-argument verbs in both the VN and SP conditions ($p < .05$). These findings were consistent with Thompson (2003)'s findings that verbs with more complex argument structures resulted in greater production difficulty than verbs with less complex argument structures. In control participants' speech, no differences were found between the VN and SP conditions ($p > .05$). In MD's speech, however, longer onset latency was found in the SP condition than in the VN condition.

Eye-movement patterns were qualitatively different across the conditions in control participants. With regard to pre-speech eye-movement patterns, in the SP condition (Figure 5), participants spent longer gazing at the Agent (e.g. *the dog* or *the boy*) compared to other event participants ($p < .05$). In contrast, in the VN condition (Figure 4), participants spent more time gazing at the Theme (e.g. *the cat*, *the guitar*) and no preference for the Agent was found ($p > .05$). Furthermore, in the SP condition, eye movements after speech onset showed evidence of incremental planning and encoding, as shown in previous studies (Griffin & Bock, 2000). Following initial looks to the Agent, participants looked at the Theme (followed by Goal for three-argument sentences) in the order in which they were produced, with fixations preceding production of each. However, there was no corresponding shift in visual attention during production in the VN condition. Interestingly, these patterns were also found for MD (Figure 6). For both the two-argument and three-argument verbs, he showed evidence of incremental encoding. Even though his speech onset was slower than controls', his eye gaze anticipated the arguments he was about to encode during sentence production.

<u>Discussion</u>

The current finding, showing longer speech onset for three-argument verbs than ones with two-argument verbs, suggests that verbs with greater argument structure complexity engender greater encoding difficulty and processing time. This also suggests that speakers access all verb arguments not only when producing a sentence, but also when producing a single verb. Longer onset latencies for MD's speech are also suggestive of delayed language processing for individuals with agrammatic Broca's aphasia.

Unlike the speech onset latency data, the eye movement data show linguistically qualitative differences between single verb and sentence production. Eye movement patterns shown in the SP condition provide evidence of real-time encoding processes for verb argument structure. These patterns are only found in the SP condition, but not in the VN condition, where multiple elements need to be prepared and named. Control participants gazed at the arguments as they were about to encode them, showing their ability to generate syntactic structure for the arguments in real time. Interestingly, MD's eye-movement patterns also provide evidence for normal-like incremental planning and encoding of argument structure. While his speech onset was slower, he exhibited the same pattern of incremental eye gaze as controls. This result suggests that considerable capacity for incremental generation of syntactic structure may remain intact in agrammatism.

This result must be replicated with other agrammatic individuals before we can confidently assign an interpretation to it. This work is currently underway. Implications of these results for the treatment of aphasic sentence-production disorders will be discussed.

References

De Bleser, R., & Kauchke, C. (2003). *Acquisition and loss of nouns and verbs: Parallel or divergent patterns?* Journal of Neurolinguistics, 16 (2-3), 213-229.

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

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), 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.

Luzzatti, C., Raggi, R., Zonca, G., Pistarini, C., Contardi, A., & Pinna, G-D. (2002). Verb-noun double dissociation in aphasic lexical impairments: The role of word frequency and imageability. *Brain and Language*, 81 (1-3), 432-444.

Menn, L., & Obler, L.K. (1990). *Agrammatic Aphasia*: *A cross-language narrative sourcebook*. Amsterdam/Philadelphia: John Benjamins Publishing Company.

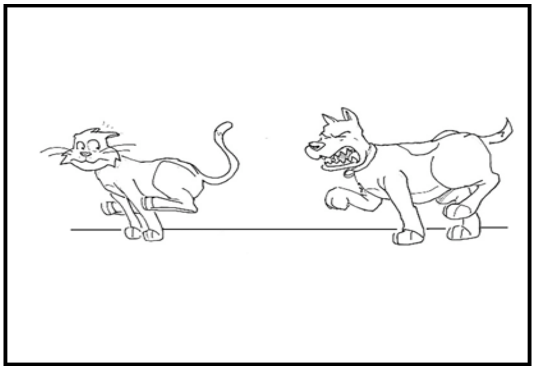
Meyer, A., Sleiderink, A., & Levelt, W. (1998). Viewing and naming objects: eye movements during noun phrase production. *Cognition*, 66, B25-B33.

Miceli, G., Silveri, M.C., Villa, G., & Caramazza, A. (1984). On the basis for the agrammatic's difficulty in producing main verbs. *Cortex*, 20, 207-220.

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.

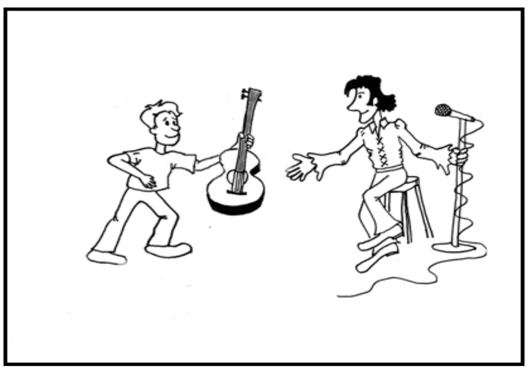
Thompson, C.K. (2003). Unaccusative verb production in agrammatic aphasia: the argument structure complexity hypothesis. *Journal of Neurolinguistics*, 16, 151-167.

Figure 1. Example picture stimuli for two-argument verbs



Target sentence: The dog is chasing the cat.

Figure 2. Example picture stimuli for three-argument verbs



Target sentence: The boy is giving the guitar to the musician.

Figure 3. Speech onset latencies for control participants and MD in both verb naming (VN) and sentence production (SP) conditions

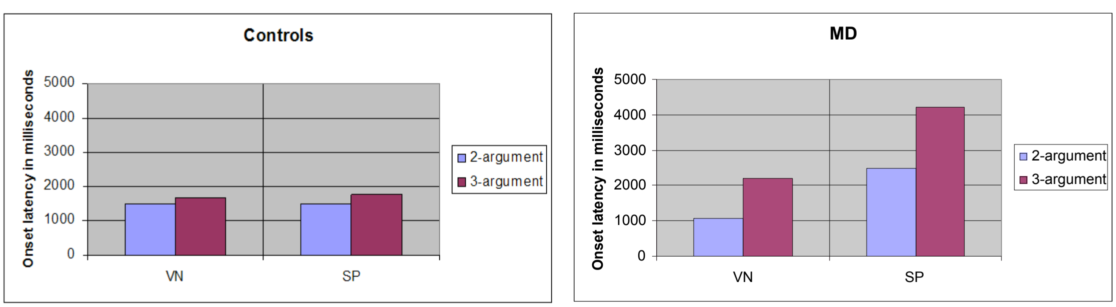
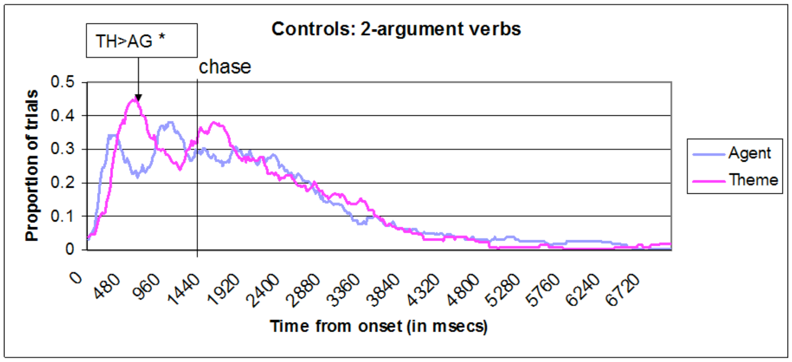


Figure 4. Mean gaze duration of the VN condition using two- (top) and three- (bottom) argument verbs for control participants



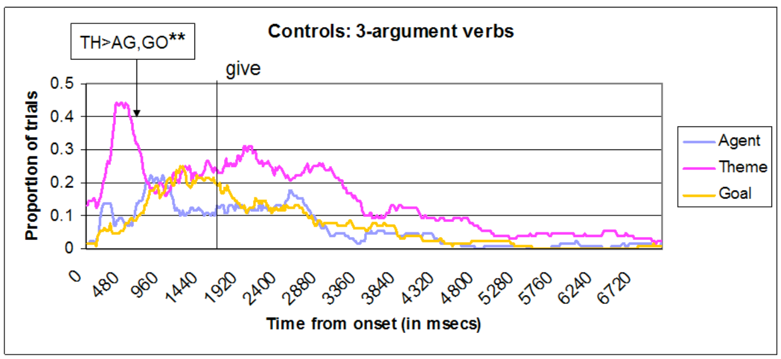
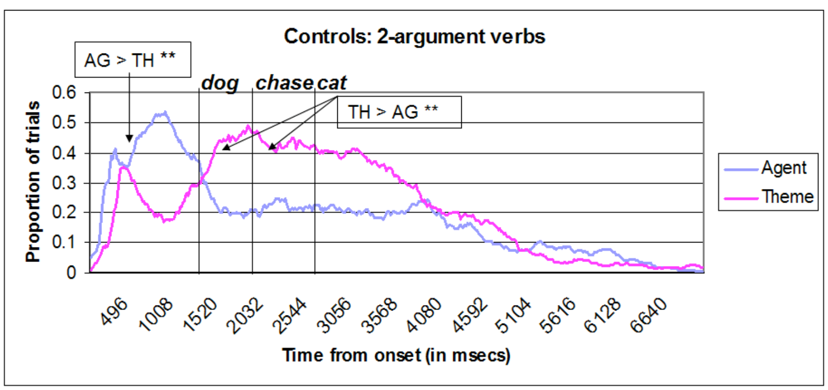


Figure 5. Mean gaze duration of the SP condition using two- (top) and three- (bottom) argument verbs for control participants



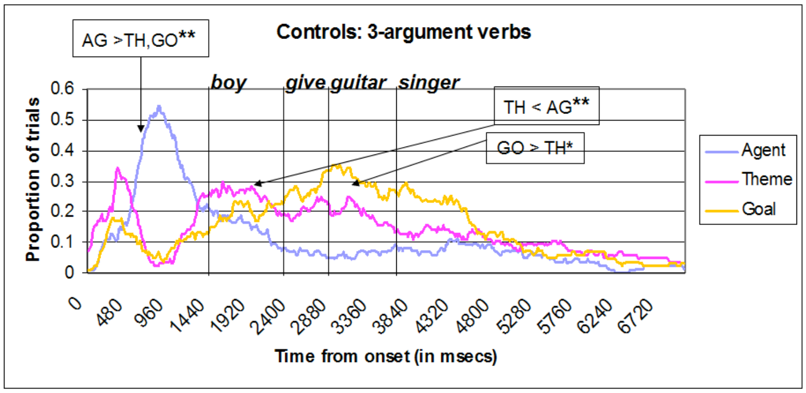


Figure 6. Mean gaze duration of the SP condition using two- (top) and three- (bottom) argument verbs for the aphasic participant, MD