Agrammatism is one of the hall-marks of Broca's aphasia, and an important contributor to the lack of fluency in these patients. Goodglass and colleagues [1] describe agrammatic speech as "a speech pattern that is defective because it lacks inflectional markers, prepositions, auxiliary verbs, copulas—often articles and verbs as well" (p. 8). Until recently, decisions about which of these omissions were required and how frequently they should occur to warrant a diagnosis of agrammatism were largely left to clinical judgement. Furthermore, non-fluent speech results from other deficits, including articulation difficulties, prosodic disruptions, problems with word-finding or phonological encoding, and slowed conceptual processing. To render the diagnosis of agrammatism more systematic and objective, Saffran, Berndt and colleagues developed the Quantitative Production Analysis (QPA), a protocol for transcribing and analyzing connected speech samples [2, 3]. This protocol has been used primarily to specify the grammatical deficits in non-fluent aphasia [3, 4], or to contrast non-fluent patterns with the grammatical performance of a small number of fluent aphasics [5-7]. The current study aims to extend these results by analyzing the grammaticality of spontaneous speech samples collected from an unselected group of aphasic subjects, and using a different method of elicitation—picture description instead of story retelling.

Methods

Thirty-four subjects with a primary diagnosis of aphasia, all at least 3 months post-onset of a stroke, were asked to describe 10 Norman Rockwell pictures. Descriptions of the same pictures were collected from 6 non-brain-damaged elderly control subjects, in order to compare the performance of normal speakers in picture description to previous studies involving story retelling and to establish norms for comparison to the aphasic speakers. Speech samples were audiotaped and transcribed, with transcripts verified by a second listener.

Transcript analyses from all of the control subjects and 10 of the aphasic subjects are included in the current study. According to the Boston Diagnostic Aphasia Exam [8], the aphasic subjects ranged in severity from 2 to 5, with a mean of 3.6 (0 being the most severe; 5 the least). Auditory comprehension scores ranged from $60^{th}$ to $98^{th}$ percentile (mean $80^{th}$); naming scores from $50^{th}$ to $100^{th}$ percentile (average $85^{th}$). Subjects were unselected for aphasia diagnosis, and included both fluent and non-fluent aphasics with a variety of lesion sites in the left middle cerebral artery territory. Thus, the aphasic subjects represent a fairly broad range of aphasia, though somewhat skewed towards milder severity levels.

Comparison of Tasks

Data from the control subjects' picture descriptions were compared to normative data from three previous studies, all of which used a story retelling method [5]. Table 1 compares mean values (weighted by number of subjects) from these three studies to the mean values from the current study.

Although the results are broadly similar, some differences were noted. For example, a lower proportion of narrative words occurred in sentences in the picture description samples, because picture description more frequently results in a 'listing' style of discourse (e.g. "A girl with her bike. Two guys over here."). Relatedly, sentences also tended to be shorter in picture description. In addition, the number of embedded clauses relative to the number of sentences, the inclusion of required determiners, and the auxiliary score are all lower in picture description. The

latter measure, which reflects the elaboration of the main verb (e.g. through auxiliary verbs or tense marking), may reflect the predominant use of the present tense in picture description and the past tense in story retelling. The lower number of determiners may again reflect the listing style of discourse adopted by some subjects. However, the sentence elaboration index, which combines open-class word counts in subject noun phrases and verb phrases, suggests that, despite being shorter and syntactically less complex, sentences were at least as *semantically* elaborated in picture description as in story retelling, and perhaps more so.

Despite these structural differences, discourse-level measures—speech rate and the proportion of words uttered that contribute to the narrative (e.g. excluding repeated words and task comments)—were quite similar in the two elicitation techniques. Lexical measures (proportion of closed class words, noun:pronoun ratio, noun:verb ratio), were also remarkably similar, suggesting that lexical retrieval demands are comparable in the two tasks.

### Comparison of Normal and Aphasic Speakers

Table 2 shows mean values of the QPA for the 6 control and 10 aphasic subjects in the current study. As a group, the aphasic subjects reflect a pattern similar to that demonstrated by the non-fluent aphasics examined by Saffran and colleagues [3]. Significant differences between aphasic and normal speakers were found on speech rate and sentence length measures, and on indices of sentence elaboration and embedding. A trend towards significance was also evident in the proportions of words which occurred in sentences, and of narrative words in the transcript. If these differences represent global aphasic characteristics, they should be expected to correlate highly with the severity of aphasia. In fact, as indicated in Table 2, all of the discourse and structural scores showed correlations with BDAE severity ratings which were close to or greater than 0.50. (The notable exception is the proportion of well-formed sentences, likely an artifact of the picture description paradigm.)

On the other hand, none of the lexical measures show significant differences between the control and aphasic groups, and all show low correlations with severity ratings. Unlike structural and discourse measures, the range of values of the lexical ratios in the aphasic group extends in both directions beyond the range of scores in the normal group. That is, the values of these ratios may be either pathologically high or pathologically low, as expected in a population including both fluent and non-fluent aphasics. Although there are insufficient data in the current sample to examine the distribution of these scores in detail, the analysis of further subjects will determine whether aphasic speakers fall into a bimodal distribution or a continuum on these measures.

### Discussion

The fact that the QPA measures showed largely the same pattern in non-brain-damaged speakers using picture description instead of story retelling validates the use of the QPA with different methods of eliciting spontaneous speech. However, the few task differences observed illustrate that normal speakers are not infrequently ungrammatical, and underline the necessity to collect data from normal speakers *in the same task* as for aphasic speakers, in order to ensure that comparisons are valid.

The comparison of normal speakers with an unselected group of aphasic speakers illustrates that many of the structural measures reflect, at least in part, general aphasia severity factors, and should be expected to be reduced in all sub-types of aphasia. The lexical ratios, by contrast, should be expected to vary with type of aphasia, and may be useful to distinguish fluent

and non-fluent syndromes. This concept, though not new, has not been systematically analyzed in the spontaneous speech of a range of aphasic subjects. Further planned analyses involve the additional of subjects to the aphasic group, and an investigation of the semantic appropriateness of the content of the samples, which supplements the QPA's focus on form. The combination of these two approaches is expected to provide an in-depth characterization of spontaneous speech output for the gamut of aphasic sub-types and levels of severity.

**Table 1:  Normative QPA Mean Values from Story Retelling and Picture Description**

| Discourse measures | Story Retelling | Picture Description |
|---|---|---|
| % narrative wds / complete wds | 84.2 % [1] | 79.9 % |
| speech rate (wpm) | 148 | 158 |
| **Structural measures** | | |
| % words in sentences | 98.9 % | 90.8 % |
| % sentences well-formed | 95.0 % | 88.2 % |
| mean sentence length | 11.4 words | 9.8 words |
| sentence elaboration index | 3.28 | 3.44 |
| # embeddings / # sentences | .372 | .288 |
| auxiliary score | 1.30 | 1.13 |
| inflectable verbs inflected | 94.9% | 91.8 % |
| % obligatory determiners | 99.5 % | 96.5 % |
| **Lexical ratios** | | |
| % closed class words | 54.6 % | 55.0 % |
| % pronouns / nouns + pronouns | 39.6 % | 38.5 % |
| % verbs / nouns + verbs | 47.2 % | 44.7 % |

[1] available from Rochon et al. (2000) only

**Table 2:  QPA Values from Control Subjects and Aphasic Subjects in Picture Description**

| | Control Subjects | | Aphasic Subjects | | |
|---|---|---|---|---|---|
| Discourse measures | Mean | Range | Mean | Range | Correlation w/ severity |
| total # narrative words | 1734 | 855 – 3415 | 998 | 121 – 1871 | $r = 0.859$ |
| % narrative wds / complete wds | 79.9 % | 70 – 86 % | 67.4 % (*) | 41 – 89 % | $r = 0.787$ |
| speech rate (wpm) | 158 | 116 – 230 | 80 * | 10 – 145 | $r = 0.651$ |
| **Structural measures** | | | | | |
| % words in sentences | 90.8 % | 82 – 96 % | 68.9 % (*) | 8 – 93 % | $r = 0.725$ |
| % sentences well-formed | 88.2 % | 78 – 95 % | 83.9 % | 69 – 100 % | $r = 0.118$ |
| mean sentence length (# wds) | 9.8 | 8.1 – 12.3 | 7.3 * | 4.5 – 10.0 | $r = 0.727$ |
| sentence elaboration index | 3.44 | 2.59 – 4.86 | 1.95 * | 0 – 3.45 | $r = 0.761$ |
| # embeddings / # sentences | .288 | .07 – .38 | .142 * | 0 – .22 | $r = 0.468$ |
| auxiliary score | 1.13 | .97 – 1.49 | .92 | 0 – 1.39 | $r = 0.561$ |
| inflectable verbs inflected | 91.8 % | 86 – 98 % | .74 | 0 – .94 | $r = 0.496$ |
| % obligatory determiners | 96.5 % | 90 – 99 % | 81.4 % | 6 – 99 % | $r = 0.623$ |
| **Lexical ratios** | | | | | |
| % closed class words | 55.0 % | 53 – 57 % | 54.6 % | 49 – 67 % | $r = - 0.177$ |
| % pronouns / nouns + pronouns | 38.5 % | 32 – 48 % | 34.9 % | 0 – 71 % | $r = 0.026$ |
| % verbs / nouns + verbs | 44.7 % | 37 – 53 % | 37.7 % | 3 – 69 % | $r = 0.309$ |

* significant by two-tailed $t$-test ($p < 0.05$)
(*) trend towards significance ($p < 0.06$)

# References

1. Goodglass, H., E. Kaplan, and B. Barresi. (2001). *The Assessment of Aphasia and Related Disorders*. 3rd ed. Philadelphia, PA: Lippincott, Williams & Wilkins.

2. Berndt, R.S., S. Wayland, E. Rochon, E. Saffran, and M. Schwartz. (2000). *Quantitative production analysis: A training manual for the analysis of aphasic sentence production*. Hove, UK: Psychology Press.

3. Saffran, E.M., R.S. Berndt, and M.F. Schwartz. (1989). The quantitative analysis of agrammatic production: Procedure and data. *Brain and Language*, **37**, 440-479.

4. Rochon, E., E.M. Saffran, R.S. Berndt, and M.F. Schwartz. (2000). Quantitative analysis of aphasic sentence production: Further development and new data. *Brain and Language*, **72**, 193-218.

5. Bird, H. and S. Franklin. (1995/6). Cinderella revisited: A comparison of fluent and non-fluent aphasic speech. *Journal of Neurolinguistics*, **9**(3), 187-206.

6. Hesketh, A. and D.V.M. Bishop. (1996). Agrammatism and adaptation theory. *Aphasiology*, **10**(1), 49-80.

7. Edwards, S. (1995). Profiling fluent aphasic spontaneous speech: A comparison of two methodologies. *European Journal of Disorders of Communication*, **30**, 333-345.

8. Goodglass, H., E. Kaplan, and B. Barresi. (2001). *Boston Diagnostic Aphasia Examination*. 3rd ed. Philadelphia, PA: Lippincott, Williams & Wilkins.