

Analysing Language Disorders: The Lexical Quantification of Aphasic Speech

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Introduction

The assessment and therapy of language disordered patients has been an important topic in clinical research for some three decades. Speech and language disorders often result as a direct consequence of strokes, tumours, brain injuries and neurogenic diseases and disorders. Language disorders are distinct from speech disorders which involve disturbances to the physical characteristics of speech and are diagnosed and treated differently. The most commonly occurring form of language disorder is known as "aphasia", which can result from impairment of the lexical, phonological, semantic and syntactic components of language, the severity of which depends on the extent and location of the lesion in the damaged brain. Language disorders often co-exist with speech disorders such as dysarthria and dyspraxia which result from damage to the muscular control of the speech mechanism and impairment of the phonological system.

Aphasia is a complex disorder and most of the taxonomic approaches proposed by researchers over the years have been inconsistent and subjective. The two most common approaches are 'classical', where classification is based on the localisation of lesions in the brain, and 'fluent-non-fluent dichotomy' where patients are categorised as fluent or non-fluent depending on their free speech evaluation. The latter method is more useful for therapy but unfortunately the speech characteristics which classify patients are heavily dependent upon physical characteristics of speech such as speech-tempo, instead of taking into account linguistic features. Linguistic criteria for classifying patients as fluent or non-fluent are urgently needed.

Agrammatism in speech is the most common symptom across most of the aphasia categories. Agrammatic speech is composed chiefly of open-class lexical items (nouns, verbs, adjectives) with most of the closed-class lexical items (pronouns, prepositions, articles) being either incorrectly substituted or omitted (Berndt and Caramazza, 1980). Agrammatic speakers have a severely reduced vocabulary, experience serious word-finding difficulties and have particular difficulties with certain grammatical structures. Their sentences are short and broken, and are filled with redundant stereotyped phrases. Agrammatic speech is made with effort, telegraphic, slow and poor in both grammar and lexical richness. Patients also exhibit automatisms ("you know") and perseverances ("I-I-I went there").

At present, several extensive aphasia test batteries are used in clinics all over the world to evaluate patients' performances on language tasks. These tests do not, however, directly assess conversational skills and therefore fail to measure the ability of patients to communicate effectively in a social environment as opposed to their performance under a constrained environment.

This paper looks at the problem of the quantification of the conversational speech of aphasic patients, on the basis of linguistic measures, and proposes an 'index of performance' which may be used by speech therapists as a measure of the efficacy of the therapy programme.

Data collection

Conversational speech from a total of 100 subjects was recorded; seventy of these were patients (agrammatic aphasics) and the remaining thirty were 'normal' (unimpaired) adults split into two control sets of fifteen. The first set (type-I) came from a relatively high educational background and were either working in, or had retired from, professional occupations, whilst the second set (type-II) was comprised of people with low educational backgrounds currently working as cleaners, porters or cooks. All subjects were aged 50 or higher. Each subject was recorded in private and asked simple questions about their family, career, hobbies, etc. with minimal interruption from the interviewer. No recording lasted more than thirty minutes.

The raw data in the form of speech recordings was then transformed into transcripts for lexical analysis. The words of the interviewer were erased, interjections were ignored and a few unintelligible utterances had to be omitted. Each transcription consisted of at least 1,000 words, as recommended by Andreason and Pfohl (1976), and was fed into the Oxford Concordance Program to produce an output-file for each subject consisting of word-frequency distributions and word listings from which

nouns, pronouns, adjectives and verbs were manually tagged.

Linguistic measures

It was tempting to borrow the majority of the linguistic measures from stylometric studies of written texts, but the very different nature of utterances in conversational speech caused us to settle on the eight measures described below:

- (i) Noun rate per 100 words.
- (ii) Pronoun rate per 100 words.
- (iii) Adjective rate per 100 words.
- (iv) Verb rate per 100 words.
- (v) Type-Token ratio.
- (vi) 'Clause-Like Semantic Unit' (CSU) rate per 100 words. A CSU may be defined as a string of words grammatically connected in a meaningful form, and we use the term "clause-like" since in agrammatic speech a number of clauses are left unfinished.
- (vii) Brunet's W index. (Brunet, 1978)
- (viii) Honore's R statistic. (Honore, 1979)

These eight measures, chosen for their reliability and effectiveness in quantifying the severity of agrammatism in conversation, were accordingly computed from the transcripts and OCP printouts of all 100 subjects.

Multivariate analysis

A principal components analysis (PCA) was first computed on the (100 x 8) standardized data matrix. In the plot of the data in the space of the first two principal components, type-I and type-II 'normals' cluster closely together whilst patients exhibit wide variation and tend to lie to the left of the 'normals' which is the side of lower lexical richness. To investigate this clustering pattern, a discriminant analysis was then conducted on the two groups of 'normals'. This failed to reject the null hypothesis that, in the populations from which the samples are drawn, there is no difference between the group means. Both types of 'normals' were then combined into one group and a second discriminant analysis conducted on this enhanced group and on the group of patients.

This time we can clearly reject the null hypothesis of no difference between group means. Examination of the relative contributions of the eight variables to the discriminant function shows that the most important variables in terms of their discriminating power between 'normals' and agrammatic aphasics are C-rate, A-rate, W and TTR. These results are supported by distribution-free Mann Whitney tests on individual variables for both patients versus combined 'normals' and type-I versus type-II 'normals'.

Final index of performance

The major attraction of producing a final index of performance (FIP) for the lexical ability of agrammatic patients is the ability to state improvement or performance comparisons in quantitative terms. We propose that the FIP be derived from the discriminant scores of the subjects. In this case the weightings would be the unstandardized discriminant function coefficients for the eight variables. The discriminant scores are suitably scaled so that the FIP values lie in the (0-100) range for our subjects, low scores representing severely impaired patients, both in lexical and syntactic terms. The distinction between patients and 'normals' is clearly visible from a plot of FIP values as is the relative consistency of the lexical and syntactic proficiency of the 'normals' and the huge variation in the performance of patients.

In conclusion, to test the FIP, follow-up studies were conducted on a few patients who, in the year between visits, had had time to make some recovery from their strokes with the help of speech therapy. The FIP values had increased, thereby successfully giving the speech therapist an objective quantitative measure of the conversational speech of the patients which showed the efficacy of the therapy and recovery program. We hope that FIP values will now be used for conversational assessment in the management of aphasia.

References

- Andreason, N.J. and Pfohl, B. "Linguistic Analysis of Speech in Affective Disorders", *Arch. General Psychiatry*, Vol. 33, pp 1361-1367, 1976.
- Berndt, R. and Caramazza, A. "A Redefinition of the Syndrome of Broca's Aphasia: Implications for a Neuropsychological Model of Language", *Applied Psycholinguistics*, Vol. 1, pp 255-278, 1980.
- Brunet, E. "Le Vocabulaire de Jean Giraudoux", *Structure et Evolution*, Geneve: Slatkine, 1978.
- Honore, A. "Some Simple Measures of Richness of Vocabulary", *Association for Literary and Linguistic Computing Bulletin*, Vol. 7, pp 172-177, 1979.