**Can measures of processing complexity predict progressive aphasia from speech?**

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**Introduction** Primary progressive aphasia (PPA) is a dementia characterized by progressive language decline without other notable cognitive impairment. Two main subtypes of PPA are the semantic variant (svPPA) and the nonfluent variant (nfPPA). Patients with svPPA have difficulty recalling words, and while they may produce fluent and grammatically correct sentences, their anomia can lead to speech which is empty of meaning. In contrast, nfPPA patients' speech is effortful, nonfluent, and sometimes agrammatic, while single-word comprehension is spared [1]. However, there can be considerable overlap in symptomology. Previous computational analysis of language in PPA did not uncover syntactic differences between subtypes, nor did it examine word use in context [2]. This study tests *n*-gram probabilities and psycholinguistic measures of processing complexity as possible distinguishing features for control, svPPA, and nfPPA narratives.

**Methods** Narrative speech was elicited from 11 svPPA subjects, 17 nfPPA subjects, and 23 age- and education-matched controls by asking them to tell the story of *Cinderella*. The PPA subjects were in the mild stage, with mean mini-mental state examination scores of 24.8 (svPPA) and 25.2 (nfPPA). The data were split 50-50 into a development partition (for exploration) and a test partition (for significance testing). Logistic mixed regression was used to first separate control from PPA narratives and then separate svPPA from nfPPA narratives. The evaluation baseline included a random intercept for each word and the following fixed effects: sentence position, word length, log unigram probability (obtained from SUBTL), and all 2-way interactions.

**PPA vs Controls** From the baseline, adding 5-gram probability (from Gigaword 4.0) improved classification accuracy ($p < 0.001$). Although syntactic surprisal [3] and entropy reduction [4] helped in the development partition, neither improved over 5-grams on test (both $p > 0.1$). Coefficient analysis indicates that PPA subjects use shorter sentences ($p < 0.001$) and more common words ($p < 0.001$) in unusual lexical contexts (low 5-gram probability, $p < 0.001$). Further, PPA narratives involve more short, rare words ($p < 0.001$), which may be driven by the larger proportion of non-word tokens generated by the patient group, including paraphasias and false starts.

**svPPA vs nfPPA** From the baseline, adding 5-grams improved classification accuracy ($p < 0.001$) as did subsequently adding syntactic surprisal with all 2-way surprisal interactions ($p = 0.012$). Although embedding depth helped during development, it did not help over the surprisal factors on test ($p = 0.33$). Coefficient analysis suggests nfPPA subjects produce longer sentences and tend to use long rare words more frequently (both $p < 0.001$). The production of longer sentences by nfPPA subjects is unexpected, but appears to be due to the higher incidence of repairs and false starts. Narratives from svPPA contain more contextually probable words ($p < 0.001$) and have more common words later in the sentence ($p < 0.003$). The main contribution of syntactic surprisal is an association between rare words and unusual syntax in svPPA ($p = 0.027$), but correcting for multiple comparisons reduces this effect to a non-significant trend.

**Conclusion** While this study revealed some evidence that metrics such as surprisal and embedding depth may help distinguish between PPA subtypes, the strongest predictors were related to word probability and sentence length. Further work is required to explore whether the surprisingly weak diagnostic utility of the information theoretic metrics reflects true similarities between the subtypes or is due to a lack of statistical power.

**References** **[1]** Gorno-Tempini, M. L. et al. Cognition and anatomy in three variants of primary progressive aphasia. Annals Neurol. 55, 335–346 (2004). **[2]** Fraser, K. C. et al. Automated classification of primary progressive aphasia subtypes from narrative speech transcripts. Cortex 55, 43–60 (2014). **[3]** Roark, B. et al. Deriving lexical and syntactic expectation-based measures for psycholinguistic modeling via incremental top-down parsing. Proc EMNLP 324–333 (2009). **[4]** Hale, J. Uncertainty about the rest of the sentence. Cognitive Science 30, 609–642 (2006).