The distinction between expressive aphasia and motor speech disorders in Primary Progressive Aphasia

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Introduction

- Motor speech disorders, including apraxia of speech (AOS) and dysarthria, often co-occur with aphasia (Duffy, 2020).
- However, it is often difficult to distinguish expressive aphasia and AOS which both include the production of sound based errors. As a consequence, some have questioned whether AOS can occur as a syndrome that is distinct from expressive aphasia (Aichert & Ziegler, 2004). Understanding the neural substrates of each can improve our understanding the nature of these disorders and their relationship. These issues have been examined in stroke (e.g. Basilakos, 2015, 2018) but have received scant attention in Primary Progressive Aphasia (PPA).
  - Distinguishing between AOS and expressive aphasia is especially important in the context of PPA, since AOS is used as a distinguishing characteristic in diagnosing different PPA variants, and is specifically associated with non-fluent variant PPA (nfvPPA; Gorno-Tempini et al., 2011). However, previous studies have reported AOS in other PPA variants (Croot et al., 2012).

Research questions:

Q1: How are the presence and severity of expressive aphasia/AOS/dysarthria distributed across PPA variants?

Q2: Which brain areas are associated with expressive aphasia/AOS/dysarthria?

Methods

Participants: 34 PPA individuals (19 females; 12 lvPPA, 12 nfvPPA, 7 svPPA, 1 mixed, 2 unclassifiable) and 24 age-matched healthy controls (14 females)

- No significant differences between PPA variants in terms of age, years of education, years post onset, or FTD-CDR

Table 1. Demographics of PPA participants.

Variable Mean (SD)	lvPPA (n = 12)	nfvPPA (n = 12)	svPPA (n = 7)
Age	66.75 (9.47)	67.58 (5.28)	65.14 (9.21)
Years of education	16.17 (2.89)	16.50 (2.43)	16.67 (1.03)
Years post onset	3.67 (2.45)	2.71 (1.64)	4.86 (3.13)
FTD-CDR	6.29 (3.17)	4.13 (3.16)	5.25 (3.08)

Data:

- Behavioral test scores
  - Boston Naming Test (**BNT**; Williams et al., 1989)
  - Subtest 2 of Apraxia Battery for Adults (**ABA2**), 2nd edition (Dabul, 2000)
    - Deterioration scores (difference in total item scores between the longest and shortest words in each triplet), reflecting the effect of word length on repetition performance
    - Total score (sum of scores of all 60 items), reflecting overall performance in repetition
- SLP ratings: for **expressive aphasia**, **AOS**, and **dysarthria**
  - Based on audio recordings of BNT, ABA subtest 2, and picture description
  - Using an in-house scale of 0-3 (0 = absent, 3 = severe)
    - SLP ratings were highly correlated with specific standardized test scores: expressive aphasia with BNT, AOS with ABA2-B deterioration, dysarthria with ABA2 total (all p-values < .01)
- Neuroimaging: T1-weighted MPRAGE structural scans

Analysis 1: Distribution of aphasia, AOS, and dysarthria diagnoses across PPA variants

- Welch's t-test between pairs of variants for each diagnosis
- Sensitivity and specificity scores of each diagnosis for the 3 PPA variants

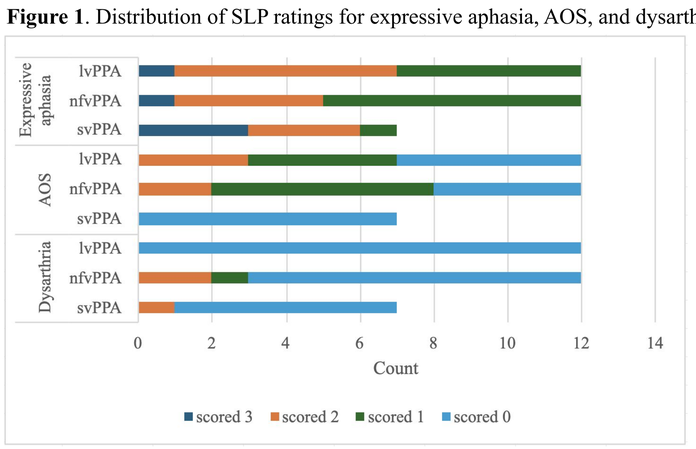
Analysis 2: Relationship between volume and diagnoses

- Whole-brain voxel-based morphometry (VBM) was conducted on the T1-weighted images using FSL-VBM (Douaud et al., 2007) to identify
  - voxels significantly atrophied ($p < .001$) for each PPA variant and
  - voxels significantly correlated ($p < .05$) with each behavioral score and/or SLP rating

Results

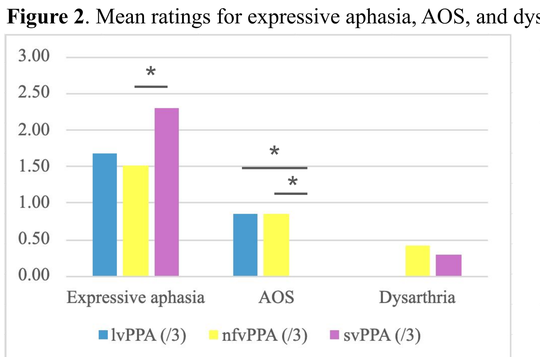
Analysis 1:

Figure 1. Distribution of SLP ratings for expressive aphasia, AOS, and dysarthria.



- Expressive aphasia was present in all 3 PPA variants
- Dysarthria was present only in nfvPPA and 1 svPPA
- **AOS was not only present in nfvPPA, but also in lvPPA**

Figure 2. Mean ratings for expressive aphasia, AOS, and dysarthria.



*, significant at $p < .05$.

- lvPPA and nfvPPA have the same mean AOS rating
- Sensitivity scores for AOS are 56.3%, 66.7%, and 0% in lvPPA, nfvPPA, and svPPA respectively
  - AOS is not particularly sensitive to any of the three PPA variants
- Specificity scores for AOS are 56.9%, 63.2%, and 37.5% in lvPPA, nfvPPA, and svPPA respectively
  - AOS is not specific to any of the three PPA variants

Analysis 2:

Figure 3. VBM results: Voxels significantly associated with expressive aphasia ratings.

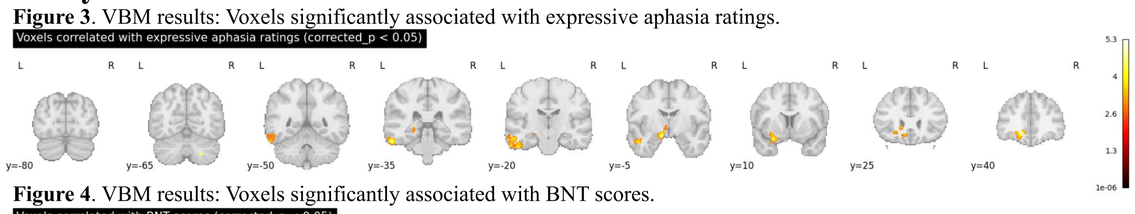


Figure 4. VBM results: Voxels significantly associated with BNT scores.

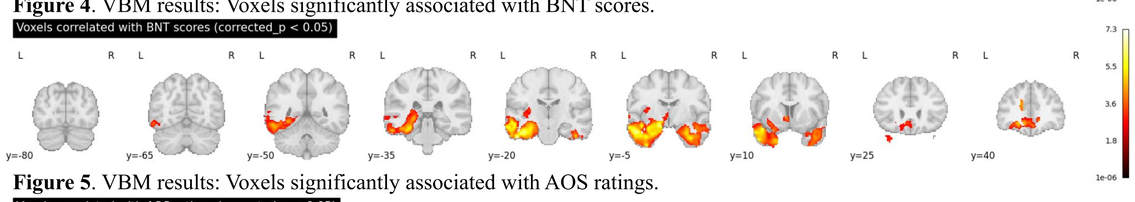


Figure 5. VBM results: Voxels significantly associated with AOS ratings.

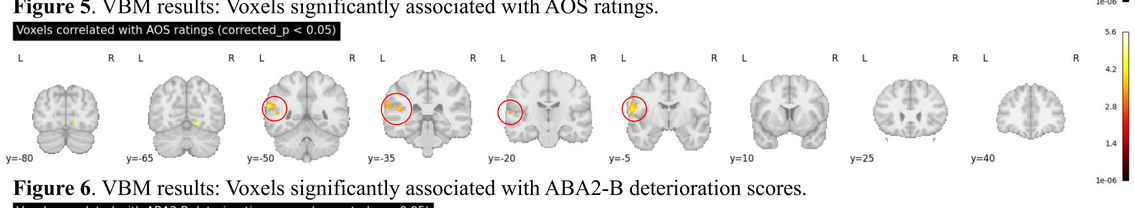
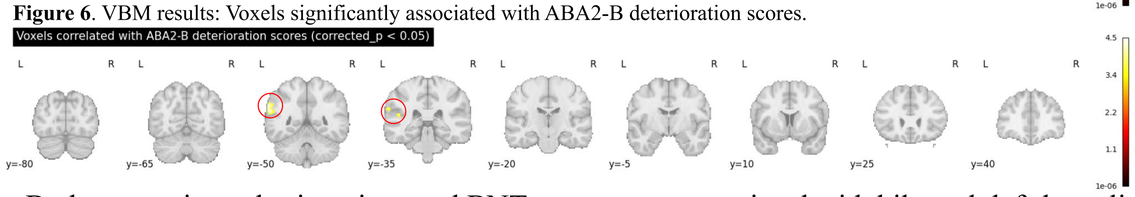


Figure 6. VBM results: Voxels significantly associated with ABA2-B deterioration scores.



- Both expressive aphasia ratings and BNT scores were associated with bilateral, left-lateralized cortical volumes in the temporal lobes, with BNT associated with more extensive areas
- Both AOS ratings and ABA2-B deterioration scores were primarily associated with cortical volume in the left AG, SMG, and PoCG. Additionally, AOS ratings showed correlations with cortical volume in the left PrCG
- No significant results at $p < .05$ for dysarthria ratings, ABA2-A deterioration scores, or ABA2 total scores

Discussion

Q1: How are the presence and severity of expressive aphasia/AOS/dysarthria distributed across PPA variants?

- Absence of AOS distinguished svPPA from the other two variants, but did not distinguish between lvPPA and nfvPPA
- AOS was not exclusively associated with nfvPPA, consistent with findings in other studies (Ash et al., 2010; Wilson et al., 2010; Croot et al., 2012)
- Dysarthria was almost exclusively found in nfvPPA (with the exception of one svPPA participant)

Q2: Which brain areas are associated with expressive aphasia/AOS/dysarthria?

- SLP diagnosis of expressive aphasia (and correlated behavioral score) identified areas in the temporal lobes, while that of AOS (and correlated behavioral score) identified areas in left PrCG, left PoCG, left AG, and left SMG
  - Correlation analyses did not show significant voxels for SLP diagnosis of dysarthria (or correlated behavioral score), likely due to the fact that only 4 PPA participants were diagnosed with the disorder

What do the areas associated with AOS reveal about the specific processes that are impaired?

- AOS was significantly correlated with cortical volume in
  - left PrCG, the motor cortex, consistent with motor speech planning impairment
  - left PoCG, suggesting impaired sensory feedback for motor speech processing
  - left SMG, suggesting that an impairment in phonological working memory may contribute to this disorder

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