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Introduction

Apraxia of speech (AoS) is a distinct motor speech deficit which can occur independently or alongside other language disorders such as aphasia (linguistic impairment) and dysarthria (speech motor execution and muscle weakness). It can be difficult to isolate and may mask problems associated with co-occurring disorders such as phonological planning deficits (Stark et al., 2017), making it difficult to identify the root of incorrect or null responses on speech tasks. However, to produce patient-specific impairment-based interventions, we need to have a good understanding of the functional deficits within individuals. Therefore, the aims of this project were to

1. To investigate the neural correlates of AoS and phonological planning deficits
2. To identify if there are individuals with AoS who consistently have phonological planning problems, or if some score well one phonological planning

Methods

Participants were in the chronic stage of recovery (N=107, 44 Females; stroke age M=56.66 years, SD=11.64, >6 months post-stroke), following a left-hemisphere stroke with no accompanying neuropsychological disorders. They completed a battery of behavioral tests including subtests of the Psycholinguistic Assessments of Language Processing in Aphasia (PALPA; Kay et al., 1996), and the Aphasia Severity Rating Scale (ASRS; Strand et al., 2014). PALPA14 (covert (i.e., non-auditory) rhyme judgement requiring picture selection) was identified as a test of 'inner-speech' or phonological planning without articulation.

Multivariate region-based lesion-symptom mapping (RLSM) analyses using Freedman-Lane were conducted using PALPA14 and AoS severity scores to identify whether articulation (phonetic planning) and inner-speech (phonological planning) deficits are associated with different underlying neural substrates (2,000 permutations, $p<0.05$) using the NiiStat toolbox for Matlab (https://www.nitrc.org/projects/niistat/).

Individuals with similar deficits were grouped using hierarchical cluster analysis based on PALPA14 and AoS severity scores. Discriminant function analysis was used to predict groupings using other behavioral scores which involved a phonological component.

Results

Multivariate RLSM revealed that both the post-central (z=3.09) and pre-central gyrus (z=3.45) uniquely predicted AoS severity scores significantly, whereas the retrolenticular portion of the internal capsule (z=3.37), superior longitudinal fasciculus (SLF; z=2.88) and the posterior insula (z=2.82) uniquely predicted PALPA14 scores (see Figure 1).

Four clusters emerged from the hierarchical cluster analysis and are summarized in Table 1. Discriminant function analysis predicting groupings based on AoS severity and PALPA14 scores revealed only 61.8% of cases, and 26.5% of cross-validated grouped cases were correctly classified.

Conclusions

Initial neuroimaging results suggest the role of different underlying neural correlates for each deficit. However, the picture becomes less clear when scrutinized at an individual level, and the distinction between AoS and phonological planning deficits is not predicted by other tasks with phonological aspects. Possible explanations include that there is no true phonological planning deficit, that it often co-occurs with other deficits making it difficult to disentangle, or that PALPA14 is too challenging for individuals with more severe aphasia subtypes. Future studies would benefit from the design and application of tasks which are less reliant on working memory, but still tap into phonological planning deficits without the need for speech production.

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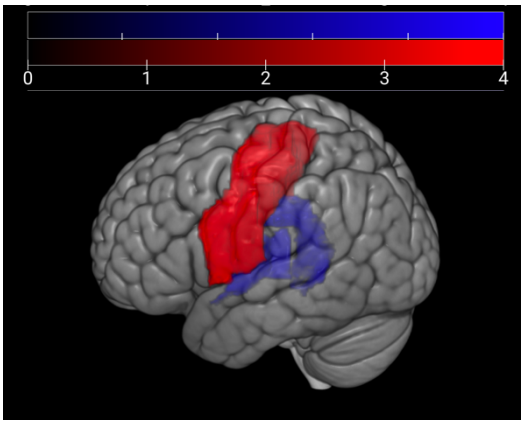

Figure 1. Regions from the multivariate VLSM analysis which significantly predicted AoS severity scores (red) and PALPA 14 scores (blue).

Table 1. Hierarchical cluster analysis group summary. Scores reflect mean(SD).

Group	Number of Individuals	PALPA14 Score (max 40)	Apraxia of Speech Severity (max 4)
1	27	25.7 (6.28)	0.93 (1.17)
2	39	21.90 (3.75)	1.64 (1.68)
3	6	17.83 (2.32)	0 (0)
4	22	19.14 (2.85)	3.05 (0.84)