Automatic analysis of natural speech in Lewy body spectrum disorders with Alzheimer's disease co-pathology

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Introduction

- Lewy Body Spectrum Disorders (LBSD) are a group of phenotypically-diverse neurodegenerative diseases characterized by misfolded α-synuclein protein inclusions. Up to 50% of LBSD autopsy cases have co-occurring Alzheimer’s Disease (AD) which is associated with worse antemortem cognitive-linguistic impairments and shorter survival [1-3].
- In vivo identification of AD co-pathology is crucial for delivering targeted clinical care and to improve patient recruitment for protein-targeted therapeutic trials. This is currently supported through invasive cerebrospinal fluid (CSF) AD biomarkers and/or molecular PET imaging; there remains a need for robust, non-invasive, inexpensive measures that can serve as screening tools for AD co-pathology.
- In this study, we compare acoustic and lexical-semantic properties of a short natural speech task derived using objective, reproducible, fully automated methods between LBSD patients with biologically-confirmed AD (LBSD+AD) versus those without (LBSD). We contrast findings with phenotypic comparisons between Parkinson’s disease with dementia (PDD) and dementia with Lewy bodies (DLB), latter of which has been linked to greater AD co-pathology [4].

Methods

Subjects

<table>
<thead>
<tr>
<th>Characteristic, Mean (1SD)</th>
<th>LBSD</th>
<th>LBSD+AD</th>
</tr>
</thead>
<tbody>
<tr>
<td>N (%Male)</td>
<td>39 (69%)</td>
<td>28 (79%)</td>
</tr>
<tr>
<td>Age (y)</td>
<td>67.02 (7.26)</td>
<td>71.07 (7.24)</td>
</tr>
<tr>
<td>Education (y)</td>
<td>15.77 (2.43)</td>
<td>15.21 (2.47)</td>
</tr>
<tr>
<td>Disease duration (m)</td>
<td>101.64 (57.16)</td>
<td>87.85 (80.13)</td>
</tr>
<tr>
<td>UPDRS P3 total</td>
<td>28.06 (11.64)</td>
<td>29.25 (7.74)</td>
</tr>
<tr>
<td>UPDRS P3 speech</td>
<td>1.21 (0.86)</td>
<td>1.62 (0.77)</td>
</tr>
<tr>
<td>MoCA total</td>
<td>24.45 (3.27)</td>
<td>20.86 (8.83)</td>
</tr>
<tr>
<td>MoCA memory recall total</td>
<td>2.25 (1.86)</td>
<td>1.57 (1.65)</td>
</tr>
<tr>
<td>F letter fluency (# correct)</td>
<td>14.25 (6.04)</td>
<td>10.28 (5.83)</td>
</tr>
<tr>
<td>Rey figure copy</td>
<td>10.04 (3.42)</td>
<td>9.44 (4.32)</td>
</tr>
<tr>
<td>%PPD; %DLB</td>
<td>13%; 36%</td>
<td>21%; 43%</td>
</tr>
</tbody>
</table>

Neuropsych. comparisons covaried for age, *= sig group difference, p < .05.

Procedures

- Speech data: ~1-min. Cookie Theft picture description
- AD co-pathology was confirmed using neuropathological diagnosis or autopsy-validated CSF AD biomarker cut-point: t-tau: Aβ42 ratio >0.3 [6].

Automatic Speech Processing Pipeline

1) Acoustic signals were automatically segmented into voiced speech and silent pauses [7] => durational measures, such as mean speech and pause segment duration, % pause time, and pause rate, were calculated;
2) Transcripts were tokenized and tagged for part-of-speech (POS) with spaCy [8] => number of syllables were counted [9] => POS counts per 100 words, total words, and total syllables were calculated;
3) Combined acoustic-lexical measures, such as speaking (words per min., WPM) and articulatory rate (syllables per sec.) were calculated.

Results

LBSD+AD produce shorter speech segments and spend more time pausing than pure LBSD.†

LBSD+AD produce fewer adjectives and adverbs, and more interjections per 100 words than pure LBSD.†

PDD vs. DLB

- 11 PDD (7 males) & 26 DLB (21 males)
- PDD group was significantly older and had longer disease duration than DLB.
- PDD and DLB did not differ in sex, education, nor UPDRS P3 scores.
- Groups did not differ on any neuropsychological tests.

PDD and DLB did not differ on any acoustic or lexical-semantic measures.†

Conclusions

- Picture descriptions of LBSD with AD co-pathology were different in both acoustic and lexical-semantic aspects from patients with pure LBSD (no AD), while neuropsychological scores were comparable.
- Speech characteristics did not differ between dementia phenotypes (PDD vs. DLB).
- Our study shows that automatic analysis of a short natural speech task can serve as a screening tool for identification of AD co-pathology in LBSD.

References


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