Connected speech and syntactic impairment in Primary Progressive Aphasia

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Disclosure
Naida Graham

Relevant financial relationships

– Employed at the University of Toronto
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Relevant non-financial relationships

– Non-salaried member of Communication Research Team, Toronto Rehabilitation Institute
Outline of talk

• Diagnosis of PPA & its variants
• Description of connected speech in each variant
• Evaluation of connected speech in PPA
  
  **Study 1:** Automated analyses of connected speech in PPA
  
  **Study 2:** Evaluation of agrammatism in nonfluent variant
  
  **Study 3:** Agrammatism in spoken vs. written production in nonfluent variant

• Conclusions
Diagnosis of PPA
Primary Progressive Aphasia (PPA)

Definition
A dementia in which language is the earliest and most severely affected aspect of cognitive functioning

Diagnostic Criteria
Diagnosis of PPA

• Insidious onset & gradual progression of language impairment (i.e., aphasia)

• Aphasia should initially be the most salient impairment and should be the main factor contributing to disruption of ADLs

• Diagnostic testing suggests a neurodegenerative process
Diagnosis of PPA – Exclusion criteria

- Pattern of deficits better accounted for by another disorder
- Prominent initial cognitive impairments outside the language domain (e.g., episodic memory, visuospatial skills)
- Prominent initial behavioural disturbance
Semantic variant

• Impairments in
  1) Naming
  2) Single word comprehension

• At least 3 of:
  1) Spared repetition
  2) Spared speech production with respect to grammar and motor speech
  3) Impaired object knowledge
  4) Surface dyslexia or dysgraphia
Nonfluent variant

• Must have at least 1 of the core features:
  – Agrammatism in language production
  – Effortful, halting speech with distortions & inconsistent speech sound errors (apraxia of speech)

• Must have at least 2 subsidiary features
  1) Impaired syntactic comprehension
  2) Spared single word comprehension
  3) Spared object knowledge
Logopenic variant

• Must have
  – Impaired single word retrieval
  – Impaired repetition of sentences and phrases

• Also, at least 3 of these features
  1) Spared motor speech
  2) Absence of frank agrammatism
  3) Spared single-word comprehension & object knowledge
  4) Phonological errors
PPA variants – imaging-supported diagnosis

svPPA
Anterior temporal
	nfPPA
Left posterior fronto-insular

LvPPA
Left posterior perisylvian or parietal
Description of connected speech in each variant
Speech in semantic variant – quantitative analyses

Strengths

• Normal rates of
  – Syntactic errors (Wilson et al 2010; Sajjadi et al 2012)
  – Phonological errors (Wilson et al 2010; Sajjadi et al 2012)
  – False starts, filled pauses & repaired sequences (Wilson et al 2010)
Speech in semantic variant – quantitative analyses

Deficits (relative to controls)

• Reduced proportions of open class words (Garrard & Forsyth 2010; Wilson et al 2010; Ash et al 2013)

• Use general terms (Garrard & Forsyth 2010; Hoffman et al 2014)

• Use higher frequency & familiarity words (Bird et al 2000; Meteyard & Patterson 2009; Wilson et al 2010; Ash et al 2013; Fraser et al 2014; Mack et al 2015)

• Use more pronouns & more pronouns with ambiguous referents (Patterson & McDonald 2006; Kave et al 2007; Garrard & Forsyth 2010; Pakhomov et al 2010; Wilson et al 2010)
Speech in svPPA – syntactic skills

Strengths

• Rate of syntactic errors is no higher than controls (Wilson et al 2010; Sajjadi et al 2012)

Weaknesses

• Mean length of utterance is reduced (Wilson et al 2010)
• Speech is reduced in syntactic complexity (Patterson & McDonald 2006; Sajjadi et al 2012; Meteyard et al 2013)
• Patients rely on a restricted range of syntactic constructions (Patterson & McDonald 2006; Sajjadi et al 2012; Meteyard et al 2013)

Suggests mild expressive syntactic impairment
Speech in nonfluent variant – quantitative analyses

Deficits (relative to controls)

• Produce fewer words (Graham et al 2004; Wilson et al 2010)

• Use shorter utterances (Ash et al 2006, 2009; Thompson et al 2012)

• Speak more slowly (Rogers & Alarcon 1998; Graham et al 2004; Ash et al 2006; Knibb et al 2009; Wilson et al 2010)

• Produce more phonemic errors & distortions (Ash et al 2010; Sajjadi et al 2012; Ash et al 2013; Grossman et al 2013)
Broca’s aphasia vs. nfPPA


• Subsequent investigations have supported (Thompson et al 2013) and disputed (Patterson et al 2006) this idea
(Frank) agrammatism - definition

- Tendency to omit &/or substitute grammatical morphemes
  -> syntactic errors
- Reductions in:
  - Syntactic complexity
  - Proportion of verbs
  - Proportion of closed-class words

Speech in nfPPA – syntactic skills

Deficits (relative to controls)


• **More grammatical errors** *(Knibb et al 2009; Ash et al 2010; Wilson et al 2010; Sajjadi et al 2012)*
Speech in nfPPA – syntactic skills

Deficits (relative to controls)


• More grammatical errors (Knibb et al 2009; Ash et al 2010; Wilson et al 2010; Sajjadi et al 2012)

In contrast

• Normal rates of grammatical errors, or errors made only by a minority of patients (Graham et al 2004; Clark et al 2005; Knibb et al 2006; Silveri et al 2014)
Lack of frank agrammatism in nfPPA

- Speech of patients with nfPPA may include *normal* proportions of
  - **Closed class words** (Sajjadi et al 2012; Thompson et al 2012, 2013)

- But other studies have found contradictory results (Ash et al 2009, 2010; Wilson et al 2010)
Grammatical skills in nfPPA

- Features of frank agrammatism are inconsistently documented in group studies of nfPPA

- When features of agrammatism are documented, there may be individuals whose results do not follow the group pattern

Across patients, there is a high degree of variability in grammatical skills
Speech in IvPPA—quantitative analyses

Signs of dysfluency

• Speech rate is slower than controls (Wilson et al 2010; Thompson et al 2012, 2013; Ash et al 2013)

• High rate of pauses (Wilson et al 2010; Ash et al 2013, Teichmann et al 2013)

• False starts & hesitations/filled pauses (Wilson et al 2010; Ash et al 2013)

• Increased number of repaired sequences (Wilson et al 2010)
Speech in IvPPA—quantitative analyses

Signs of word finding impairment

• Pauses occur especially before nouns (Mack et al 2015, Teichmann et al 2013)
• Increased number of pronouns (Wilson et al 2010)
• Reduced proportion open class words (Ash et al 2013)

At the single word level

• Phonological errors in some patients (Wilson et al 2010)
• Well articulated, no distortions (Wilson et al 2010)
Syntactic production in lvPPA

• Reduced mean length of utterance (Wilson et al 2010; Thompson et al 2012)

• Proportion of grammatical sentences is lower than controls, but higher than nfPPA (Thompson et al 2012; Ash et al 2013)

• Increased syntactic errors, but attributed to constant re-wordings (Wilson et al 2010)
Syntactic production in lvPPA

Is there a syntactic impairment?

• **Yes**, but mild & in a minority of patients *(Teichmann et al 2013)*

• **No** *(Thompson et al 2013)* – but part of diagnosis of lvPPA was that patients passed a syntactic production test
Study 1: Automated analyses of connected speech in PPA
Study 1 – automated analyses of narrative speech in nfPPA & svPPA

- Task: recounting Cinderella story
- Participants: 10 svPPA, 14 nfPPA, 16 controls
- Method:
  
  Using computational techniques, syntactic & semantic features were automatically extracted from transcriptions of narrative speech

Automatically extracted features

<table>
<thead>
<tr>
<th>12 part-of-speech features</th>
<th>26 complexity features</th>
</tr>
</thead>
<tbody>
<tr>
<td>e.g. Nouns</td>
<td>e.g. Mean length of:</td>
</tr>
<tr>
<td></td>
<td>sentence, clause, T-unit</td>
</tr>
<tr>
<td></td>
<td>Coordinate conjunctions</td>
</tr>
<tr>
<td>Verbs</td>
<td>Parse tree height</td>
</tr>
<tr>
<td>Adjectives</td>
<td></td>
</tr>
</tbody>
</table>
Automatically extracted features

<table>
<thead>
<tr>
<th>5 fluency features</th>
<th>11 psycholinguistic features</th>
</tr>
</thead>
<tbody>
<tr>
<td>e.g. Word length</td>
<td>e.g. Frequency</td>
</tr>
<tr>
<td>Speech rate</td>
<td>Familiarity</td>
</tr>
<tr>
<td>Total words</td>
<td>Age-of-acquisition</td>
</tr>
<tr>
<td>Um, uh</td>
<td>Light verbs</td>
</tr>
</tbody>
</table>
Results - Features that best distinguished svPPA & Controls

Elevated in svPPA

- Frequency
- Familiarity
- # Demonstrative pronouns
- # Clauses

Reduced in svPPA

- # Nouns
- Noun:verb ratio
- Word length
- Clause length
Features that best distinguished nfPPA & Controls

Elevated in nfPPA
- Frequency – esp verbs

Reduced in nfPPA
- Speech rate
- Word length
Study 1 – summary – relative to controls

svPPA & nfPPA

• used words that were higher in frequency, especially nouns for svPPA & verbs for nfPPA

svPPA

• used words which were higher in familiarity
• produced fewer nouns but more demonstratives

nfPPA

• had slower speech & used shorter words
Surprisingly

None of the grammatical features distinguished nfPPA from controls
Study 2: Evaluation of agrammatism in nonfluent variant PPA
Potential reasons for variability in grammatical skills in nfPPA

• Studies include variable numbers of patients whose dysfluency arises from a motor speech impairment

• Difficulty distinguishing nonfluent & logopenic variants
Potential reasons for variability in grammatical skills in nfPPA

• Studies include variable numbers of patients whose dysfluency arises from a motor speech impairment – Addressed this by evaluating motor speech skills in our PPA patients

• Difficulty distinguishing nonfluent & logopenic variants – Addressed this using volumetric MRI data to provide unbiased imaging-supported diagnosis
Study 2 – Evaluation of agrammatism in nfPPA

• **Background** – Inconsistent results in the literature with respect to grammatical skills in nfPPA

• **Aim** – To examine syntactic production in nfPPA patients with
  – Preserved motor speech skills
  – Diagnosis independently supported by volumetric MRI data

• **Participants** - 14 nfPPA, 14 svPPA, 4 lvPPA
Study 2: grammatical production & motor speech skills

Blinded expert raters evaluated speech samples for features of agrammatism & AOS

• Narratives
  • Topic-directed interviews (Orange et al 1998)

• Tasks sensitive to apraxia of speech (Duffy, 2013)
  • Repetition of words of increasing length
  • Repetition of polysyllabic words/phrases 3X
  • Diadochokinesis (Puh-tuh-kuh)
Agrammatism checklist – example features

- Lack of functor/closed class words (articles, prepositions, etc.)
- Omission/substitution of inflectional affixes
- “Sentences” are simple & incomplete
- Limited variety of sentence structure

Based on Saffran et al 1980
Apraxia of speech checklist – example features

- Syllable segregation
- Phonemic anticipatory, perseverative or transposition errors
- Intrusion of schwa between syllables or in consonant clusters
- Visible/audible searching (articulatory groping)

Based on Dabul et al 2000; Duffy 2013
Study 2 – methods for imaging analyses

• Analyzed regions of interest (all left-sided)

\[
\begin{align*}
\text{Inferior frontal} & \quad \text{nfPPA} \\
\text{Insula} & \\
\text{Anterior temporal} & \quad \text{svPPA} \\
\text{Inferior parietal} & \quad \text{lvPPA} \\
\text{Posterior temporal} &
\end{align*}
\]

• Atrophy scores were calculated for each individual for each brain region (accounted for variation in brain/head size)
Criteria for imaging supported diagnosis of nfPPA

Atrophy scores were:

– Abnormal in insula &/or inferior frontal
– Normal in inferior parietal & posterior temporal
Study 2 - results

14 svPPA, 14 nfPPA, 4 lvPPA

3 frank agrammatism & AOS

10 no frank agrammatism or AOS

1 AOS only

5 imaging consistent with nfPPA

5 imaging cannot rule-out lvPPA
Study 2 - results

14 svPPA, 14 nfPPA, 4 lvPPA

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5 imaging consistent with nfPPA

5 imaging cannot rule out lvPPA
Transcription of nfPPA patient

- **Examiner:** Tell me about what you do each day

- **Patient:** I read a lot, and uh, I look at television here and there, and uh, then, I do go out . . . I don’t do very much, really, uh, I go visiting and have an odd person in to have a cup of tea and uh, then on the weekends I go out with my family
Study 2 – Stage of illness

• Symptom duration:
  Range 1.7 – 6.2 years, mean = 3.5 years

• Some of the patients were beyond the earliest stages of illness
Do nfPPA patients exhibit frank agrammatism?

The main finding – Some nfPPA patients had

✓ Imaging-supported diagnosis
✗ Frank agrammatism in speech
✗ Apraxia of speech
Differentiation of nfPPA & lvPPA

- Some researchers classify as lvPPA patients whose speech is nonfluent but without frank agrammatism or AOS
- The present results suggest this would lead to misclassification in some cases

Agrammatism in production in nfPPA

- May be difficult to detect in the clinic because in some patients it may be subtle
Study 3: Agrammatism in spoken vs. written production in nfPPA
Study 3 – Agrammatism in spoken vs. written production in nfPPA

• 14 nfPPA, 11 controls
• Study was done prior to current diagnostic criteria. At least 12 patients are unlikely to have lvPPA (9 had imaging with predominant left frontal/insular abnormality; 4 developed CBS)
• Written & spoken descriptions of cookie theft picture

Graham, Patterson & Hodges (2004) When more yields less: Speaking & writing deficits in nonfluent progressive aphasia, Neurocase, 10, 141-155
Study 3 - Results

• Spoken picture description - nfPPA patients had normal
  – Noun:verb ratios
  – Content:function word ratios
  – Rates of syntactic errors

• Written picture description
  – Same results except produced more syntactic errors than controls
Study 3 - Implications

• Once again, results suggest that some nfPPA patients do not have frank agrammatism

• Agrammatism may be apparent in writing before it is noticeable in spoken language
Final comment & conclusions
Final comment - Methods of assessing grammatical skills in speech

• Make a sentence test (Billette et al 2015, in Aphasiology)
  – Emma bake pie party -> Emma baked a pie for the party

• Progressive aphasia language scale (Leyton et al 2011, in Brain) & Progressive aphasia severity scale (Sapolsky et al 2014, in Aphasiology)
  – Provide ratings for severity of impairment in grammatical production & morphology
Conclusions

svPPA - There is evidence that grammatical production is simplified, although without errors

nfPPA - There is a high degree of variability across patients with respect to grammatical skills

IvPPA - Some patients may exhibit grammatical dysfunction, but the impairment is usually mild and occurs in a minority of patients
Collaborators

In Toronto, Canada:

Elizabeth Rochon            David Tang-Wai
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Graeme Hirst

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