Impairments in complex language following damage to the pre-frontal cortex

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Objectives

1. Review proposed language functions of prefrontal cortex
2. Discuss assessment approaches for discourse impairments following acquired brain injuries
3. Summarize preliminary data from Vietnam Head Injury Study

Language functions of the prefrontal cortex: Evidence from brain injury

- Frontal lobes long implicated in language function, less known about role PFC
- Barbizet et al. (1975) noted localized lesions
  - basic language preserved
  - impaired spontaneous discourse regardless side of lesion
  - diminished complexity of propositional language
Language functions of the prefrontal cortex: Evidence from brain injury

- Anterior RBD (Wapner et al., 1981)
  - tendency to embellish & confabulate
  - difficulty with selection of story-significant elements

- Right PFC (Grafman, 2002)
  - center for course, slower processing of loosely associated info - themes/morals

- Left PFC (Beeman, 1993)
  - involved in specific coding - immediate & obvious connections

Language functions of the prefrontal cortex: Evidence from brain injury

(Kaczmarek, 1984, 1987)

Left dorsolateral group
- Difficulty developing narratives
- Tendency to perseverate on first proposition
- Fewer complex sentences

Left orbitofrontal group
- Frequent digressions
- More complex grammar
- Apparent inability to regulate verbalizations

Language functions of the prefrontal cortex: Evidence from brain injury

- Double dissociation syntax- and script-level abilities (Sirigu et al., 1998)
  - Lesions to Broca’s area
    - ordered word groups correctly - logical sequence of actions
    - severely impaired - similar word groups - ordered as syntactically well-formed sentence
  - Dorsolateral prefrontal lesions
    - intact syntactical processing - sentence level
    - pronounced deficit producing temporally coherent sequences actions
What is discourse?

- Continuous strings of language which convey a message

- Discourse types include:
  - descriptive
  - narrative
  - procedural
  - conversational

Rationale for looking at discourse following TBI

- Aphasia batteries often used to assess language after TBI
  - assess language at single word or sentence level
  - do not examine language in complex tasks

Vietnam Head Injury Study

Phase I: 1967-1970
Army surgeons in field hospitals complete questionnaires on 1000 soldiers who survived severe head wounds during Vietnam War

Phase II: 1982-1987
~ 500 survivors recruited to Walter Reed Army Medical Center for seven days of neuropsych testing and CT scans

~ 200 survivors recruited to National Naval Medical Center for five days of neuropsych testing and CT scans
Data from Vietnam Head Injury Study

Participants
- 15 males, 55-62 years of age, severe head wound between 1967-1970 in Vietnam War
- Native speakers of English
  - 6 participants with exclusively left dorsolateral lesions
    - 12-16 years of educ.
    - AFQT scores of 42-98
    - BNT scores of 35-60
    - TT scores of 91-100

PHI data cont.

Participants cont.
- 9 participants with exclusively right dorsolateral lesions
  - 14-16 years of educ.
  - AFQT scores of 49-94
  - BNT scores of 42-60
  - TT scores of 90-100

Comparison group
- 46 Vietnam war veterans with no history of neurological disease or injury
- Native speakers of English
- 55-65 years of age
- 11-17 years of educ.
- AFQT scores of 21-90
- BNT scores of 46-60
- TT scores of 96-100
Quantification of brain Lesions

- Identified via CT scans, digitized and analyzed with software – Analysis of Brain Lesions (ABLe) (Soloman, et al., 2006; 2007)

- Program quantifies:
  - brain lesion size
  - Brodmann areas contained within boundaries of lesion
  - percentage of brain volume loss
Discourse analysis procedures

• Participants shown picture story with no sound track on a computer screen
• Upon completion “tell me that story you just watched”
• Each retelling - digitally video-recorded
• Recordings transcribed verbatim, segmented into T-units
• Analyzed at multiple levels

Discourse samples

NBI participant
1. Old McDonald and his wife uh left the farm in Iowa and moved into the big city
2. they found an apartment building and uh got an apartment
3. and he started to uh- brought in all those tools and his implements
4. and uh then his wife started a had a plant
5. and it didn’t seem like it was getting enough sunlight
6. so he went outside the window and cut the trees
7. and sure enough it that was the problem
8. but he started growing more stuff
9. and he started outside of his win- apartment door
10. and pretty soon he had plants and vegetables

Discourse samples

NBI cont.
11. and his neighbors started to complain
12. but ah he just kept growing
13. and he had animals
14. and he kept growing
15. he had plants everywhere til caused some of his neighbors to move leave the building
16. and the superintendent was complaining to him because he had vegetables in every floor of the building
17. and uh he was losing all his tenants
18. so finally he evicted Old McDonald and his wife
19. and but he had a bigger problem
20. what to do with all the vegetables and the animals?
21. so he came up with idea of a fruit stand to sell the vegetables
Discourse Samples

Left DL
1. it looked like Old MacDonald had grown some tomatoes in a pot
2. and he was showing I guess it was old MacDonald I mean Mrs. MacDonald
3. and then I remember Old MacDonald
4. he was entering a room
5. it looked like he was carrying a mop, a tool box and a bucket
6. looked like he was gonna do some cleaning up
7. he was like outside of the window
8. had a sledgehammer
9. looked he was beating on something or pounding in a stake
10. Then I remember he was sitting on a chair

Discourse Samples

Left DL cont.
11. and it looked like the chair had slid from under him
12. there was two people walking away
13. it looked like they were trying to sneak away
14. then I remember they were in a store
15. and there was something hanging from the ceiling
16. it looked like turnips or carrots or something
17. and one of the old ladies was grabbing for one
18. the man had one
19. he was walking out
20. it looked like there was a dog behind him
21. looked like he was trying to grab at one
22. and I remember another scene when there was two men standing kinda looked like a platform

Discourse Samples

Right DL
1. well looked like Old McDonald was the superintendent of apartment building
2. and it showed his wife having a plant
3. I thought it looked like marijuana at first
4. but then it showed him choppin the bushes outside the window
5. and her plant turned into a bigger plant tomatoes
6. and then he hauled in dirt into all the houses and started raisin vegetable and the vegetables growing through the floor down into the bottom apartments
7. and he moved some animals in there
8. and people moved out
9. and looked like the landlord chased him out and set up a fruit stand to sell the vegetables
Discourse analysis procedures

**Sentence Production**
- # words per T-unit \( [sent. \ length] \)
  (T-unit = independent clause + any subordinate clauses)
  *(and he climbed to the top of the branch where the cat was)*
- # subordinate clauses per T-unit \( [\text{grammatical complexity}] \)

**Grammatical complexity**

<table>
<thead>
<tr>
<th>Participants</th>
<th>Mean</th>
<th>SD</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comparison</td>
<td>.24</td>
<td>.16</td>
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</tr>
<tr>
<td>R DLPFC</td>
<td>.16</td>
<td>.13</td>
<td></td>
</tr>
<tr>
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<td>.13</td>
<td>.10</td>
<td>.16</td>
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**Cohesive Adequacy**
- Complete – info referred to by cohesive marker/tie easily found with no ambiguity
  *The girl was hungry. She ate her lunch.*
- Incomplete/error
  *Dave and Joe drove to the game. He forgot the tickets.*
- Percent complete ties of total ties
Cohesive adequacy

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<tr>
<td>L DLPFC</td>
<td>.51</td>
<td>.25</td>
<td>.054</td>
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Discourse analysis procedures

Coherence ratings
- Coherence ratings reveal how well an individual maintains and conveys overall theme of narrative.
  - Local coherence
  - Global coherence
  - Each T-unit in story rated for local and global coherence on 5-point scale (Van Leer & Turkstra, 1999)

Local Coherence

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<tr>
<td>L DLPFC</td>
<td>3.80</td>
<td>.96</td>
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Global Coherence

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<td>4.67*</td>
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<tr>
<td>L DLPFC</td>
<td>3.91*</td>
<td>1.04</td>
<td>&lt; .005</td>
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</table>

Discourse analysis procedures

- Story grammar guides comprehension and expression of logical relationships (temporal & causal) between people and events

- Story grammar analysis
  - Number of episodes
    - initiating event
    - Attempt
    - Direct consequence
  - T-units within episodic structure
    - T-units within episodes/ total T-units in retelling

Discourse analysis procedures

**Story Grammar**

Complete episode

Initiating event

[and this fly comes in and the Father’s bothered by this]

Attempt (action)

[so he decides to swat or hit the fly and he hits his wife]

Direct consequence

[and she goes down]
### Story Grammar

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<td>L DLPFC</td>
<td>.54</td>
<td>.37</td>
<td>.11</td>
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### Discourse analysis procedures

**Story Completeness**
- Each narrative surveyed for presence of five critical components
- Completeness score = total number of components

### Story Completeness

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<tr>
<td>L DLPFC</td>
<td>2.17*</td>
<td>2.14</td>
<td>&lt;.001</td>
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</table>

(large eff. size)
Summary/Discussion

- L DLPFC < R DLPFC < comparison group for all discourse measures

- Only three significant differences
  - L DLPFC < comparison group
    - Local coherence
    - Global coherence
    - Completeness

- Neither L or R DLPFC groups had difficulty with sentence production or cohesive adequacy

- Discourse difficulties associated with organization of longer texts than at sentence level
  - Omitted critical components from stories (completeness)
  - Couldn’t maintain relationship between content and gist of story (coherence)

- Coherence
  - Global coherence – how discourse organized: overall goal, plan, or topic
  - Local coherence – conceptual links between adjacent sentences: maintain meaning
  - Impairments reported for – diffuse pathology (AD, CHI) (Glosser & Deser, 1990) & focal perisylvian lesions (Coelho & Flewellyn, 2003)
Summary/Discussion

- **Completeness**
  - Derived from pre-determined critical story components
  - Story retelling was requested immediately, however task involved aspects of memory
  - Participant with difficulty recognizing associations among story components – greater load on WM than one able to integrate components into meaningful synopsis

Working Memory Measures

<table>
<thead>
<tr>
<th>Measure</th>
<th>Comparison</th>
<th>L DLPFC</th>
<th>R DLPFC</th>
<th>Signif</th>
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</thead>
<tbody>
<tr>
<td>Letter-Number Sequencing</td>
<td>9.18 (2.61)</td>
<td>6.83 (2.79)</td>
<td>8.33 (3.67)</td>
<td>.14</td>
</tr>
<tr>
<td>Spatial Span Backward</td>
<td>9.87 (2.86)*</td>
<td>6.00 (1.55)**</td>
<td>9.33 (2.50)*</td>
<td>.007</td>
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Pearson correlation coefficients for discourse and WM measures of L DLPFC

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<td>-.13</td>
<td>.53</td>
<td>.20</td>
<td>.14</td>
<td>.03</td>
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<tr>
<td>Spatial Span Backward</td>
<td>.82 (.08)</td>
<td>.84 (.03)</td>
<td>.84 (.04)</td>
<td>.86 (.03)</td>
<td>.72</td>
<td>.85 (.03)</td>
</tr>
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</table>
Pearson correlation coefficients for discourse and WM measures of R DLPFC

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<td>Letter- Number Sequenc ing</td>
<td>-.55</td>
<td>-.14</td>
<td>.67 (.05)</td>
<td>-.49</td>
<td>.25</td>
<td>.64</td>
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<tr>
<td>Spatial Span- Back.</td>
<td>-.73 (.03)</td>
<td>.51</td>
<td>-.09</td>
<td>-.16</td>
<td>-.40</td>
<td>.06</td>
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</tbody>
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Summary/Discussion

**Implications**
- Individuals with damage of PFC demonstrate difficulties
  - formulation of complex language
  - deficits not attributable to aphasia
  - discourse analyses useful for delineating subtle problems
- Participants 30-35 years post, discourse impairments do not resolve without treatment

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