Cross-Language Facilitation and Competition in Multilingual Aphasia

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TROMSØ
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Overview

I. Neurolinguistics of bilingualism: Evidence from aphasia
II. Assessment challenges in multilingual aphasia
III. Treatment in multilingual aphasia: Proficiency & cross-language effects
IV. Summary & conclusions
I. Neurolinguistics of bilingualism: Evidence from aphasia
Aphasia in multilinguals

- Parallel or Selective?
- Dynamic
- Relative to pre-CVA
- Measures post-CVA
Parallel or selective: Grammar

- Nouns better than verbs (Arabic, French, English) (Faroqi-Shah & Waked, 2010)
- Regular verb inflection better than irregular (Spanish, Catalan) (De Deigo Balaguer et al., 2004)
- Similar agrammatic features (Swahili, English) (Abuom & Bastiaanse, 2012)

**BUT**

- Greater difficulty with Norwegian morphology than with Persian (regular, limited set, productive) (Knoph, 2011)
Control: Language mixing

• *Language choice* may be impaired (Aglioti et al., 1996; Perecman, 1984)

• Amount and type of *code switching*
  – Comparable to healthy bilinguals (Albert & Obler, 1978; Grosjean, 1984)
  – Different from healthy bilinguals
    • Greater (Chengappa et al., 2004; Muñoz et al., 1999)
    • Strategy (Ansaldo et al., 2010)
Bilingual representation

• Language-specific, non-overlapping neural networks
  – Within the left hemisphere
    (Ojemann & Whitaker, 1978; Giussani et al., 2007)
  – Procedural vs. declarative memory

  **versus**

• Overlapping (shared) neural networks & Control
  (Green, 1998; Abutalebi & Green 2007, 2008)
  – language selection (inhibition, activation)
  – Brain region ≠ classic language areas
Abutalebi & Green, 2007

Prefrontal Cortex
- Executive functions
- Decision-making
- Response selection
- Response inhibition
- Working memory

Anterior Cingulate Cortex
- Attention
- Conflict monitoring
- Error detection

Basal Ganglia
- Language selection
- Set switching
- Language planning
- Lexical selection

Inferior Parietal Lobule
- Maintenance of Representations
- Working memory
II. Assessment challenges in multilingual aphasia
Types of bilinguals

- Age of acquisition/learning
- Manner of appropriation
- Proficiency
Assessment

• Pre-CVA: self report only?
• Post-CVA:
  – Self report
  – Standardized and experimental tests
    • The Bilingual Aphasia Test
    • Lexical retrieval: Verbal Fluency, Picture naming
    • Spontaneous speech: accuracy, efficiency
Challenges

• Comparable tests
• Repeated testing, order
• Tester
• Scoring
### Participant SE: Repeated testing

<table>
<thead>
<tr>
<th>Testing</th>
<th>Therapy</th>
<th>Testing</th>
<th>Therapy</th>
<th>Testing</th>
<th>Therapy</th>
<th>Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 languages per day 3 times</td>
<td>Spanish: Lexical &amp; Sentence production</td>
<td>2 languages per day 3 times</td>
<td>English: Lexical &amp; Sentence production</td>
<td>2 languages per day 3 times</td>
<td>Spanish: Lexical &amp; Sentence production</td>
<td>2 languages per day 3 times</td>
</tr>
</tbody>
</table>

- **Time 1**
- **Time 2**
- **Time 3**
- **Time 4**
## Participant FGF: Repeated testing

<table>
<thead>
<tr>
<th>Testing</th>
<th>Therapy</th>
<th>Testing</th>
<th>Therapy</th>
<th>Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 languages 4-5 per day 3 times</td>
<td>Dutch: Reading &amp; Sentence production</td>
<td>7 languages 4-5 per day 3 times</td>
<td>Russian: Foreign language</td>
<td>8 languages 4 per day 3 times</td>
</tr>
</tbody>
</table>
Scoring

• Code switching
  – Accented cognates, blends
  – Lexical choice
  – Language choice

• Errors
  – Non-L1
  – Cross-language transfer
Examples

- Accented cognates
- Language choice
- Lexical choice
- Language mixing
- Grammatical errors
- Cross-language transfer
### Participant CS: History

<table>
<thead>
<tr>
<th></th>
<th>Catalan</th>
<th>Spanish</th>
<th>French</th>
<th>German</th>
<th>English</th>
</tr>
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<tbody>
<tr>
<td><strong>Age learned</strong></td>
<td>Birth</td>
<td>Early</td>
<td>5</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td><strong>Manner learned</strong></td>
<td>Acquired</td>
<td>Acquired</td>
<td>Learned</td>
<td>Learned</td>
<td>Learned</td>
</tr>
<tr>
<td><strong>Use pre CVA</strong></td>
<td>Frequently</td>
<td>Frequently</td>
<td>Regularly</td>
<td>Regularly</td>
<td>Regularly</td>
</tr>
<tr>
<td><strong>Proficiency pre CVA</strong></td>
<td>9/9</td>
<td>9/9</td>
<td>7/9</td>
<td>7/9</td>
<td>6/9</td>
</tr>
<tr>
<td><strong>Self-rating pre treatment</strong></td>
<td>5/9</td>
<td>5/9</td>
<td>2/9</td>
<td>4/9</td>
<td>3/9</td>
</tr>
</tbody>
</table>
## Participant SE: History

<table>
<thead>
<tr>
<th></th>
<th>Spanish</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age learned</td>
<td>Birth</td>
<td>17</td>
</tr>
<tr>
<td>Manner learned</td>
<td>Acquired</td>
<td>Immersed</td>
</tr>
<tr>
<td>Use pre CVA</td>
<td>Frequently</td>
<td>Frequently</td>
</tr>
<tr>
<td>Proficiency pre CVA</td>
<td>9/9</td>
<td>9/9</td>
</tr>
<tr>
<td>Self-rating pre treatment</td>
<td>4/9</td>
<td>3/9</td>
</tr>
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</table>
## Participant FGF: History

<table>
<thead>
<tr>
<th>Age learned</th>
<th>Flemish</th>
<th>German</th>
<th>French</th>
<th>English</th>
<th>Italian</th>
<th>Norwegian</th>
<th>Spanish</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth</td>
<td>Early</td>
<td>Early</td>
<td>15</td>
<td>16</td>
<td>30s</td>
<td>40s</td>
<td></td>
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<table>
<thead>
<tr>
<th>Manner learned</th>
<th>Flemish</th>
<th>German</th>
<th>French</th>
<th>English</th>
<th>Italian</th>
<th>Norwegian</th>
<th>Spanish</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acquired</td>
<td>Acquired</td>
<td>Acquired</td>
<td>Learned/Acquired</td>
<td>Learned/Acquired</td>
<td>Immersed</td>
<td>Immersed</td>
<td>Immersed</td>
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</table>

<table>
<thead>
<tr>
<th>Use pre CVA</th>
<th>Flemish</th>
<th>German</th>
<th>French</th>
<th>English</th>
<th>Italian</th>
<th>Norwegian</th>
<th>Spanish</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequently</td>
<td>Regularly</td>
<td>Frequently</td>
<td>Regularly</td>
<td>Regularly</td>
<td>rarely</td>
<td>Regularly</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Self-rating pre CVA</th>
<th>Flemish</th>
<th>German</th>
<th>French</th>
<th>English</th>
<th>Italian</th>
<th>Norwegian</th>
<th>Spanish</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Self-rating post CVA</th>
<th>Flemish</th>
<th>German</th>
<th>French</th>
<th>English</th>
<th>Italian</th>
<th>Norwegian</th>
<th>Spanish</th>
</tr>
</thead>
</table>
# Participant PGE: History

<table>
<thead>
<tr>
<th></th>
<th>Persian</th>
<th>German</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age learned</strong></td>
<td>Birth</td>
<td>6</td>
<td>14</td>
</tr>
<tr>
<td><strong>Manner learned</strong></td>
<td>Acquired at home</td>
<td>Acquired in the environment; school &amp; higher</td>
<td>Learned formally; moved to US age 27</td>
</tr>
<tr>
<td><strong>Use pre CVA</strong></td>
<td>Frequently; immediate family</td>
<td>Frequently; work, friends</td>
<td>Frequently; work, environment</td>
</tr>
<tr>
<td><strong>Proficiency pre CVA</strong></td>
<td>9/9 (spoken)</td>
<td>9/9</td>
<td>9/9</td>
</tr>
<tr>
<td><strong>Use post CVA</strong></td>
<td>Rarely</td>
<td>Rarely</td>
<td>Frequently family, environment</td>
</tr>
<tr>
<td><strong>Self-rating pre treatment</strong></td>
<td>3/9</td>
<td>4/9</td>
<td>6/9</td>
</tr>
</tbody>
</table>
**Participant HEF: History**

<table>
<thead>
<tr>
<th></th>
<th>Hebrew</th>
<th>English</th>
<th>French</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age learned</td>
<td>Birth</td>
<td>10 (0-3)</td>
<td>16</td>
</tr>
<tr>
<td>Manner learned</td>
<td>Acquired at home</td>
<td>Exposed in infancy; learned formally; higher edu; lived in US</td>
<td>Learned formally; higher edu; lived in France</td>
</tr>
<tr>
<td>Use at onset</td>
<td>Rarely; extended family</td>
<td>Frequently; work, friends, environment</td>
<td>Frequently; immediate family</td>
</tr>
<tr>
<td>Proficiency at onset</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Use post CVA</td>
<td>Frequently; practice</td>
<td>Frequently; environment, practice</td>
<td>Frequently; family, practice</td>
</tr>
<tr>
<td>Self-rating post</td>
<td>1st</td>
<td>2nd</td>
<td>3rd</td>
</tr>
</tbody>
</table>
III. Treatment in multilingual aphasia: Cross-language effects & proficiency
Previous findings

• Facilitation

• No facilitation
  – Galvez & Hinckley, 2003; Meinzer, Obleser, Flaisch, Eulitz, & Rockstroh, 2007; Miller Amberber, 2012

• Mixed
  – Edmonds & Kiran, 2006; Goral, Levy, & Kastl, 2010; Goral et al., 2012; Kiran & Roberts, 2010; Meirtsch, Meisel, & Isel, 2009

• Inhibition
  – Abutalebi et al., 2009
Influencing variables

- Language acquisition (L1, non-L1)
- Language exposure and use
  - Environment, family, work
- Language proficiency (pre, post)
- Language similarities
  - Cognates
  - Less evidence regarding grammar
Hypothesis:
Proficiency-dependent cross-language effects
Compensation and Restitution

- Language dysfunction
- Unsuccessful communication
- "Punishment" embarrassment, frustration
- Behavior suppressed
- Learned non-use of spontaneous speech
- Positively reinforced
- Compensatory behavior: gesture & writing
- Less effective behavior strengthened

Adapted from Lillie & Mateer (2006). J. Head Trauma Rehabilitation, 21, 119-130
Constraint-induced treatment

• Intense

• Constrained
  – CIMT: Impaired limb
  – CIAT: Spoken modality, sentences

• Functional
  – Functional actions
  – Informative (vs. practiced) exchanges
## Participant PGE: Design

<table>
<thead>
<tr>
<th>Testing</th>
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<th>Testing</th>
<th>Therapy</th>
<th>Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 languages 3 sessions</td>
<td>English: Sentence production</td>
<td>3 languages 3 sessions</td>
<td>Persian: Sentence production</td>
<td>3 languages 3 sessions</td>
<td>German: Sentence production</td>
<td>3 languages 3 sessions</td>
</tr>
</tbody>
</table>

- Picture description (BAT)
- Narrative production
Participant PGE: BAT Description

English

Persian

German
Participant PGE: Narratives

German

Grammaticality

Code switching
E.g.: “Wer-/vi/... b-b-buying (eng) kleine [Kleider?]... k-k- k- Kuche und ... kro- ... das Pullover”
Participant PGE: Summary

- **Persian L1**
  - Increased productivity (grammaticality) post Persian
  - No change post English, German

- **German L2**
  - Increased grammaticality post German
  - Increased grammaticality post English
  - Decreased grammaticality & increased case errors post Persian

- **English L3**
  - Increased grammaticality post English
  - Increased grammaticality post German
  - Decreased grammaticality post Persian
# Participant SE: Design

<table>
<thead>
<tr>
<th>Testing</th>
<th>Therapy</th>
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<th>Testing</th>
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</tr>
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<tbody>
<tr>
<td>2 languages per day 3 times</td>
<td>Spanish: Lexical &amp; Sentence production</td>
<td>2 languages per day 3 times</td>
<td>English: Lexical &amp; Sentence production</td>
<td>2 languages per day 3 times</td>
<td>Spanish: Lexical &amp; Sentence production</td>
<td>2 languages per day 3 times</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Phase</th>
<th>Treatment</th>
<th># of hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tx 1</td>
<td>Spanish</td>
<td>2.5 hrs/session, 2-3x wk, 4-5 weeks</td>
</tr>
<tr>
<td>Tx 2</td>
<td>English</td>
<td>2.5 hrs/session, 2-3x wk, 4-5 weeks</td>
</tr>
<tr>
<td>Tx 3</td>
<td>Spanish</td>
<td>2.5 hrs/session, 2-3x wk, 4-5 weeks</td>
</tr>
<tr>
<td>Follow-up</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Participant SE: Results

BAT Picture description (Spanish)

![Bar chart showing results over time](attachment:image.png)

- **Ungrammatical**
- **Grammatical (core) sentences**

<table>
<thead>
<tr>
<th>Time</th>
<th>Baseline</th>
<th>Post Tx1</th>
<th>Post Tx2</th>
<th>Post Tx3</th>
<th>FU</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>12</td>
<td>16</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>14</td>
<td></td>
<td>16</td>
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<td>16</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>18</td>
</tr>
</tbody>
</table>
Participant SE: Results
Sentence production (Spanish)

![Bar chart showing results for Participant SE across different time points: Baseline, Post Tx 1, Post Tx 2, Post Tx 3, Follow-Up. The chart includes categories for Irrelevant, Ungrammatical, Grammatical, Irrelevant, and Grammatical, Relevant achievements.](image)
Participant SE: Summary

• Improved production in the treated Spanish
• **Decreased** performance in Spanish following treatment in the weaker English
• Minimal production in English (not shown)
Participant FGF: Design

<table>
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<th>Therapy</th>
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<th>Therapy</th>
<th>Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 languages</td>
<td>Dutch: Reading &amp;</td>
<td>7 languages</td>
<td>Russian: Foreign</td>
<td>8 languages</td>
</tr>
<tr>
<td>4-5 per day</td>
<td>Sentence production</td>
<td>4-5 per day</td>
<td>language</td>
<td>4 per day</td>
</tr>
<tr>
<td>3 times</td>
<td></td>
<td>3 times</td>
<td></td>
<td>3 times</td>
</tr>
</tbody>
</table>

• 40 hours
• 6-10 h/per week, 2 h/per day
• Modified Oral Reading for Language in Aphasia (ORLA, Cherney, 2004)
Modified ORLA

• Reading out loud
• Locating Words in Text
• Using Words in Sentences
• Reading complete text independently
• Summarizing/Retelling Paragraphs
• Answering content questions
Participant FGF: Results
Reading Rate (Dutch)

<table>
<thead>
<tr>
<th>Segment</th>
<th>Mean Pre</th>
<th>Mean Post</th>
<th>Difference</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total (Word/min)</td>
<td></td>
<td></td>
<td>24.2</td>
<td>34%</td>
</tr>
<tr>
<td>1-100 (Word/min)</td>
<td></td>
<td></td>
<td>15.4</td>
<td>17%</td>
</tr>
<tr>
<td>300-400 (Word/min)</td>
<td></td>
<td></td>
<td>36.1</td>
<td>66%</td>
</tr>
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</table>
Participant FGF: Results
Reading Rate (English)

<table>
<thead>
<tr>
<th>Segment</th>
<th>Mean pre</th>
<th>Mean post</th>
<th>Difference</th>
<th>%change</th>
</tr>
</thead>
<tbody>
<tr>
<td>(total)</td>
<td>0</td>
<td>20</td>
<td>33.1</td>
<td>61%</td>
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<tr>
<td>(1-100)</td>
<td>40</td>
<td>49.8</td>
<td>9.8</td>
<td>11%</td>
</tr>
<tr>
<td>(300-400)</td>
<td>60</td>
<td>94.4</td>
<td>34.4</td>
<td>58%</td>
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</table>
Participant FGF: Results
Reading Rate (Norwegian)

<table>
<thead>
<tr>
<th>Word per minute</th>
<th>Difference</th>
<th>%change</th>
</tr>
</thead>
<tbody>
<tr>
<td>(total)</td>
<td>2.2</td>
<td>5%</td>
</tr>
<tr>
<td>(1-100)</td>
<td>8.9</td>
<td>17%</td>
</tr>
<tr>
<td>(300-400)</td>
<td>-4.4</td>
<td>-10%</td>
</tr>
</tbody>
</table>
Participant FGF: Results
Answering wh-questions

CIUs per minute
Participant FGF: Summary

• Reading and speaking rate decreased with fatigue
• Improved rate post Dutch treatment
  – Noted later in the reading passage
• Improved rates in the non-treated languages
• Different pattern in a weaker non-treated language
Language mixing

• No change in code-switching rate during production in Norwegian following Dutch treatment (FGF)
• No change in language choice following treatment in English and Spanish (SE)
• Greater switching rates in weaker languages
  – Due to word-retrieval difficulties and/or decreased control?
IV. Summary & conclusions
Assessment

• Cross-language influences
• Practical decisions
  – Materials
  – Examiners
  – Scoring
  – Interpretation
Rehabilitation

- Facilitation between the two stronger languages (regardless of age of acquisition)
- Inhibition of a (post-CVA) stronger languages following activation of weaker (post-CVA) language
Theoretical implications

• Cross-language effects (in both directions) are consistent with overlapping representation

• Inhibition is consistent with theories of control
Control: Psycholinguistic evidence

• Both languages are active
  – Cognate & “false friends” effects
    • E.g., Dijkstra, Moscoso del Prado Martín, Schulpen, Schreuder, & Baayen, 2005; Dijkstra, Van Jaarsveld, & Brinke, 1998; P:eeters et al., 2013 ...
  – Switching cost & cognitive control
    • E.g., Kroll, Bobb, & Wodniekca, 2006; Meuter & Allport, 1999; Pivneva et al., 2014
Proficiency-related asymmetry

From: Costa & Santesteban, 2004
Prediction

• Inhibition of stronger: treating the weaker language should inhibit the stronger ones

• No inhibition of weaker: treating the stronger language should not inhibit the weaker ones
Findings

• Cross-language facilitation
  – from English to French and to Hebrew (HEF)
  – between German and English (PGE)
  – from Dutch to English (FGF)
  – but: not from Dutch to Norwegian (FGF)

• Cross-language inhibition
  – from Persian to English and to German (PGE)
  – from English to Spanish (SE)
Inhibition and facilitation: Variables

- Relative proficiency
- Structures (e.g., agreement errors)
- Measurements (e.g., grammaticality of connected language; rate)
- Language of environment
  - English for SE vs. English for PGE, CS
  - English & French for FGF
Clinical implications

• Consider proficiency: Treating the language of the majority may not be best if the minority language is stronger

• Consider structural differences

• Consider the environment
- Carmit Altman
- Inge Anema
- Maria Boklan
- Caroline Cano
- Peggy S. Conner
- Cristi Espada
- Leila Geramian
- Jessica Harris
- Monica Knoph
- Violaine Lazecki
- Erika Levy
- Kristen Maul
- Maryam Naghibolhosseini
- Loraine K. Obler
- Keren Ohayon
- Yana Pugach
- Jason Rosass
- Melissa Santander

- Lehman College and the Graduate School and University Center, CUNY
- NIDCD