Bilingual Aphasia:
Factors affecting recovery and rehabilitation

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Funding support from NIH/NIDCD RO3 # DC006359;
ASHF New Century Research Scholars Grant; ASHF New Investigator Grant
Bilingual Aphasia
Why is rehabilitation of bilingual aphasia an interesting question?

1. From a theoretical perspective: make predictions from existing models of bilingual memory

2. From a clinical perspective: make recommendations about the best language to treat the patient
Outline of presentation

- Theoretical framework for bilingual lexical access
- Factors affecting normal and aphasic bilingual language processing
- Evidence from neuroimaging studies
- Evidence from crosslanguage semantic treatment studies.
Outline of presentation

- Theoretical framework for bilingual lexical access
- Factors affecting normal and aphasic bilingual language processing
- Evidence from neuroimaging studies
- Evidence from crosslanguage semantic treatment studies.
Models of Bilingual Lexical Access

- Concept Mediation Model (Potter, So, Von Eckardt, & Feldman, 1984)
- Word Association Model (Potter et al., 1984)
- Asymmetrical Model (Kroll & Stewart, 1994)
Activating phonological representations

Target Language Non Specific Activation (Herman et al., 1998; Costa et al., 2000)

Target Language Specific Activation (Costa et al., 1999)
Model of Bilingual Lexical Access

(de Groot, 1992, 1994)

Asymmetrical Model
(Kroll & Stewart, 1994)
Model of Bilingual Lexical Access

Semantics

L1

L2

(de Groot, 1992, 1994)

Asymmetrical Model
(Kroll & Stewart, 1994)
Model of Bilingual Lexical Access

(de Groot, 1992, 1994) Asymmetrical Model
(Kroll & Stewart, 1994)
Outline of presentation

- Theoretical framework for bilingual lexical access
- Factors affecting normal and aphasic bilingual language processing
- Evidence from neuroimaging studies
- Evidence from crosslanguage semantic treatment studies.
What are the factors that influence language recovery and rehabilitation?

Level of Bilingualism factors

- Age of Acquisition
- Pre-stroke language proficiency
- Education & Background
- Self proficiency ratings
- Language use
What are the factors that influence language recovery and rehabilitation?

Level of Bilingualism factors

- Age of Acquisition
- Pre-stroke language proficiency
- Education & Background
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- Language use
What are the factors that influence language recovery and rehabilitation?

Stroke related factors

- Type of impairment in each language
- Severity of impairment
- Site/size of lesion
- Relative impairment in each language
Why Language Proficiency?

- Spanish English Bilinguals who learn English (L2) around age 3, Spanish is L1

- Accuracy during picture naming varied based on proficiency (Edmonds & Kiran, 2004)
  - Equal accuracy, English dominant, Spanish dominant

- Cross language semantic priming (Kiran & Lebel, 2007)
  - Both balanced and less balanced group show priming from more proficient to less proficient language.
  - Only less balanced bilinguals show greater priming from less proficient language to more proficient language
Dynamic Bilingual Lexical Access

Semantics

Spanish L1

English L2
Dynamic Bilingual Lexical Access

Semantics

L1
Less proficient

L2
More proficient
Cross language priming


N = 24

<table>
<thead>
<tr>
<th>AoA</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Eng</td>
<td>3.0</td>
</tr>
<tr>
<td>Spa</td>
<td>0</td>
</tr>
</tbody>
</table>
Outline of presentation

- Theoretical framework for bilingual lexical access
- Factors affecting normal and aphasic bilingual language processing
- Evidence from neuroimaging studies
- Evidence from crosslanguage semantic treatment studies.
- India has 22 different recognized languages by the constitution.

- Hindi is the national language spoken by most Indians.

- English is the medium of instruction in most cities.
Based on Chee et al., (2001) *Neuroimage*

A block design paradigm was used and each stimulus was presented for 3 sec preceded by a fixation point.

- 2 runs, 48 stimuli in each language
- 48 size (control stimuli)
- Button press response

Sebastian & Kiran, (submitted)
Self ratings of fluency in each language

N = 10

<table>
<thead>
<tr>
<th>AoA</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1: Hindi</td>
<td>0</td>
</tr>
<tr>
<td>L2: English</td>
<td>3 years</td>
</tr>
</tbody>
</table>

All born in India and moved to US. Max 3 years of stay in the US

Sebastian & Kiran, (submitted)
Percent time spent in each language

Percent usage of each language in a given week

Percent usage Hindi
Percent usage English

Participant Number

Percent usage

Mean

Sebastian & Kiran, (submitted)
Picture Naming accuracy

Naming accuracy on English and Hindi stimuli

- Naming accuracy Hindi
- Naming accuracy English

Particpant Number

Percent accuracy

0 10 20 30 40 50 60 70 80 90 100

1 2 3 4 5 6 7 8 9 10 MEAN

Participant Number
Dynamic Bilingual Lexical Access

Semantics

Hindi
L1

English
L2
Dynamic Bilingual Lexical Access

Semantics

L1
Less proficient

L2
More proficient
Mean RT on task

Current effect: $F(2, 189)=72.610, p=0.0000$
Semantic > Size

R L

Cluster threshold Z>2.3, p < .05

Sebastian & Kiran, (submitted)
Size > Semantic

English = Red
Hindi = Blue
Overlap = Pink

cluster threshold $Z > 2.3, p < .05$

Sebastian & Kiran, (submitted)
**fMRI experimental design**

<table>
<thead>
<tr>
<th>bulb</th>
<th>Δ✓♦</th>
<th>गाजर</th>
<th>%Δ+</th>
</tr>
</thead>
<tbody>
<tr>
<td>bug</td>
<td>Δ✓♦</td>
<td>मटर कमरा</td>
<td>%Δ+</td>
</tr>
<tr>
<td>lamp</td>
<td>Δ✓♦</td>
<td></td>
<td>%Δ+</td>
</tr>
</tbody>
</table>

- Based on Chee et al., (2001) *Neuroimage*
- A block design paradigm was used and each stimulus was presented for 3 sec preceded by a fixation point.
- 2 runs, 48 stimuli in each language
- 48 size (control stimuli)
- Button press response

Sebastian & Kiran, (submitted)
Based on Chee et al., (2001) *Neuroimage*

A block design paradigm was used and each stimulus was presented for 3 sec preceded by a fixation point.

- 2 runs, 48 stimuli in each language
- 48 size (control stimuli)
- Button press response
Self ratings of fluency in each language

N =8

<table>
<thead>
<tr>
<th></th>
<th>AoA</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1: Spanish</td>
<td>0</td>
</tr>
<tr>
<td>L2: English</td>
<td>2.3 years</td>
</tr>
</tbody>
</table>

Self ratings of language proficiency

Fluency Spanish
Fluency English

Participant number

Self rating out of a score of 7

Sebastian & Kiran, (submitted)
Percent time spent in each language

Percent use of each language in a given week

- Spanish
- English

Sebastian & Kiran, (submitted)
Picture Naming Accuracy

![Bar chart showing naming accuracy in English and Spanish for different participants.](chart.png)

- **Participant number**: 1 to 8
- **Percent accuracy**: 0 to 100

<table>
<thead>
<tr>
<th>Participant</th>
<th>English</th>
<th>Spanish</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>90</td>
<td>80</td>
</tr>
<tr>
<td>2</td>
<td>85</td>
<td>75</td>
</tr>
<tr>
<td>3</td>
<td>95</td>
<td>90</td>
</tr>
<tr>
<td>4</td>
<td>80</td>
<td>70</td>
</tr>
<tr>
<td>5</td>
<td>90</td>
<td>85</td>
</tr>
<tr>
<td>6</td>
<td>95</td>
<td>90</td>
</tr>
<tr>
<td>7</td>
<td>85</td>
<td>80</td>
</tr>
<tr>
<td>8</td>
<td>90</td>
<td>85</td>
</tr>
<tr>
<td><strong>MEAN</strong></td>
<td>90</td>
<td>85</td>
</tr>
</tbody>
</table>

Sebastian & Kiran, (submitted)
Dynamic Bilingual Lexical Access

Semantics

Spanish
L1

English
L2
Dynamic Bilingual Lexical Access

Semantics

L1
Less proficient

L2
More proficient
Mean RT on Task

Current effect: $F(2, 1531)=22.611, p=.00000$

Sebastian & Kiran, (submitted)
Activation in Inferior Frontal Gyrus

Mean ±1.96*SE

Semantic > Size

English = Red Spanish = Blue Overlap = Purple

cluster threshold Z>2.3, p < .05

Sebastian & Kiran, (submitted)
cluster threshold $Z > 2.3$, $p < .05$
Level of Bilingualism factors

- Age of Acquisition
- Current language proficiency
- Education & Background
- Self proficiency ratings
- Language use
In Bilingual Aphasia

- Does current language proficiency also influence language processing skills?

- What are the neural correlates of bilingual semantic processing in aphasia patients?
Bilingual Aphasia

Pre-stroke proficiency

Age

Estimated/post hoc

Stroke

Post stroke impairment
In Bilingual Aphasia

- Does current language proficiency also influence language processing skills?
- What are the neural correlates of bilingual semantic processing in aphasia patients?
<table>
<thead>
<tr>
<th>Sex</th>
<th>Age</th>
<th>MPO</th>
<th>Family / Social</th>
<th>Work</th>
<th>Education</th>
<th>Self-ratings (L1/L2) (1–7)</th>
<th>BNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>59</td>
<td>97</td>
<td>Both languages from birth</td>
<td>Surveyor:</td>
<td>Educated in English</td>
<td>English = 5</td>
<td>English = 19/60</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Prior to CVA, Spanish primarily with mother (bilingual)</td>
<td>70% English</td>
<td>- No Spanish training</td>
<td>Spanish = 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- 100% English at home with spouse</td>
<td>30% Spanish</td>
<td>- Read in English for leisure</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Spanish = 1/60
P1 – behavioral performance on task

Current effect: F(2, 138)=.22294, p=.80045

<table>
<thead>
<tr>
<th>Condition</th>
<th>English</th>
<th>Control</th>
<th>Spanish</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>52%</td>
<td>33%</td>
<td>52%</td>
</tr>
</tbody>
</table>

SlideProbe.RT
P1 activation

Semantic > Size

cluster threshold $Z > 2.3$, $p < .05$

English = Red
Spanish = Blue
Overlap = Purple
<table>
<thead>
<tr>
<th>Sex</th>
<th>Age</th>
<th>MPO</th>
<th>Family / Social</th>
<th>Work</th>
<th>Education</th>
<th>Self-ratings (L1/L2) (1–7)</th>
<th>BNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>52</td>
<td>9</td>
<td>Born in US</td>
<td>Paralegal</td>
<td>Elementary education in English</td>
<td>English = 4.7</td>
<td>English = 4/60</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Raised in bilingual environment</td>
<td>75% English</td>
<td>Middle School/College in both languages</td>
<td>Spanish = 3.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Bilingual partner</td>
<td>25% Spanish</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

|     |     |     |                                                     |                    |                                                | English = 3/60             |       |
P2-behavioral performance on task

Current effect: $F(2, 138)=6.8671, p=.00144$

<table>
<thead>
<tr>
<th>Condition</th>
<th>1200</th>
<th>1400</th>
<th>1600</th>
<th>1800</th>
<th>2000</th>
<th>2200</th>
<th>2400</th>
<th>2600</th>
<th>2800</th>
<th>3000</th>
<th>3200</th>
<th>3400</th>
<th>3600</th>
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</thead>
<tbody>
<tr>
<td>English</td>
<td>44%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>61%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spanish</td>
<td>47%</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SlideProbe.RT

Incorrect
Correct
P2 activation

Semantic > Size

cluster threshold $Z>2.3$, $p < .05$
Preliminary findings

- Different sites and lesion sizes

But:
- Both patients more proficient in English prior to stroke

- Both patients showed similar activation patterns for Spanish (less proficient language)
  - Level of bilingualism?
  - Error correction/judgment and corresponding adjustments in performance (Ridderinkhof et al. (2004) *Science*), ?
- Or both?
Outline of presentation

- Theoretical framework for bilingual lexical access
- Factors affecting normal and aphasic bilingual language processing
- Evidence from neuroimaging studies
- Evidence from crosslanguage semantic treatment studies.
What are the factors that influence language rehabilitation?

- **Level of Bilingualism factors**
  - Age of Acquisition
  - Pre-stroke language proficiency
  - Education & Background
  - Self proficiency ratings
  - Language use
<table>
<thead>
<tr>
<th>Pt</th>
<th>Sex</th>
<th>Age</th>
<th>MPO</th>
<th>Family / Social</th>
<th>Work</th>
<th>Education</th>
<th>Self-ratings (L1/L2) (1–7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>F</td>
<td>53</td>
<td>9</td>
<td>Spanish only until 21 years</td>
<td>Factory:</td>
<td>-Educated in Spanish</td>
<td>Speech: 6/7 Comp: 7/7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-Prior to CVA, 100% English at home with</td>
<td>50% English</td>
<td>-Learned and used English</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-Spanish and English with grown children</td>
<td>50% Spanish</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>M</td>
<td>54</td>
<td>8</td>
<td>Both languages from birth</td>
<td>Surveyor:</td>
<td>Educated in English</td>
<td>Speech: 7/5 Comp: 7/6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-Prior to CVA, Spanish primarily with mother</td>
<td>70% English</td>
<td>-No Spanish training</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(bilingual)</td>
<td>30% Spanish</td>
<td>-Read in English for leisure</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-100% English at home with spouse</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>F</td>
<td>53</td>
<td>9</td>
<td>-Both languages from birth</td>
<td>Retail:</td>
<td>-Educated in English</td>
<td>Speech: 7/3 Comp: 7/5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-Prior to CVA, 80% English and 20% Spanish (with</td>
<td>70% English</td>
<td>-No Spanish training</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>husband) at home</td>
<td>30% Spanish</td>
<td>-English only at work</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-Read in English for leisure</td>
<td></td>
</tr>
</tbody>
</table>
Self Rated Pre- Morbid Language Proficiency

Participant 1
Spanish: 7/7
English: 6/7
(.78)  
Participant 2
Spanish: 5.5/7
English: 7/7
(.78)  
Participant 3
Spanish: 4/7
English: 7/7
(.57)  

Edmonds & Kiran, (2006) JSLHR
Pre treatment BNT scores

<table>
<thead>
<tr>
<th></th>
<th>Participant 1</th>
<th>Participant 2</th>
<th>Participant 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>English</td>
<td>Spanish</td>
<td>English</td>
</tr>
<tr>
<td>Boston Naming Test (BNT) ((N = 60))</td>
<td>41.7</td>
<td>40.0</td>
<td>1.7</td>
</tr>
</tbody>
</table>

Despite, varying language dominance equal levels of impairment across languages.

Edmonds & Kiran, (2006) JSLHR
Stimuli

- For each participant, a different list of stimuli were developed.
- Frequency of items matched within language and across languages for each participant.
  - Matched semantically unrelated control set for English and Spanish (e.g., boat, *vaca*) (N=5 for each set).
  - No cognates (e.g., elephant/*elefante*) or pairs with 50% or more phonetic similarity (*cat*/*gato*).
  - Only one pair per semantic category used (e.g., tools, furniture).
  - No more than 4 syllables for any word.

Edmonds & Kiran, (2006) *JSLHR*
Treatment design

- Single subject experimental design across participants and behaviors
- Order of language counterbalanced across participants
- Criteria for acquisition: 80% accuracy across two consecutive sessions or 10 sessions
- Criteria for generalization: improvement of 40% over maximum baseline levels
Participant 1 (equally proficient)

Edmonds & Kiran, (2006) JSLHR
Interpretation of Participant 1 (balanced) results

Spanish treatment

Semantics

“Celery” “Cabbage”

“Apio” “Repollo”

L1 L2

Edmonds & Kiran, (2006) JSLHR
Participant 2 (English dominant) results

English (dominant language) treatment

- "Apple" -> "Manzana"
- "Orange" -> "Naranja"

Spanish (non-dominant language) treatment

- "Orange" -> "Naranja"
- "Apple" -> "Manzana"

Edmonds & Kiran, (2006) JSLHR
Participant 3 (English dominant) Results

Edmonds & Kiran, (2006) *JSLHR*
Participant 3 replicates findings of Participant 2 (both English dominant)

Participant 2
Spanish (non-dominant language) treatment

Participant 3
Spanish (non-dominant language) treatment

Edmonds & Kiran, (2006) JSLHR
Clinical/Theoretical Implications of treatment

- Pre-stroke proficiency important in determining the extent of cross language generalization

- Crosslinguistic generalization
  - Usually train the dominant language of a bilingual patient
  - Training the less proficient language facilitates greater cross linguistic generalization

- Consistent with CATE/Complexity hypothesis
  (Thompson, 2007; Kiran, 2007)
Is pre-stroke language proficiency the only factor that influences the extent of language recovery and rehabilitation outcomes?
What are the factors that influence language recovery and rehabilitation?

**Stroke related factors**

- Type of impairment in each language
- Severity of impairment
- Relative impairment in each language
- Site/size of lesion
<table>
<thead>
<tr>
<th>Pt</th>
<th>Sex</th>
<th>Age</th>
<th>MPO</th>
<th>Family / Social</th>
<th>Work</th>
<th>Reading/Writing</th>
<th>Self-ratings (L1/L2) (1–7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>F</td>
<td>55</td>
<td>11</td>
<td>Born in US. Began English at age 5. Spanish from birth. Married to bilingual Spanish speaker.</td>
<td>Clerk in bilingual setting English: 50% Spanish 50%</td>
<td>Educated in English Self taught Spanish Read and wrote English and Spanish materials</td>
<td>Speech 6/7 Comp 6/7 Reading 4/7 Writing 4/7</td>
</tr>
<tr>
<td>5</td>
<td>F</td>
<td>87</td>
<td>6</td>
<td>Spanish only with parents, siblings, relatives, friends. English with grandchildren and other professionals.</td>
<td>Mexican fiction author 50% English 50% Spanish</td>
<td>Educated in Spanish Wrote letters and lists in Spanish Learned and used English Read and Wrote English and Spanish materials</td>
<td>Speak: 7/7 Comp: 7/7 Read: 7/7 Write: 7/7</td>
</tr>
</tbody>
</table>

Kiran, S. & Roberts, P. (accepted)
Self Rated Pre-Morbid Language Proficiency

Participant 4  (.78)
Participant 5  (1.0)

A_B
English Dominant

Balanced
Bilingual = (1.0)

A_B
Spanish Dominant

Kiran, S. & Roberts, P. (accepted)
<table>
<thead>
<tr>
<th></th>
<th>Participant 4</th>
<th>Participant 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>English</td>
<td>34</td>
<td>5</td>
</tr>
<tr>
<td>Spanish</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td><strong>Boston Naming Test (BNT)</strong> <em>(N = 60)</em></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

What are the factors that influence language recovery and rehabilitation?

- Stroke related factors
  - Type of impairment in each language
  - Severity of impairment
  - Site/size of lesion
  - Relative impairment in each language
Results of P4

Spanish Treatment

“Shark”
“Tiburón”

“Whale”
“Ballena”

Kiran, S. & Roberts, P. (accepted)
Kiran, S. & Roberts, P. (accepted)
Results of P5

English Treatment

Spanish Treatment

“Shark”
“Whale”

“Tiburón”
“Ballena”

“Shark”
“Whale”

“Tiburón”
“Ballena”

Kiran, S. & Roberts, P. (accepted)
Clinical/Theoretical Implications of treatment

- Within language generalization always seen
  - Semantic based naming treatment

- Crosslinguistic generalization

- Other factors such as aphasia severity, relative impairment may also influence treatment outcome
Analysis of Errors in naming
The road ahead…

- Extend the treatment results to larger groups of patients and other language combinations

- Develop and implement the optimal language to be treated in bilingual aphasic patients

- Understand the neural basis of language recovery in treated patients
Acknowledgments

- University of Texas
  - Rajani Sebastian
  - Chaleece Sandberg
  - David Schnyer
- University of Florida
  - Lisa Edmonds
- UT- Southwestern
  - Mike Devous
- University of Ottawa
  - Patricia Roberts
- No Response 0: No response
- Neologism 1: Less than 50% overlap with target word
- Unrelated 2: Real word with no semantic/phonemic relationship to target word
- Phonemic Error-TL 3: Greater than 50% overlap with target word in the target language
- Semantic Error-TL 4: Semantically related to the target word in the target language
- Circumlocution 5: Indirect description of the correct word
- Mixed 6: Semantically related to the target word, but contains a phonemic error as well
- Phonemic Error-NTL 7: Greater than 50% overlap with target in non-target language
  - (ex: Target “gancho” but Pt says “hooka” (hook))
- Semantic Error-NTL 8: Semantically related to the target in the non-target language
  - (ex: Target “chair” but Pt says “mesa”)
- Correct-NTL 9: Correct response in non-target language
  - (ex: Target “gato” but Pt says “cat”)
- Correct –TL 10: Correct response in target language
Pre post tx responses in English

Wilks lambda = 0.63483, F(20, 174) = 2.2192, p = 0.00319

English Dominant (N = 4)

Equally Proficient (N = 2)
Pre post tx responses in Spanish

Wilks lambda = .72188, F(20, 174) = 1.5397, p = .07342

English Dominant (N = 4)

Equally Proficient (N = 2)
Activating phonological representations

Semantic system

Apple  /æpl/

Manzana  /manzana/
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<td>Neologism 1:</td>
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<td>Unrelated 2:</td>
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<td>Circumlocution 5:</td>
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<td>Mixed 6:</td>
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<td>Correct –TL 10:</td>
<td>Correct response in target language</td>
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Subject x condition interaction in fMRI Spanish-English bilinguals

Current effect: $F(14, 1510)=9.2680, p=0.0000$
Size versus semantic comparison for P1

Size versus semantic comparison for P2
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</table>
Schematic of treatment for each participant

Pre-treatment assessment:
- Western Aphasia Battery
- BNT
- Bilingual Aphasia Test

Baselines: Naming across consecutive sessions & languages

Treatment on 1 set of examples in 1 language

Session 1: Training
Session 2: Testing & Training
Session 2: Testing & Training
Session 2: Testing & Training

Week 1
Week 2
Week 3
Week 4

Post-treatment assessment:
- Standardized language tests

Until 80% accuracy achieved on items trained

No feedback provided regarding accuracy

Edmonds & Kiran, (2006) JSLHR
<table>
<thead>
<tr>
<th>Author</th>
<th>Languages</th>
<th>Proficiency</th>
<th>L2 acquisition</th>
<th>Task</th>
<th>Baseline</th>
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<td>Size judgment</td>
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<td>High</td>
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<td>FIXATION</td>
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Results of the ALE subtraction meta-analysis between high and low proficiency studies. The analysis demonstrated a primarily left-lateralized network, with activation seen in frontal region and temporal regions.
Language: English IFG activation = 2.2267 - 0.0233x; 0.95 Conf. Int.
Language: Hindi IFG activation = -0.3028 + 0.0374x; 0.95 Conf. Int.
Picture naming in English and Spanish

N = 23

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Edmonds & Kiran, (2004) *Aphasiology*
Cross language priming


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"Apple" "Naranja"