Bilingual Aphasia: Factors affecting recovery and rehabilitation

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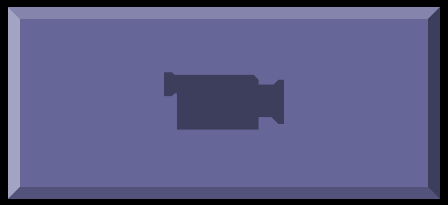
ASHF New Century Research Scholars Grant; ASHF New Investigator Grant

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 crosslangauge semantic treatment studies.

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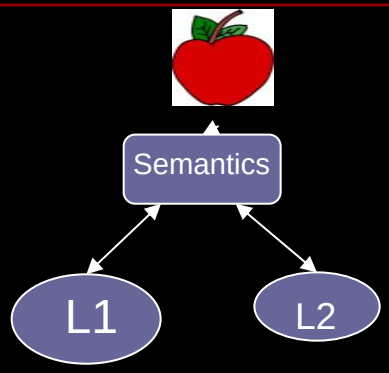
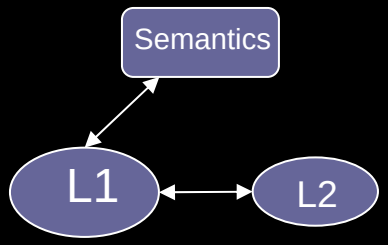
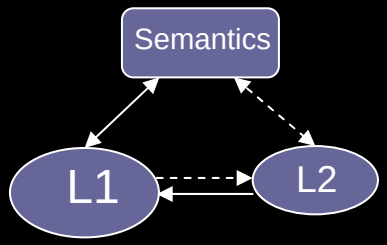
Models of Bilingual Lexical Access



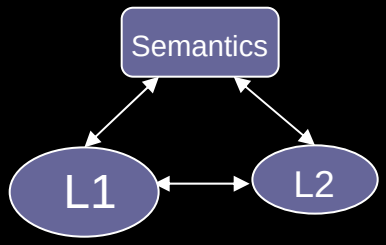
Concept Mediation Model
(Potter, So, Von Eckardt, & Feldman, 1984)



Word Association Model
(Potter et al., 1984)

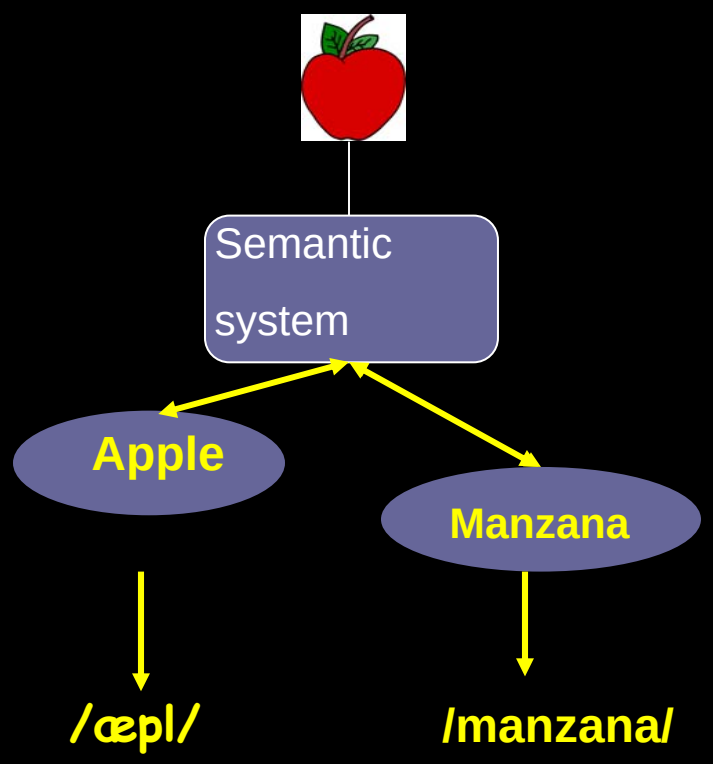


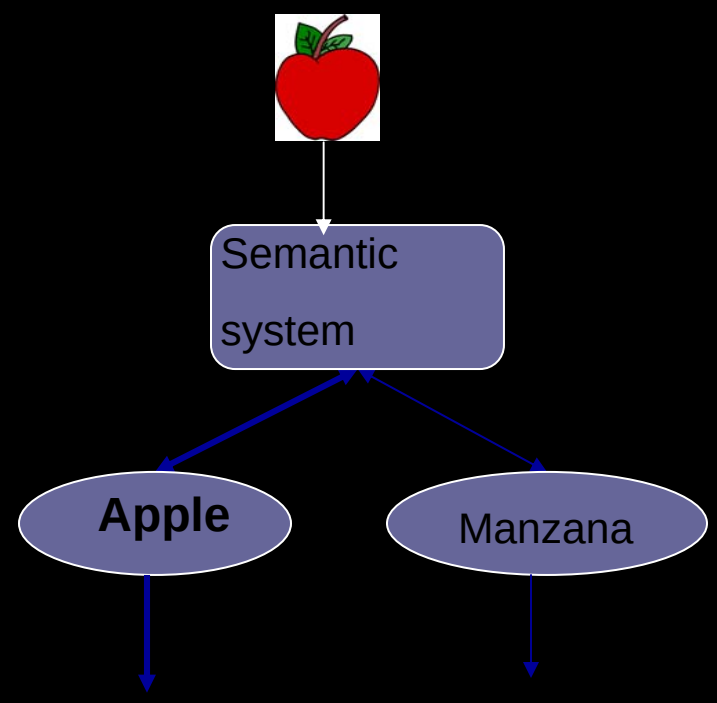
Asymmetrical Model
(Kroll & Stewart, 1994)



Mixed Model
(de Groot, 1992, 1994)

Activating phonological representations

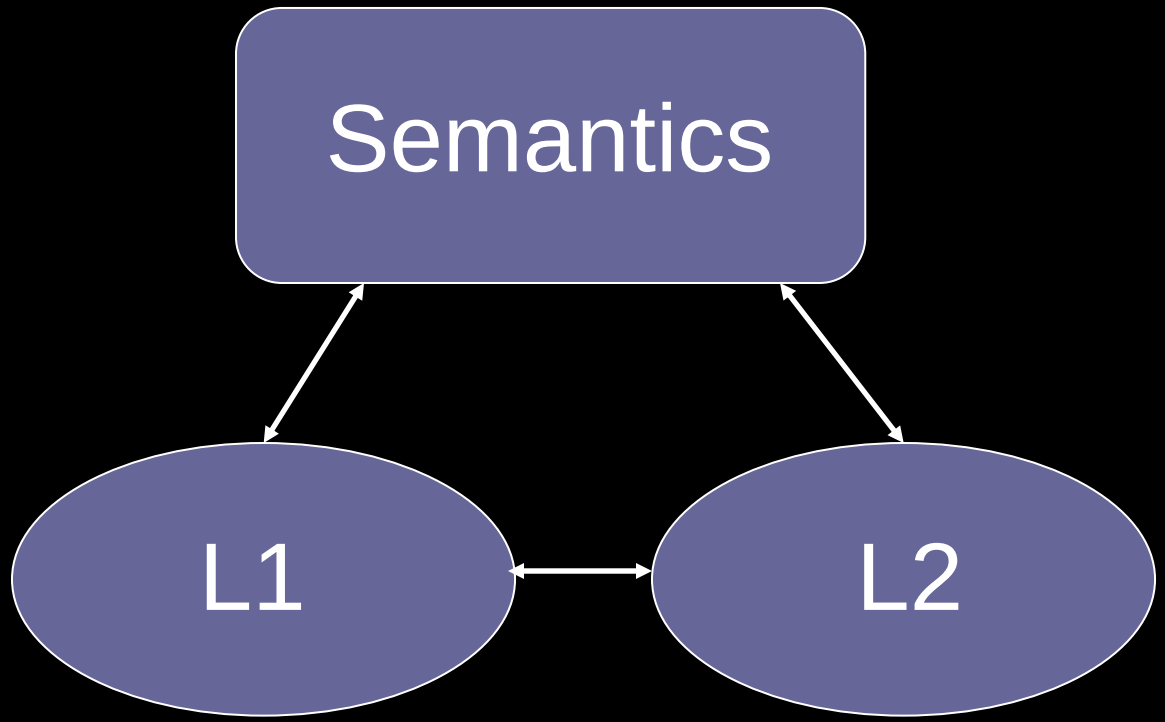




Target Language Non Specific Activation
(Herman et al., 1998; Costa et al., 2000)

Target Language Specific Activation
(Costa et al., 1999)

Model of Bilingual Lexical Access



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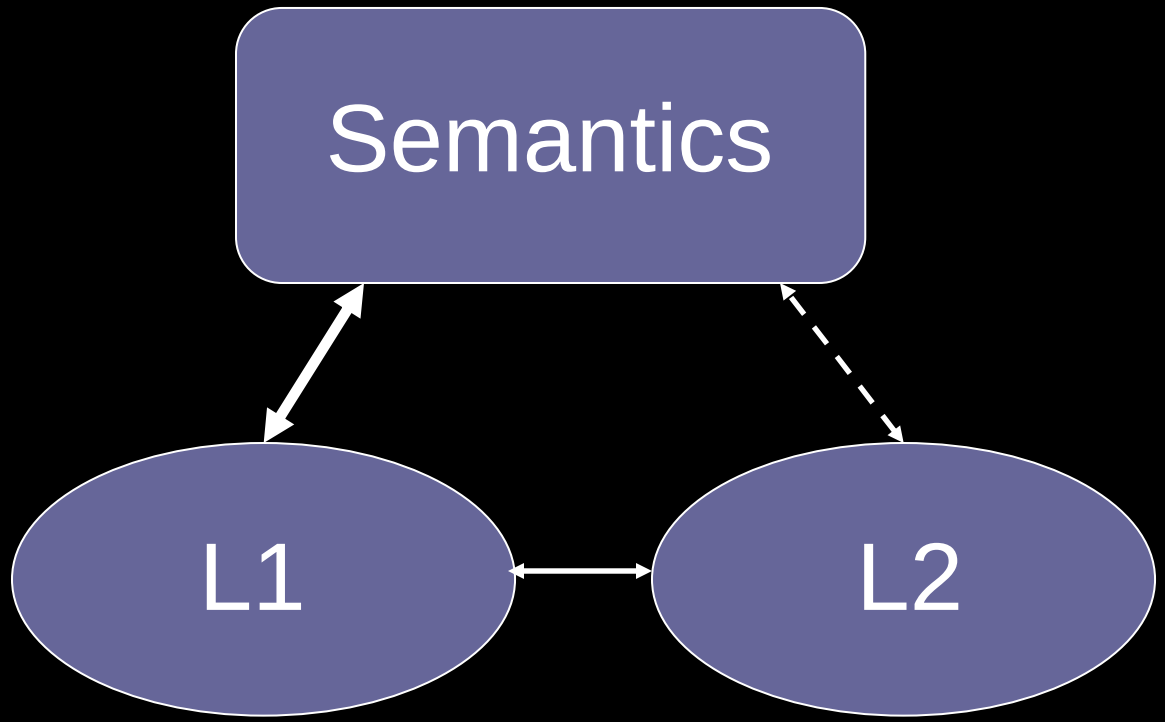

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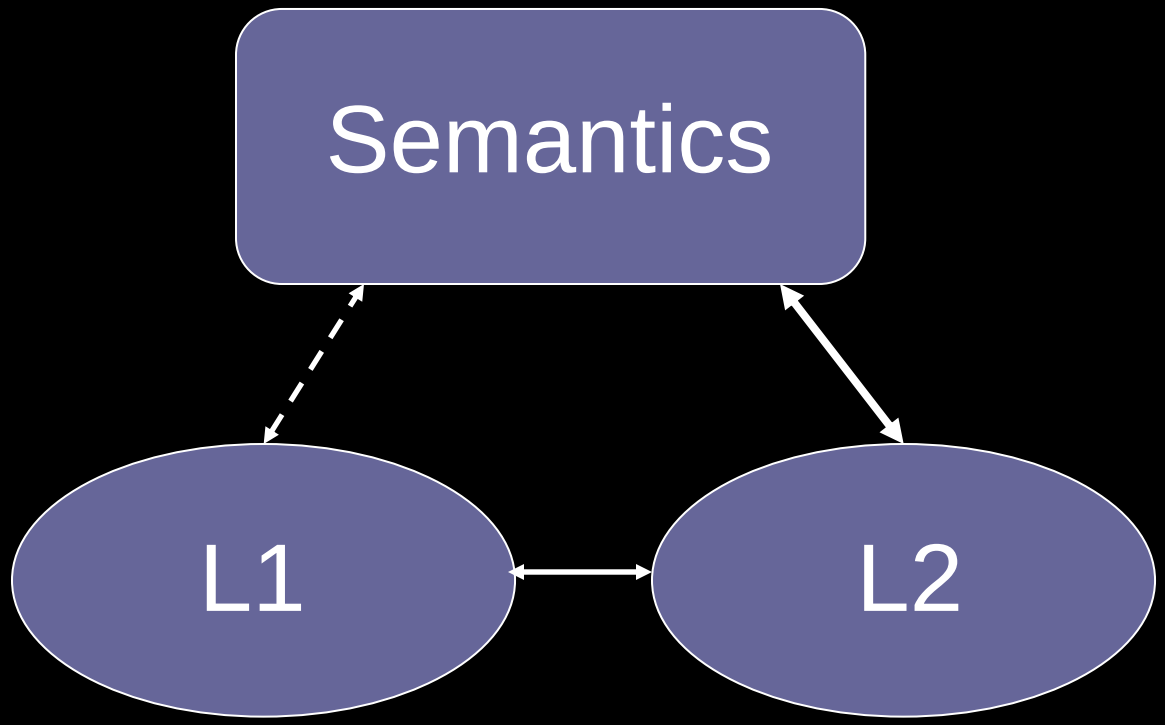

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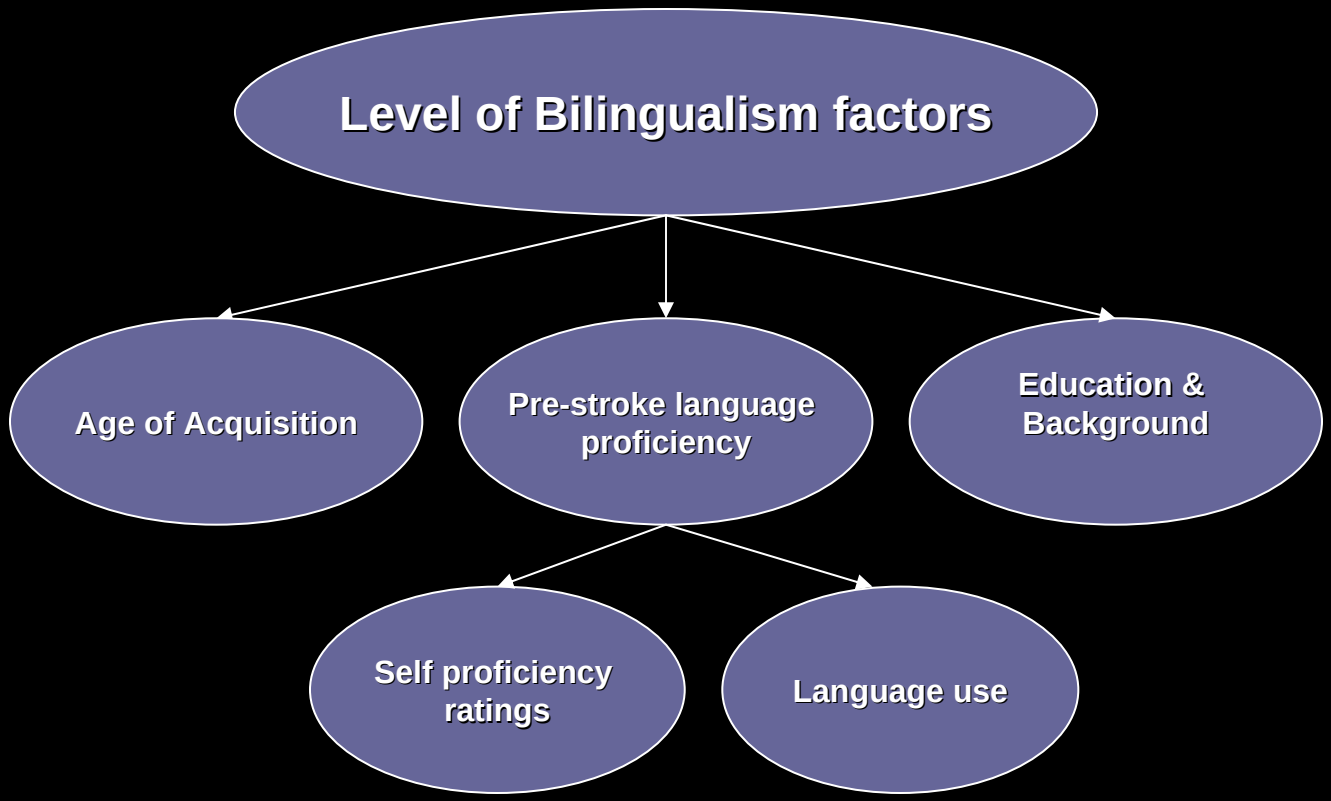
What are the factors that influence language recovery and rehabilitation?



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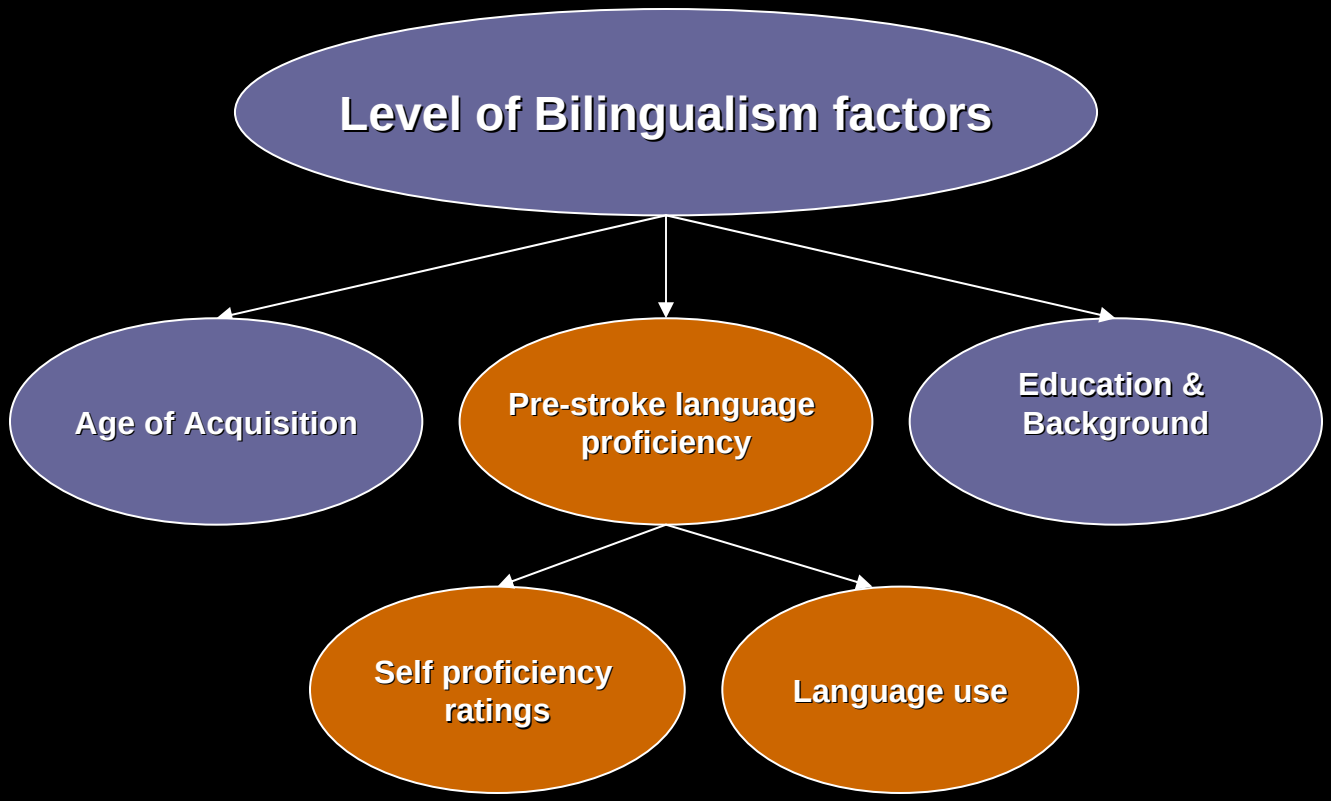

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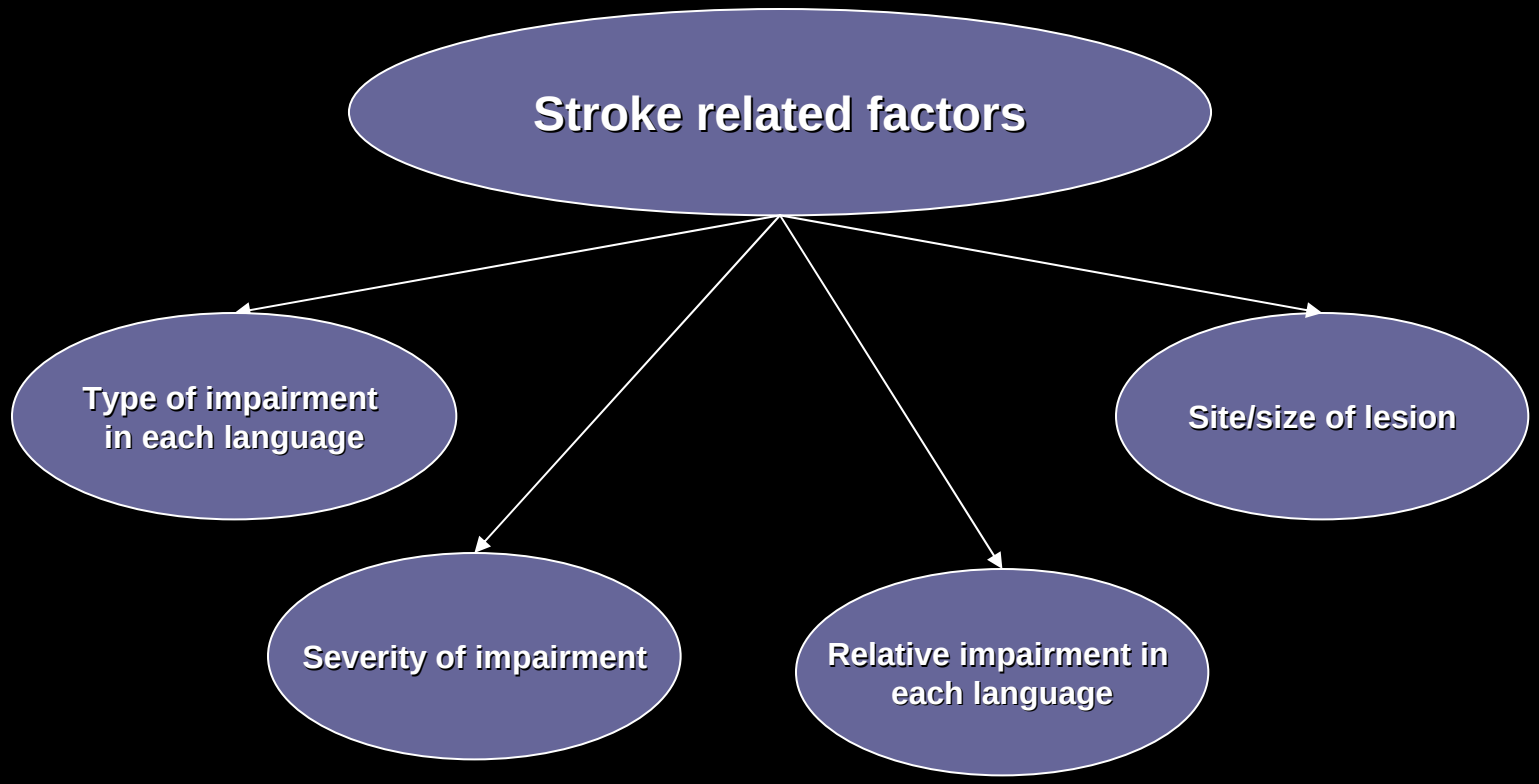
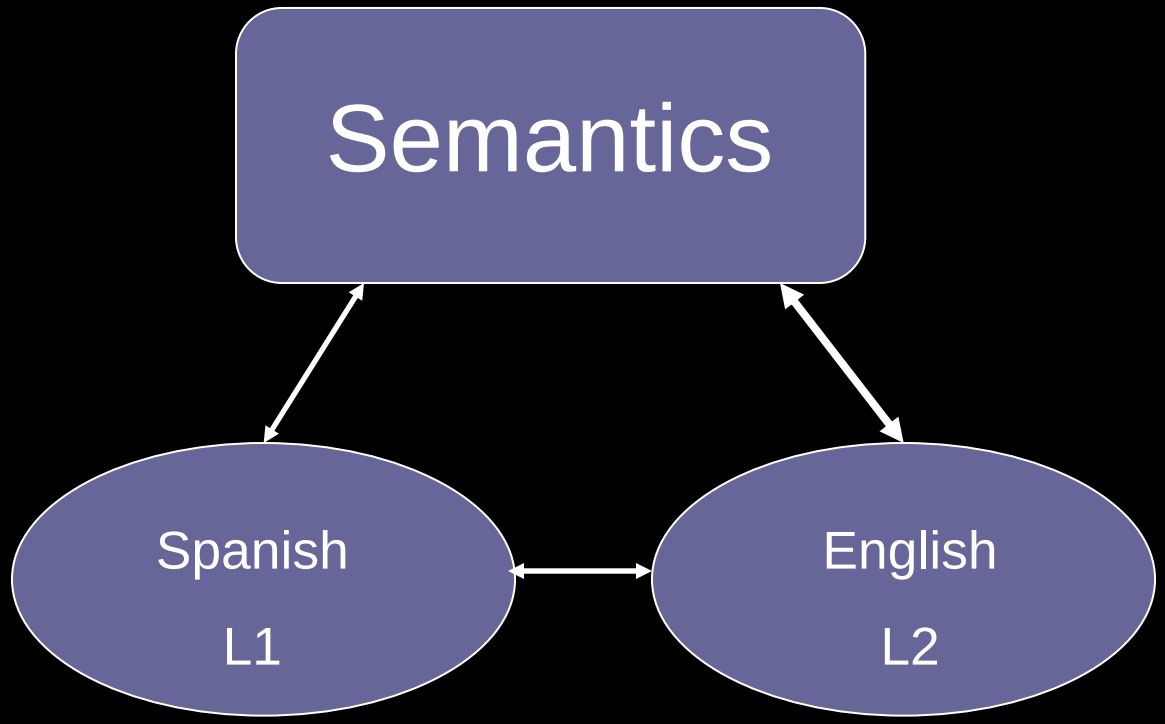


Why Language Proficiency ?

- 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



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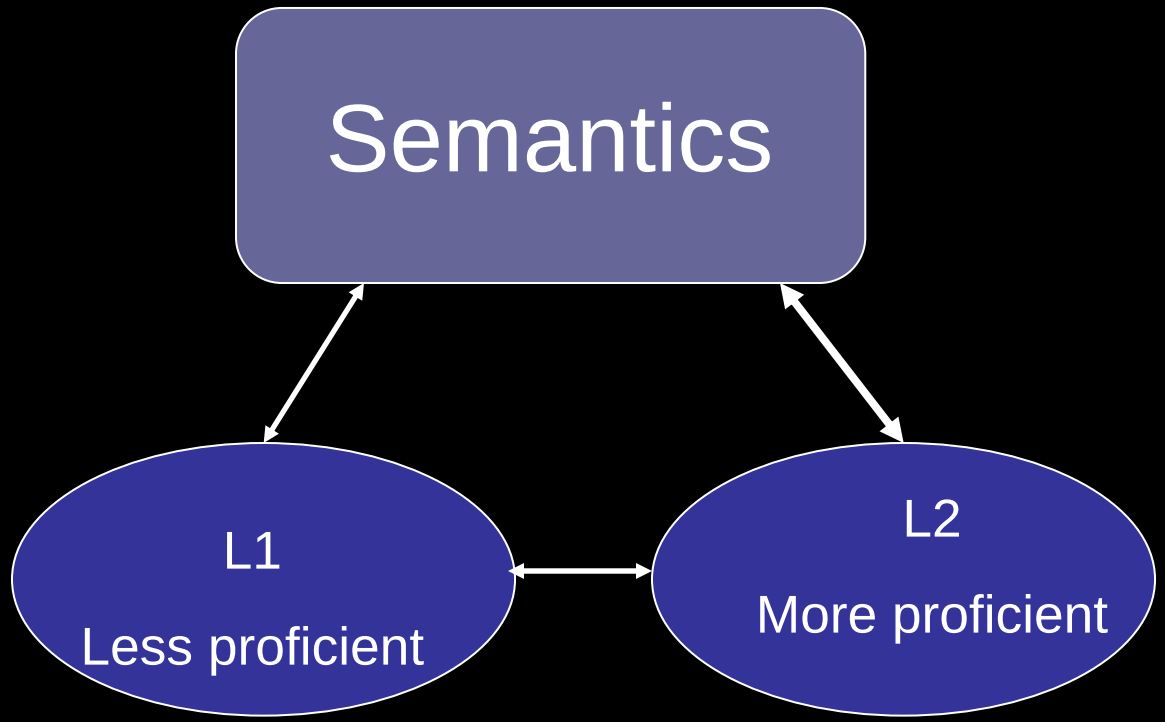
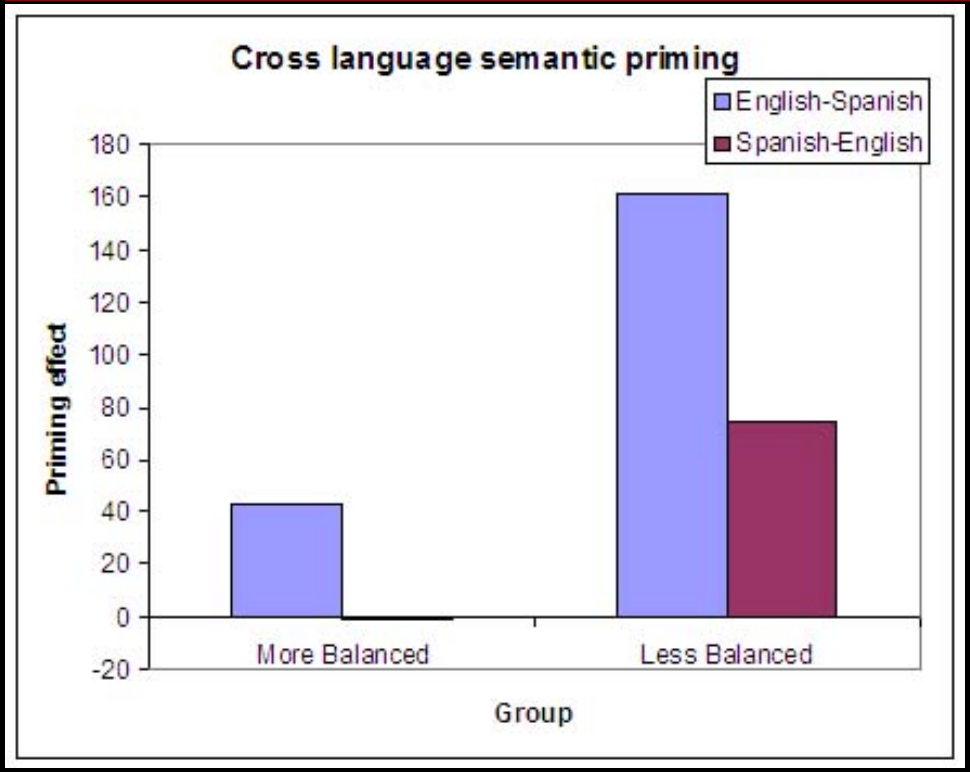
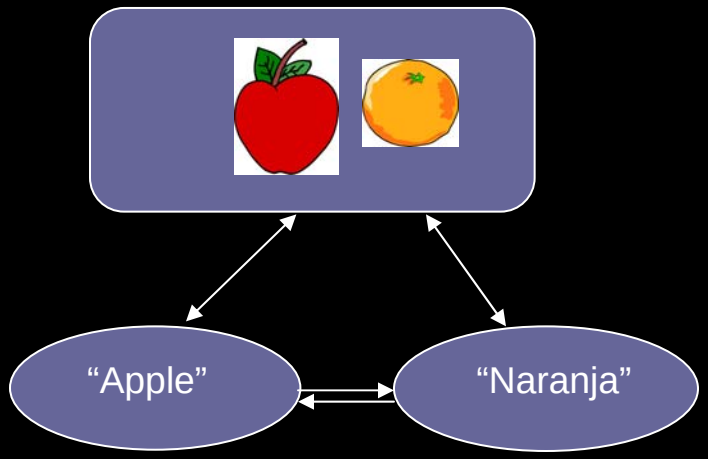


Cross language priming

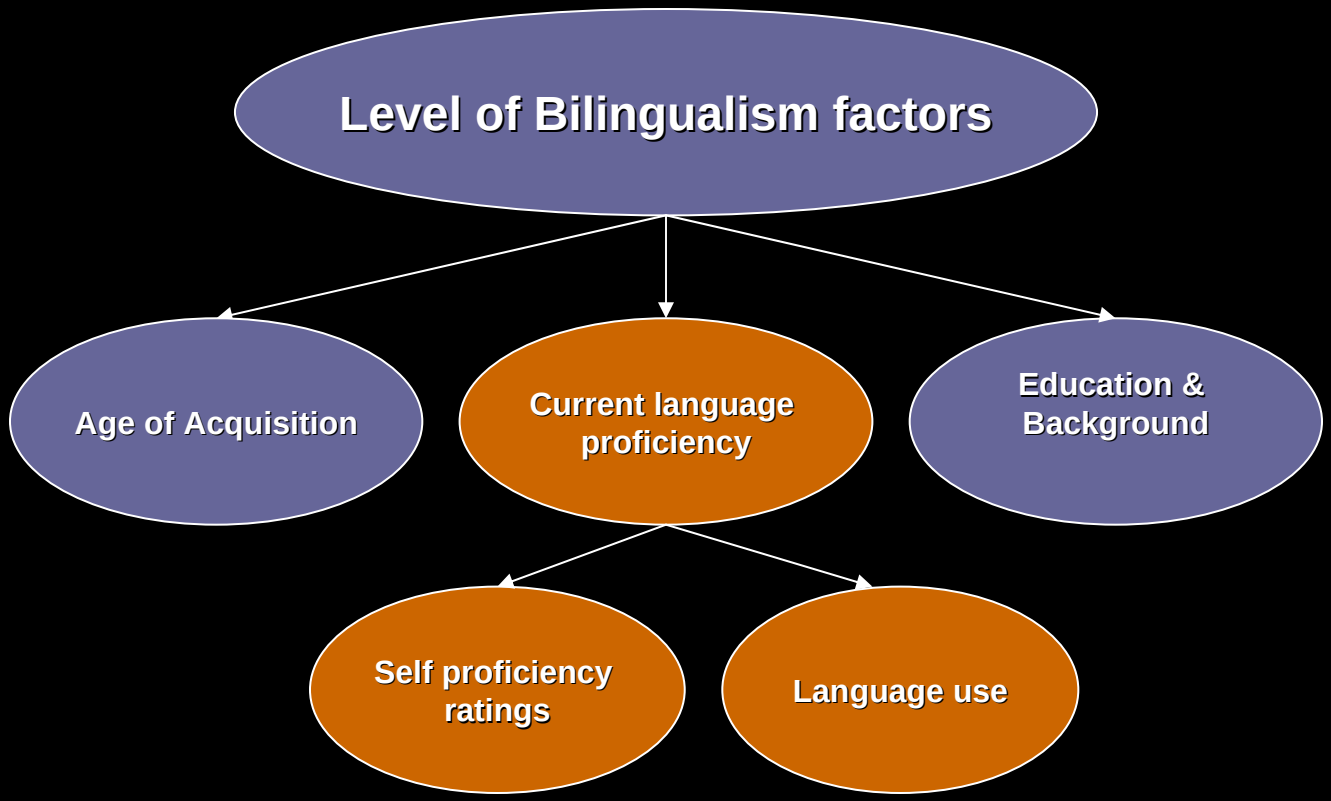


N = 24

	AoA
Eng	3.0
Spa	0



Kiran & Lebel, (2007) *Clinical Linguistics and Phonetics*


Level of Bilingualism factors
Age of Acquisition
Current language proficiency
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Self proficiency ratings
Language use

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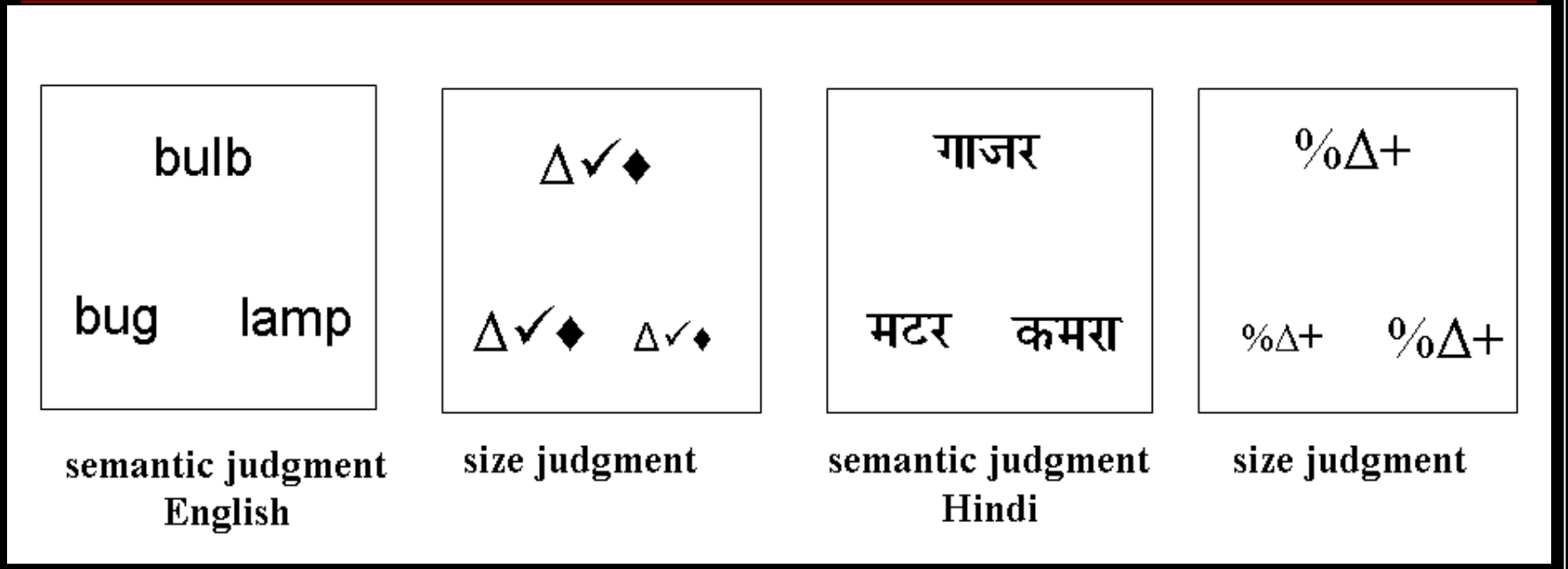
- India has 22 different recognized languages by the constitution.
- Hindi is the national language spoken by most Indians.
- English is the medium of instruction in most cities.

fMRI experimental design



- 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

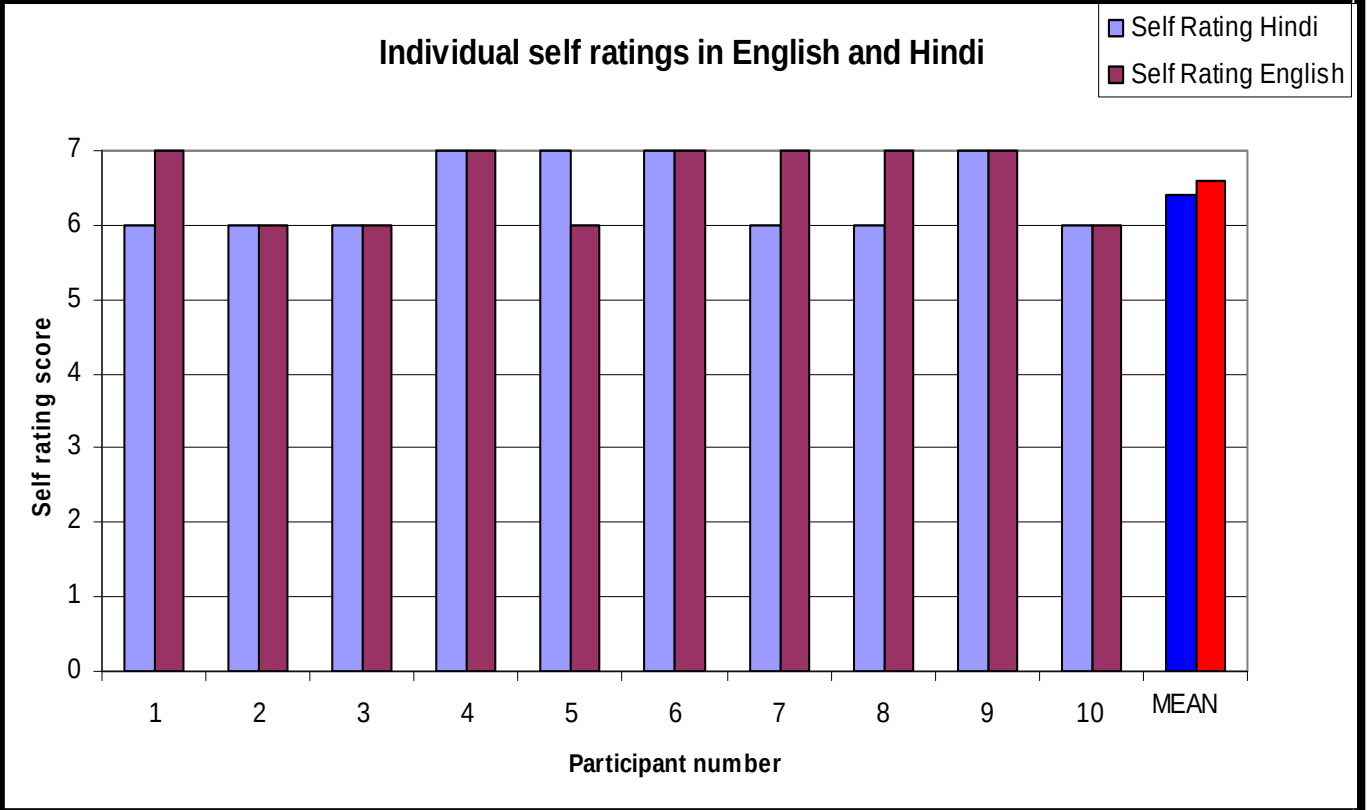
Sebastian & Kiran, (submitted)

Self ratings of fluency in each language

N = 10

	AoA
L1: Hindi	0
L2: English	3 years

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



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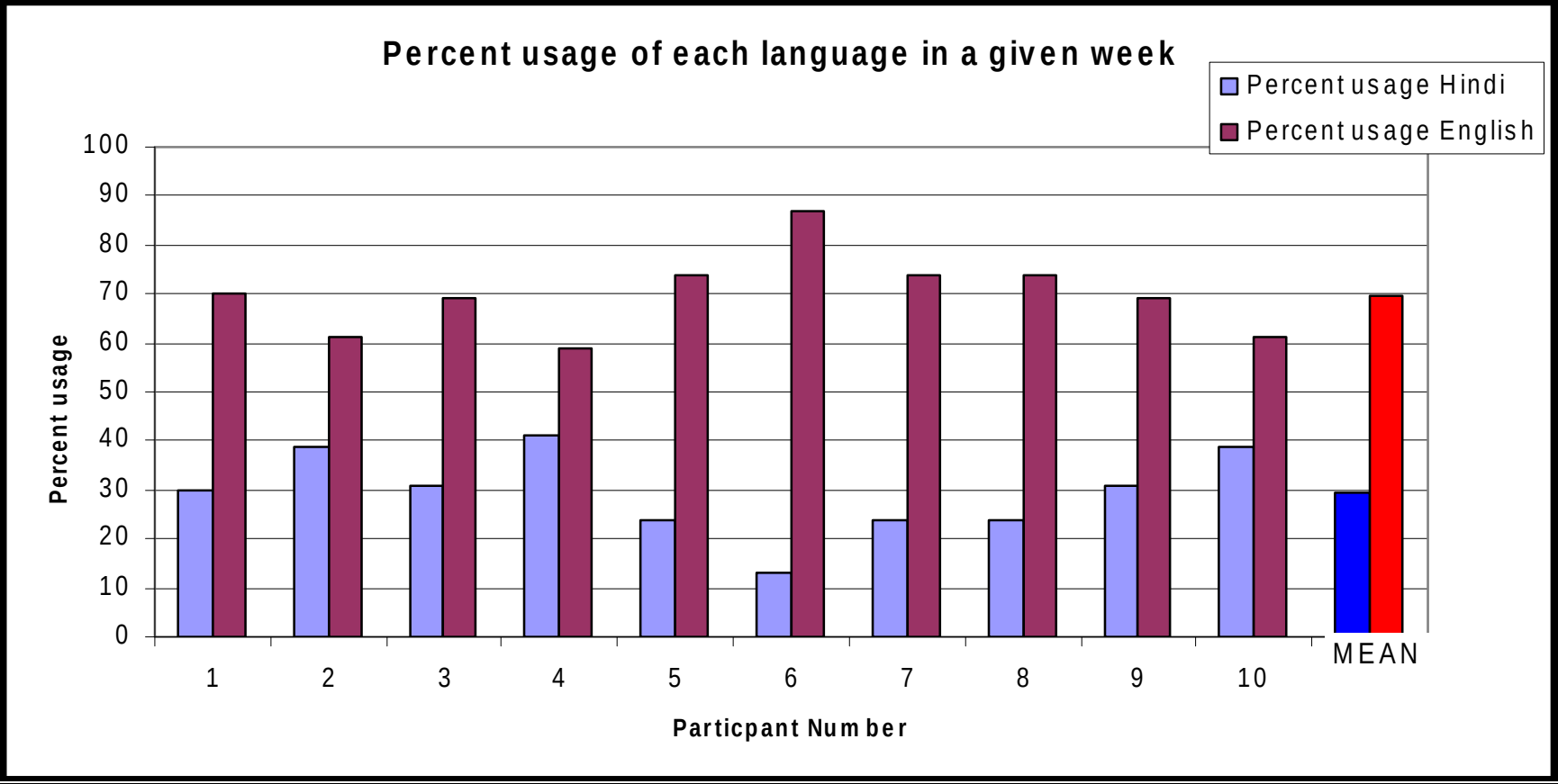
Percent time spent in each language



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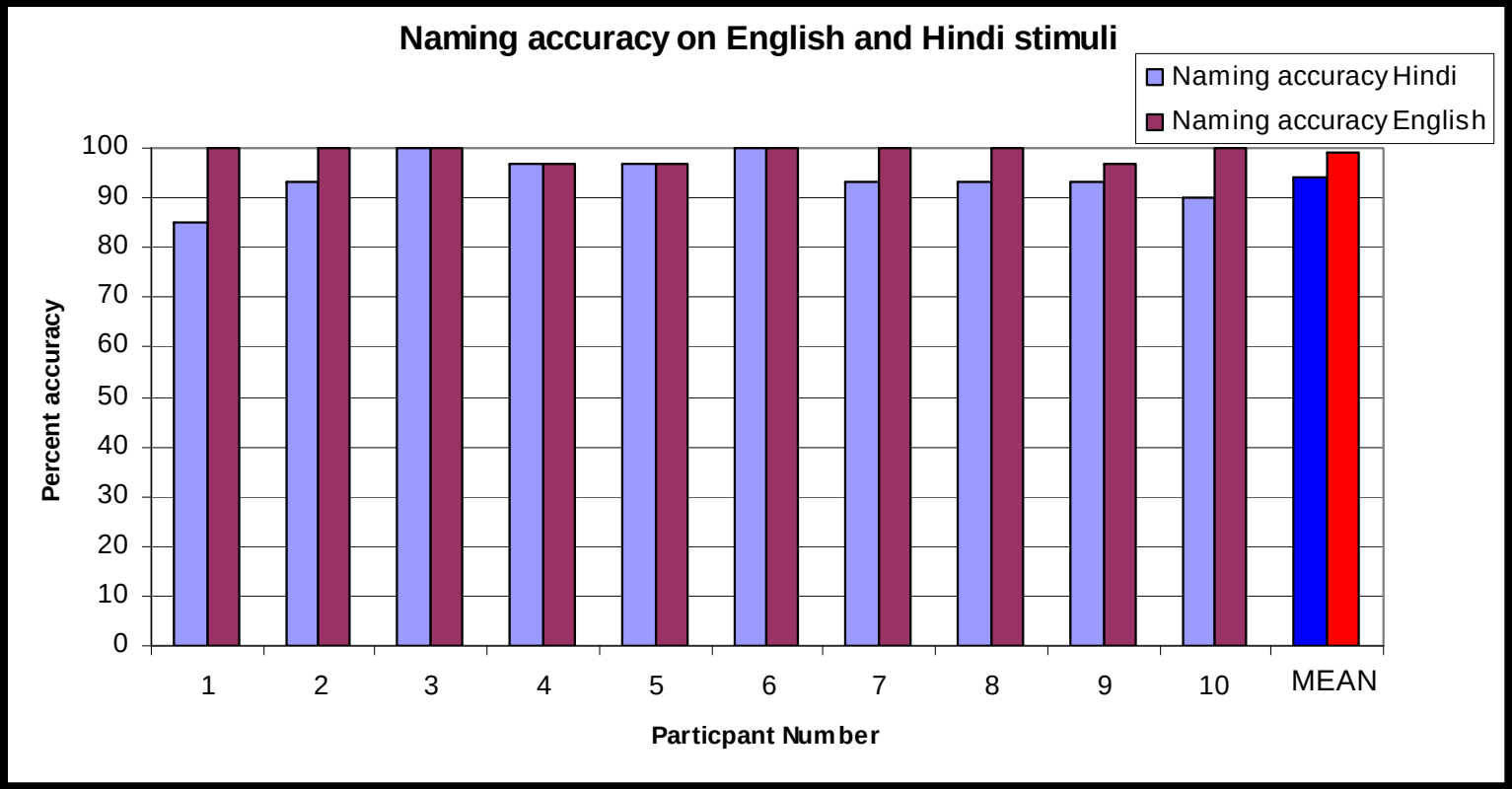
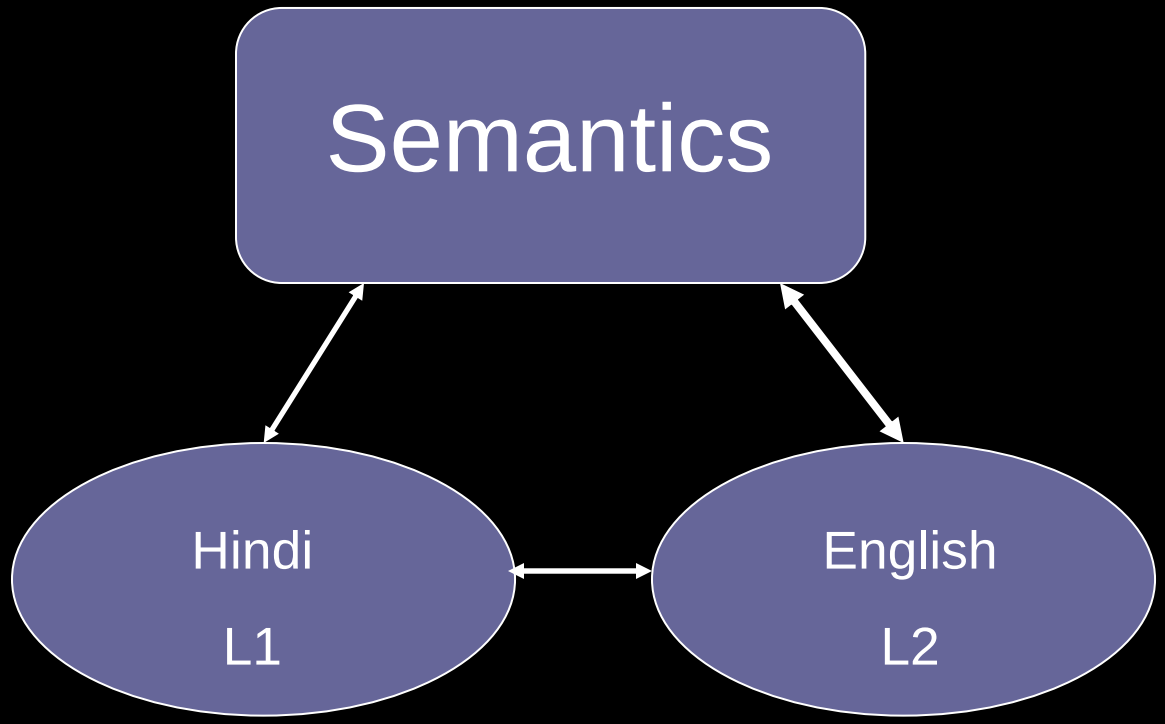
Picture Naming accuracy



Dynamic Bilingual Lexical Access



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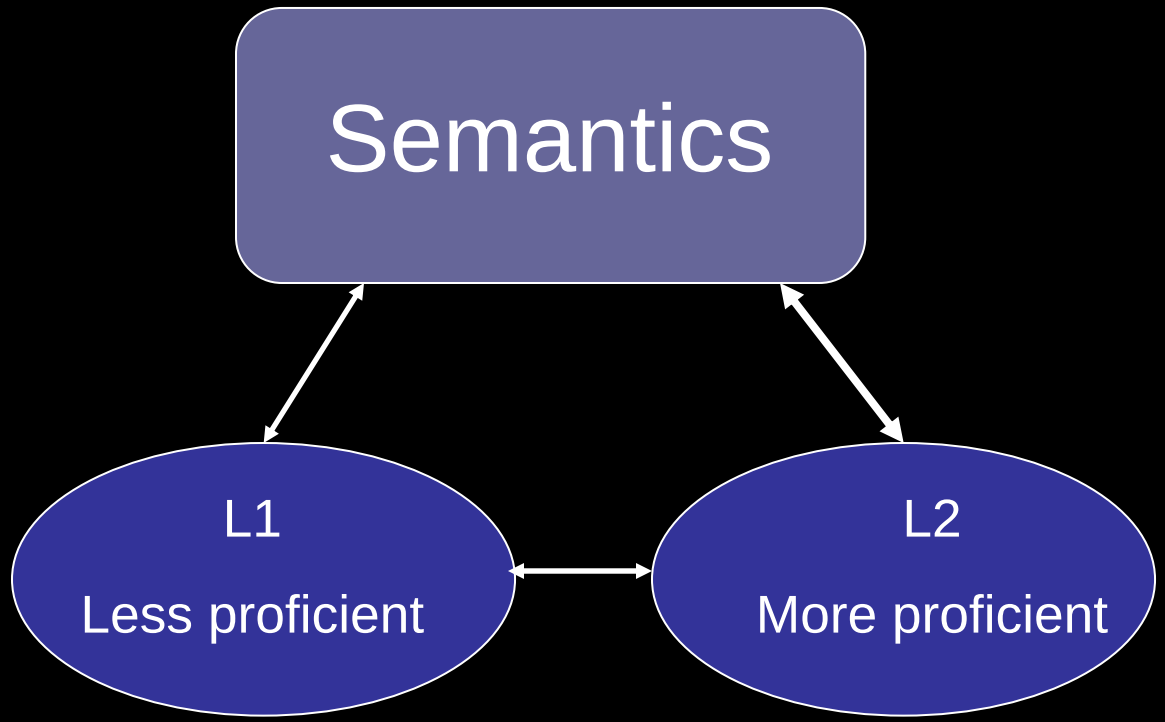
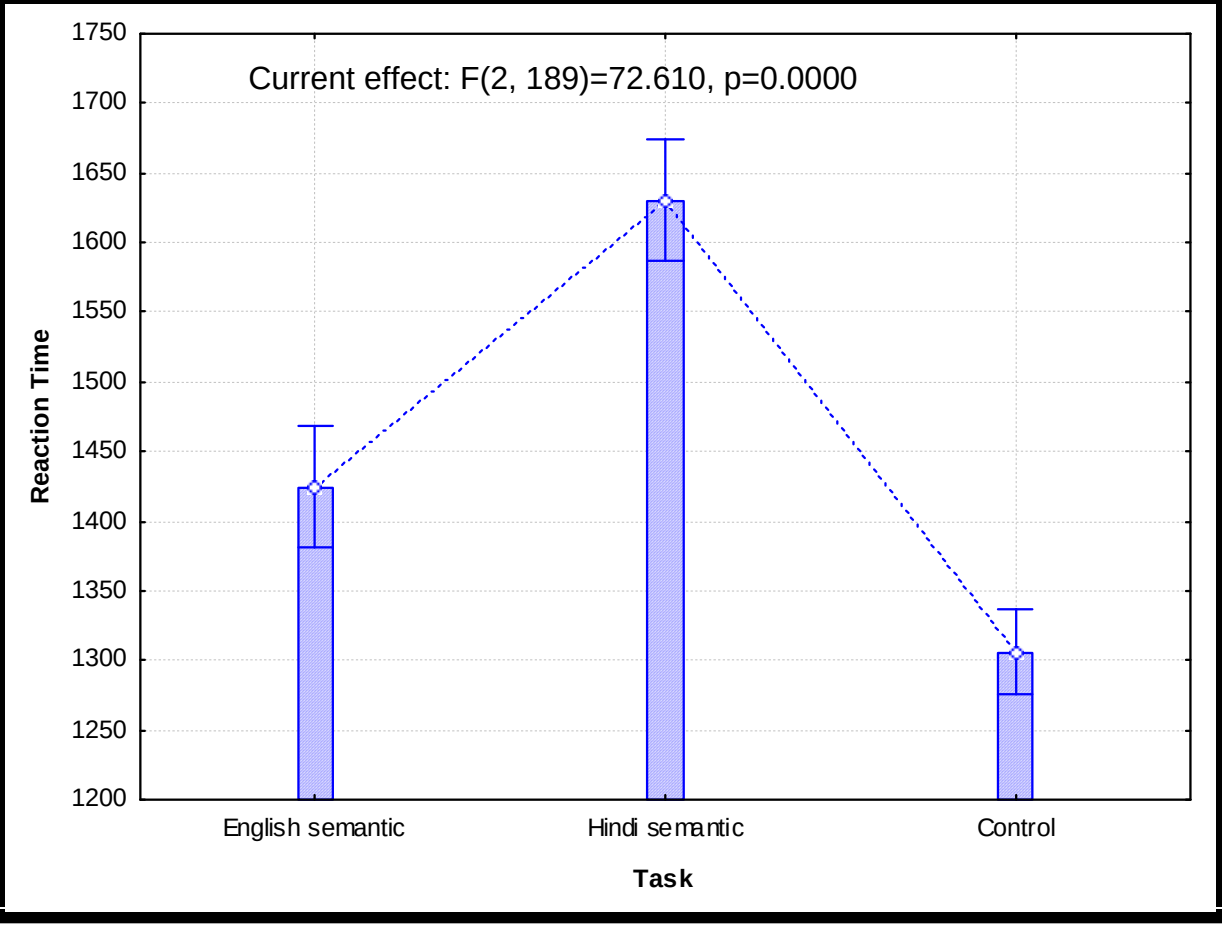


Mean RT on task



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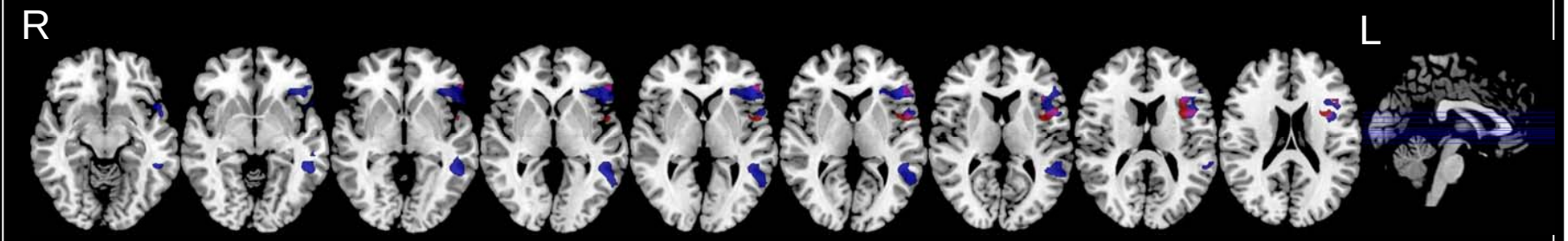
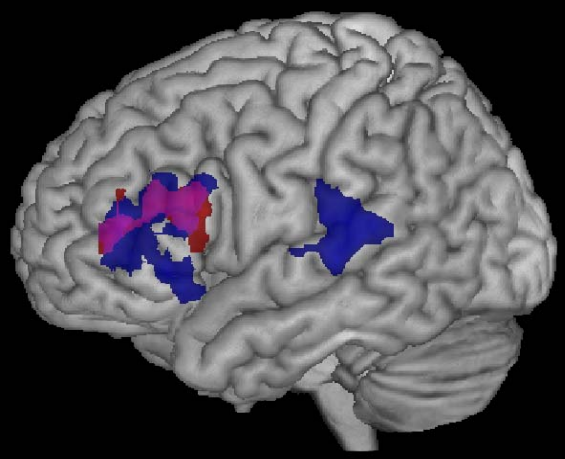
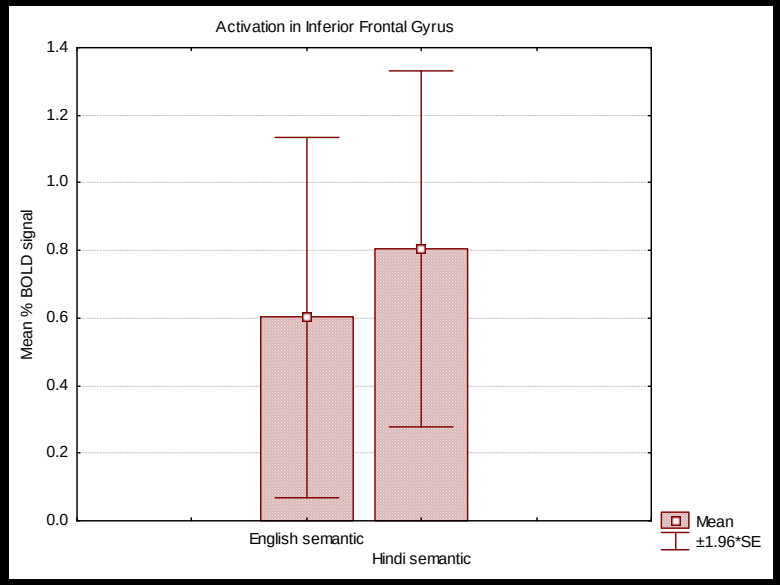
Semantic > Size



English = Red Hindi = Blue Overlap

Semantic > Size





cluster threshold Z>2.3, p < .05

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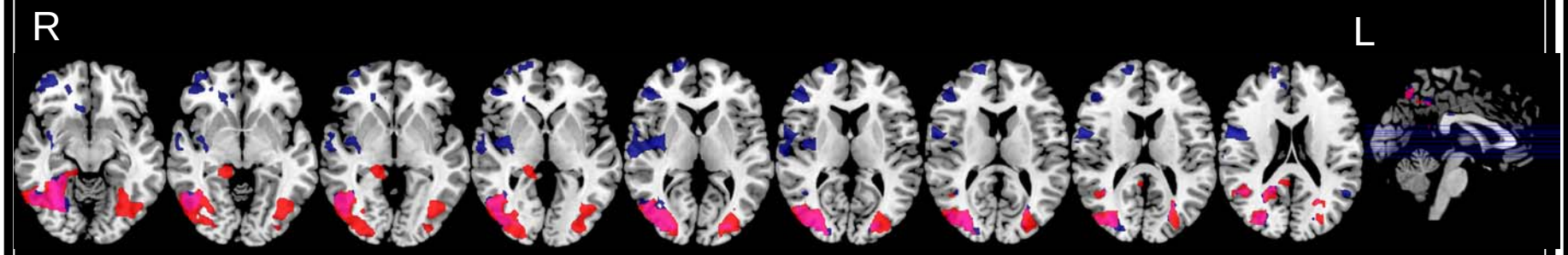
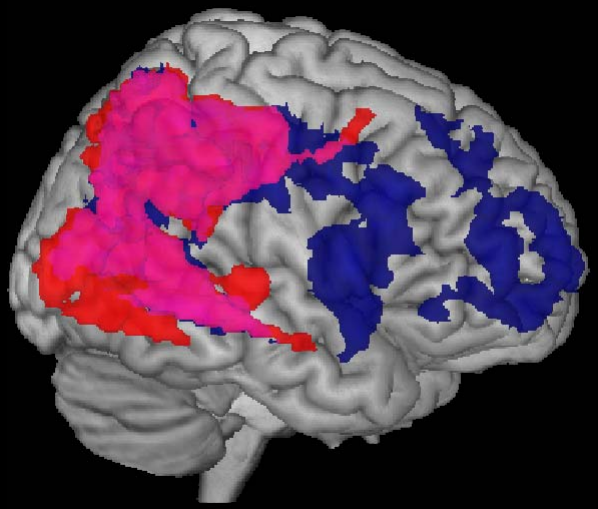


Size > Semantic

English = Red
Hindi = Blue
Overlap = Pink



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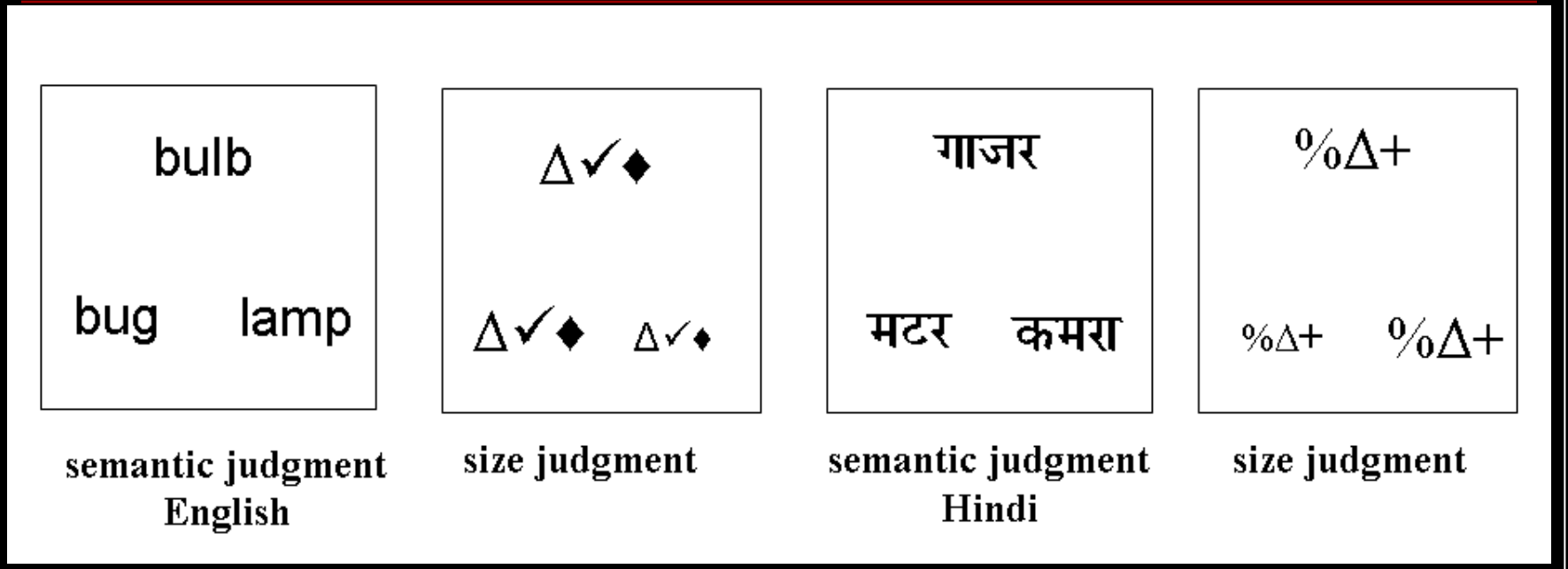

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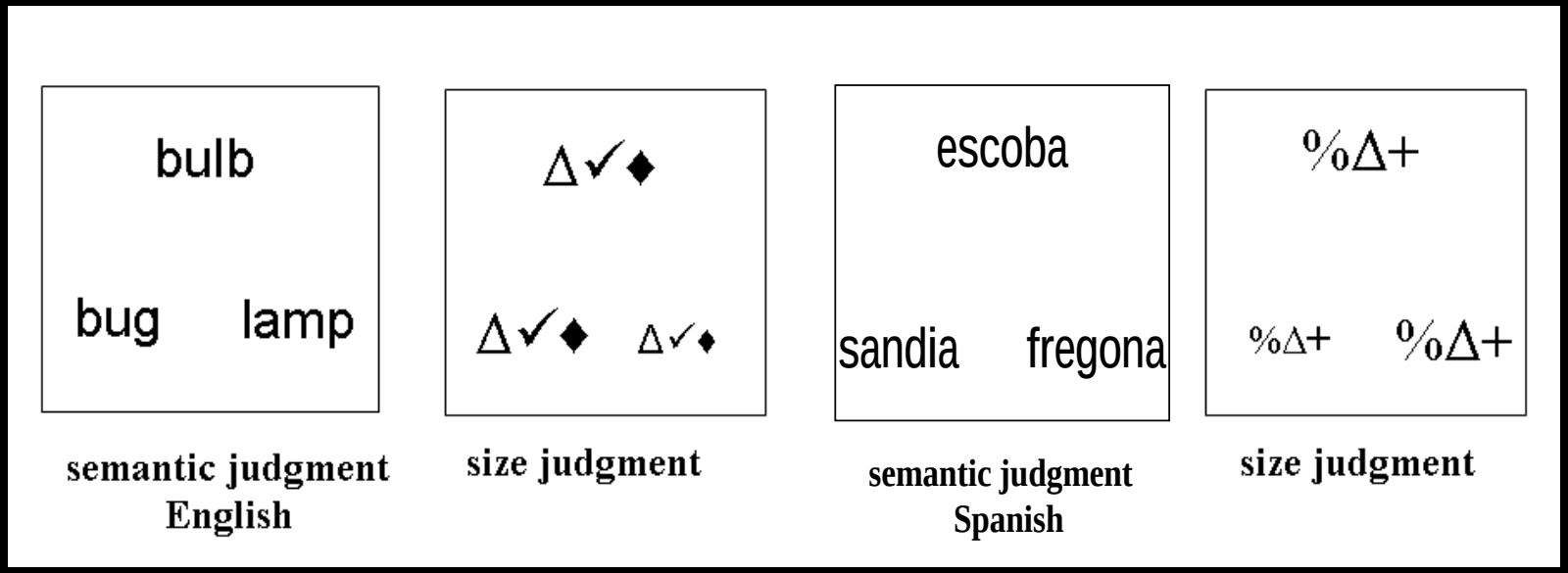

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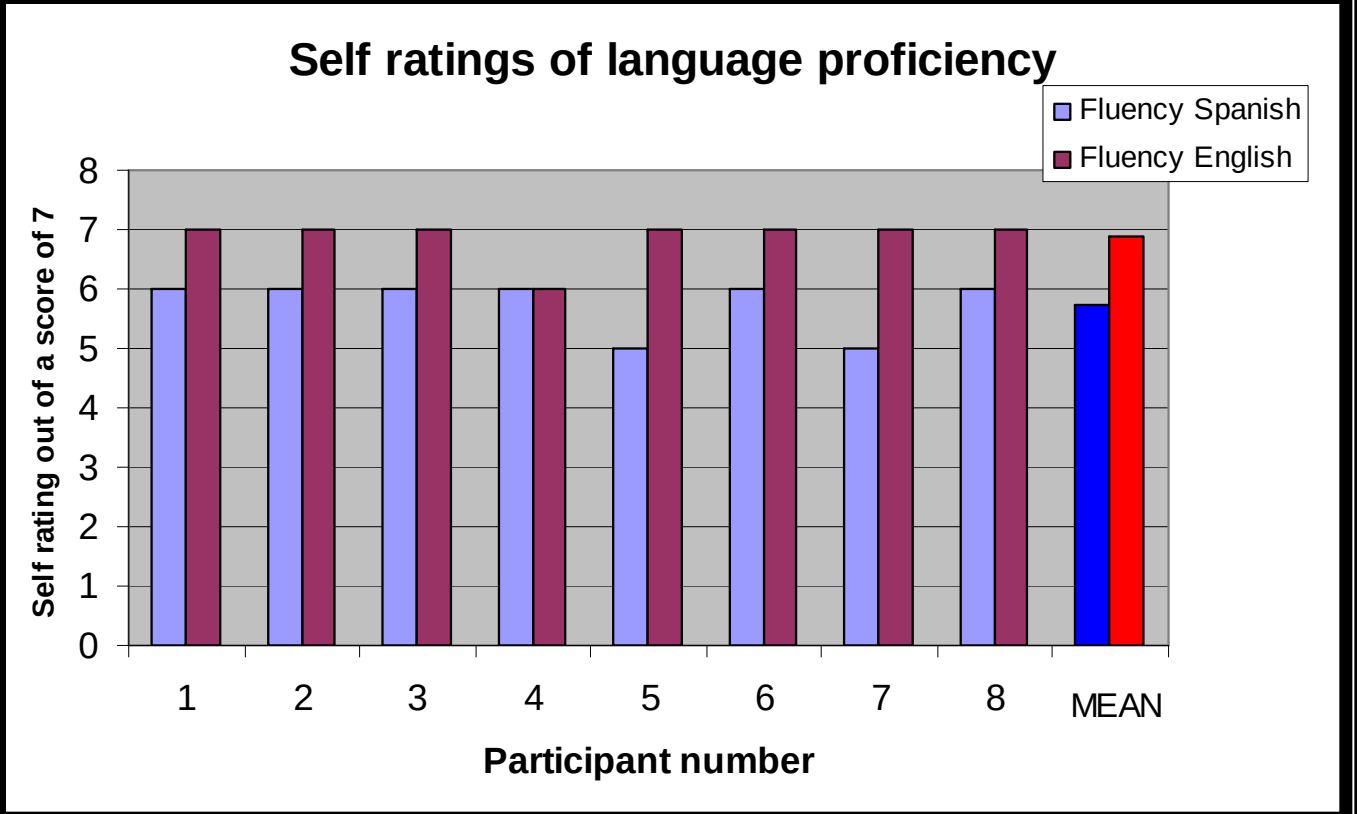
Self ratings of fluency in each language

N =8

	AoA
L1: Spanish	0
L2: English	2.3 years



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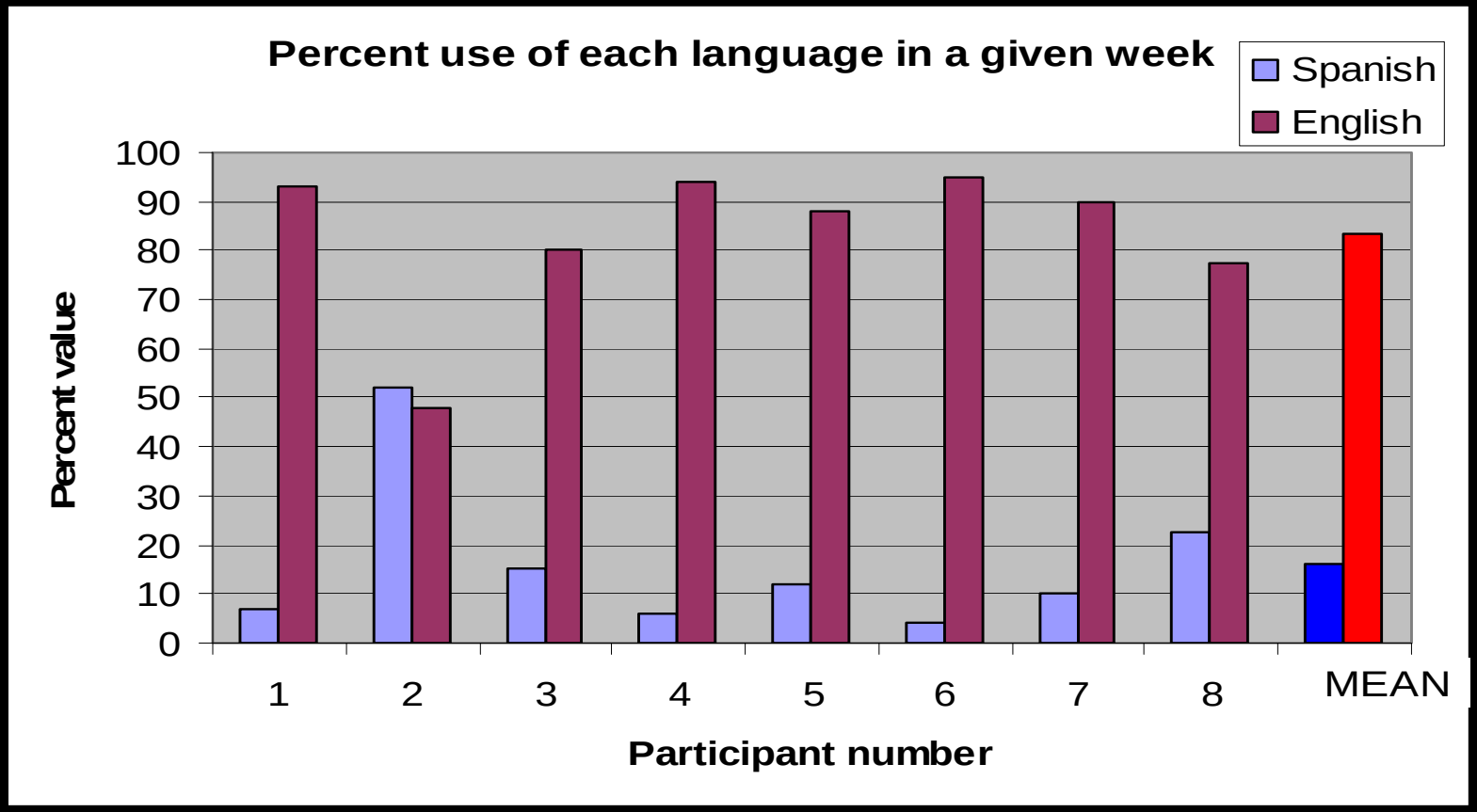

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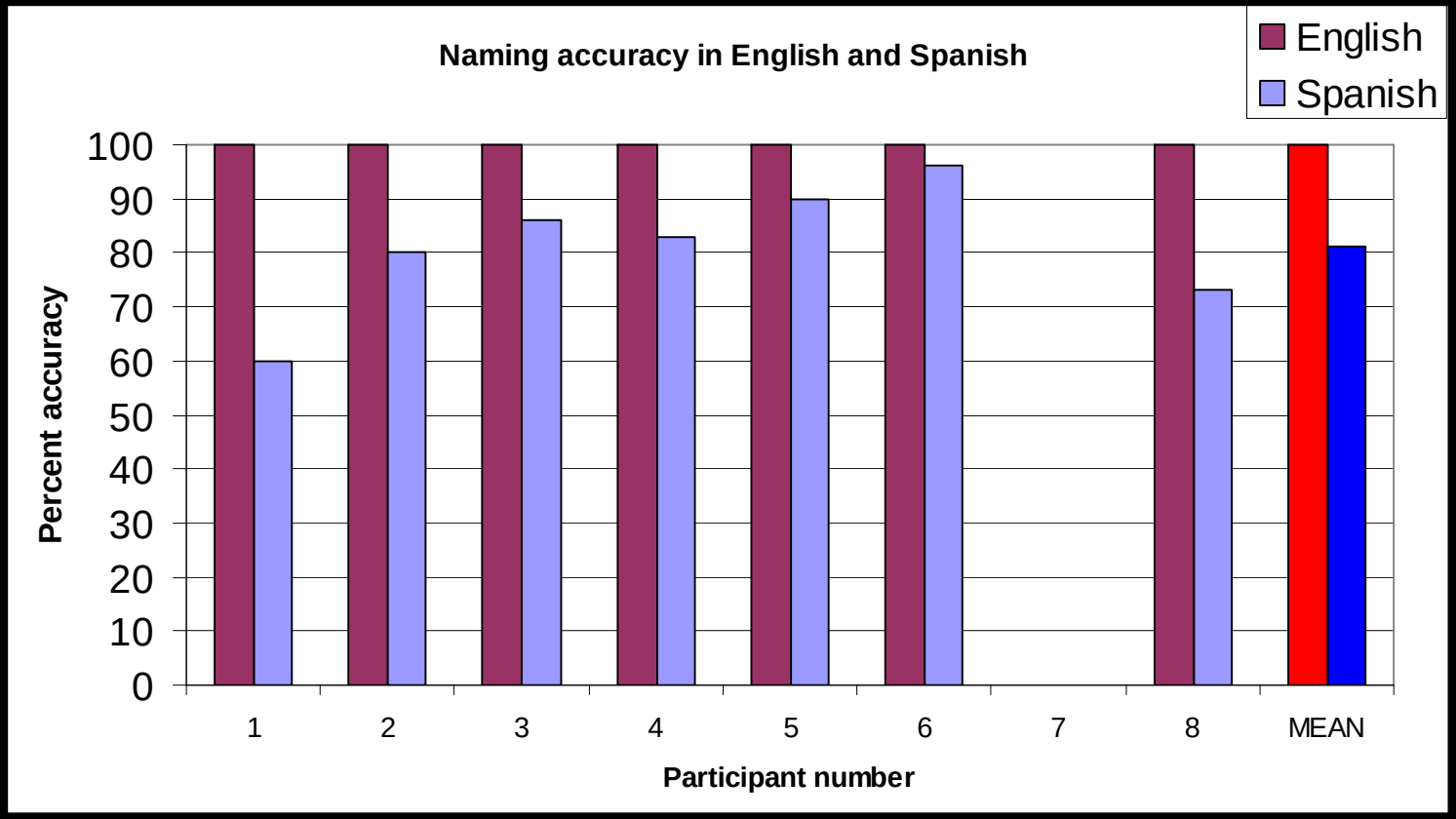

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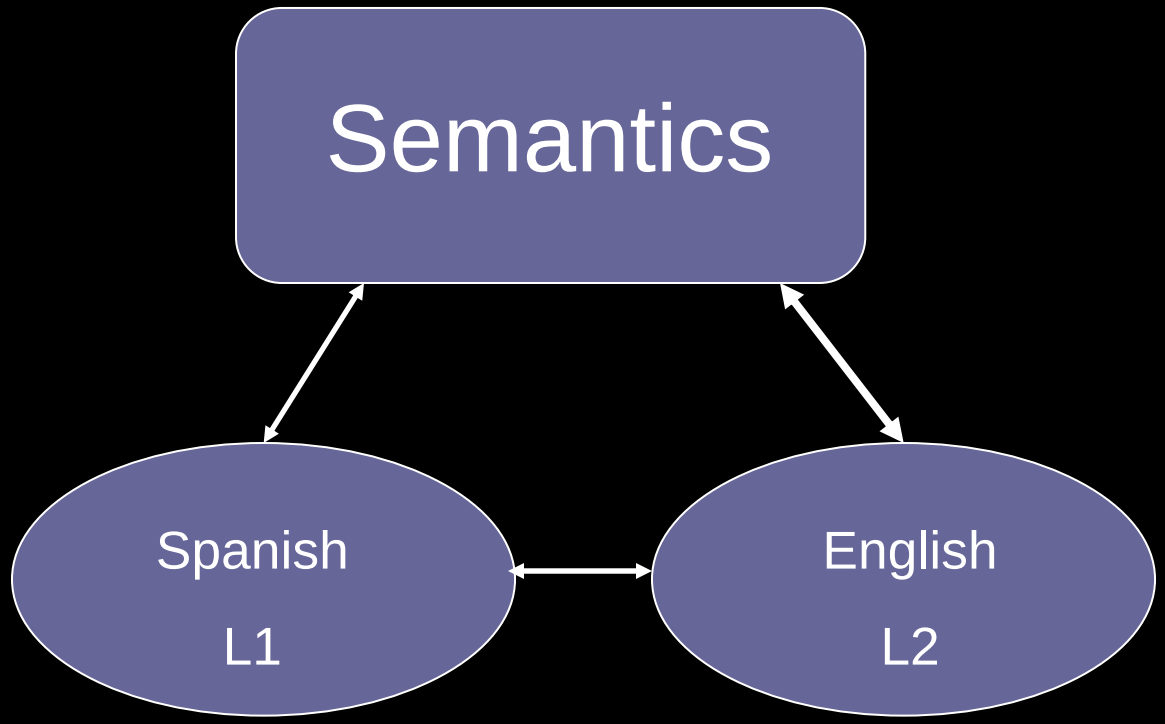

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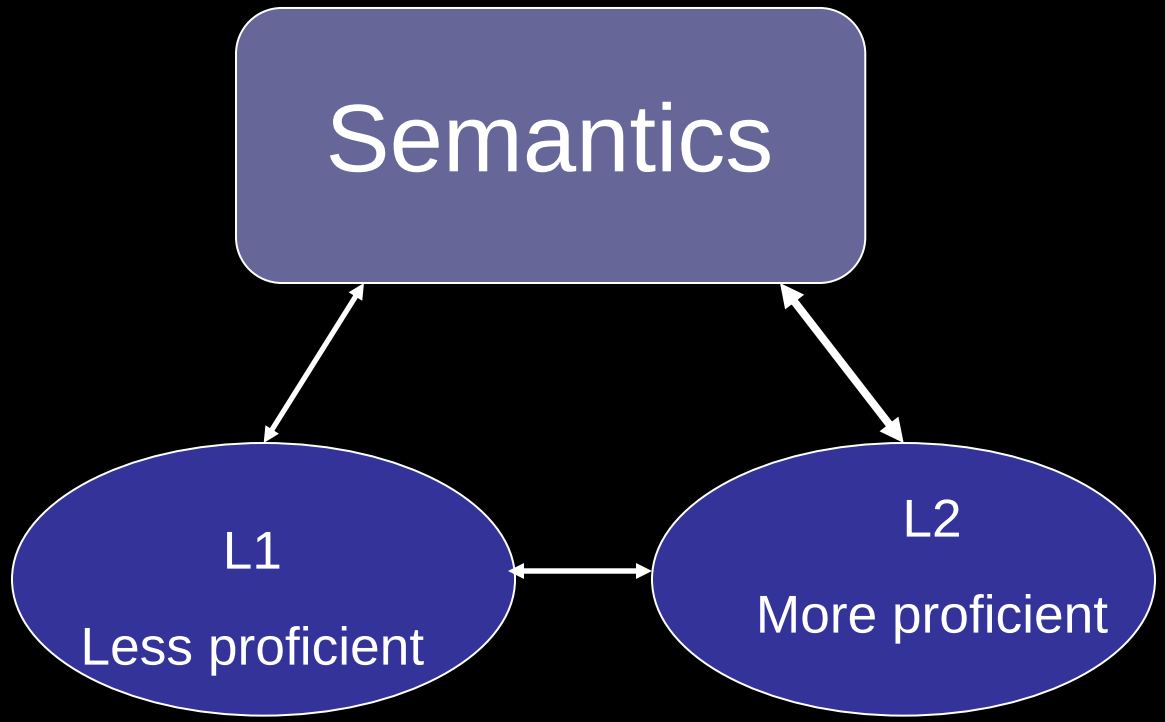

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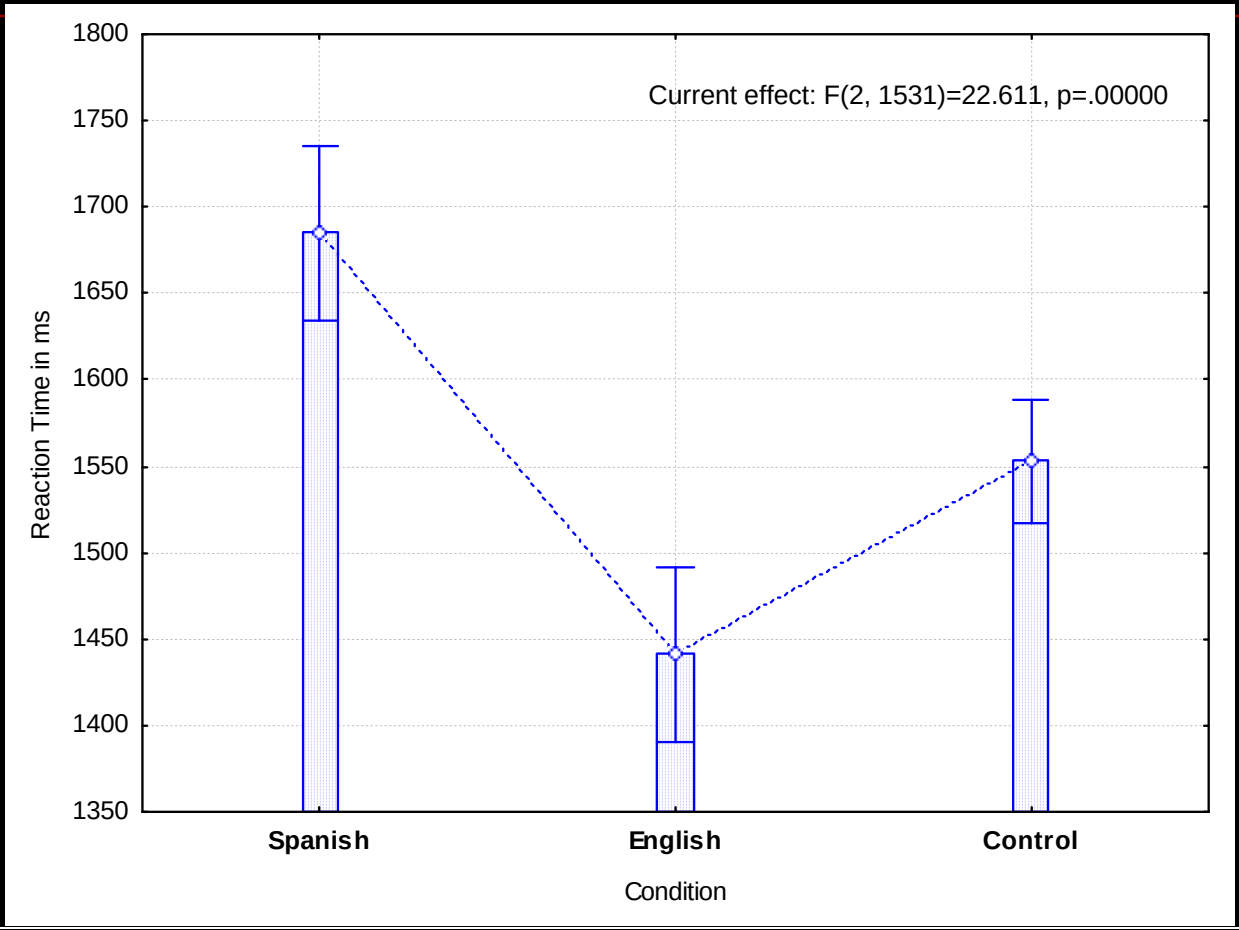
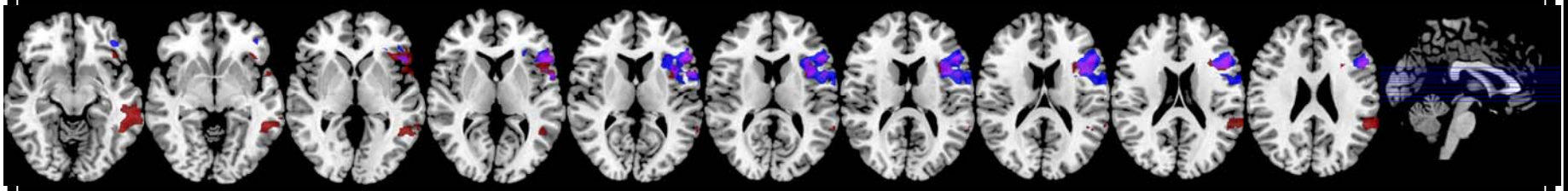


Sebastian & Kiran, (submitted)

R

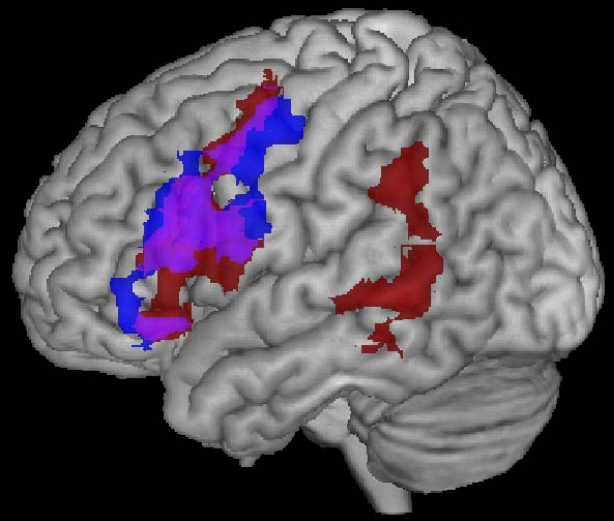
Semantic > Size

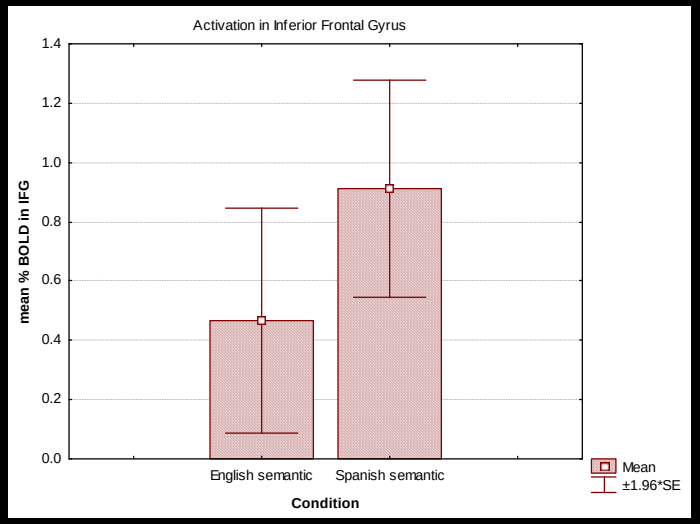
L



English = Red Spanish = Blue Overlap = Purple

Semantic > Size





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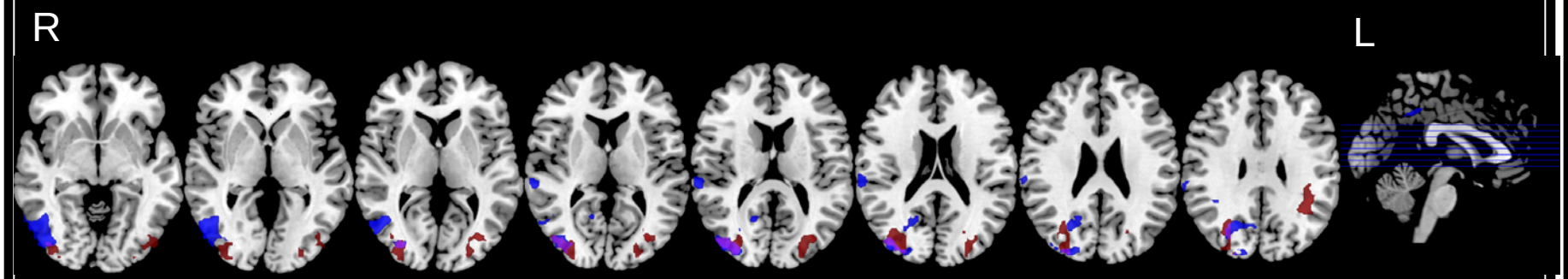

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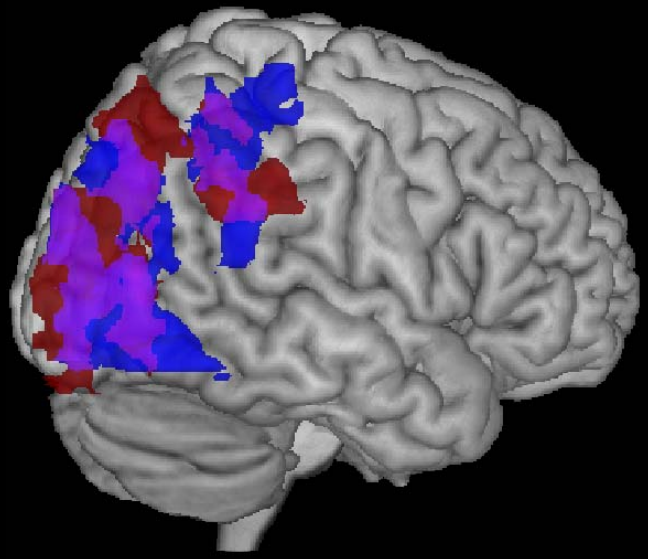

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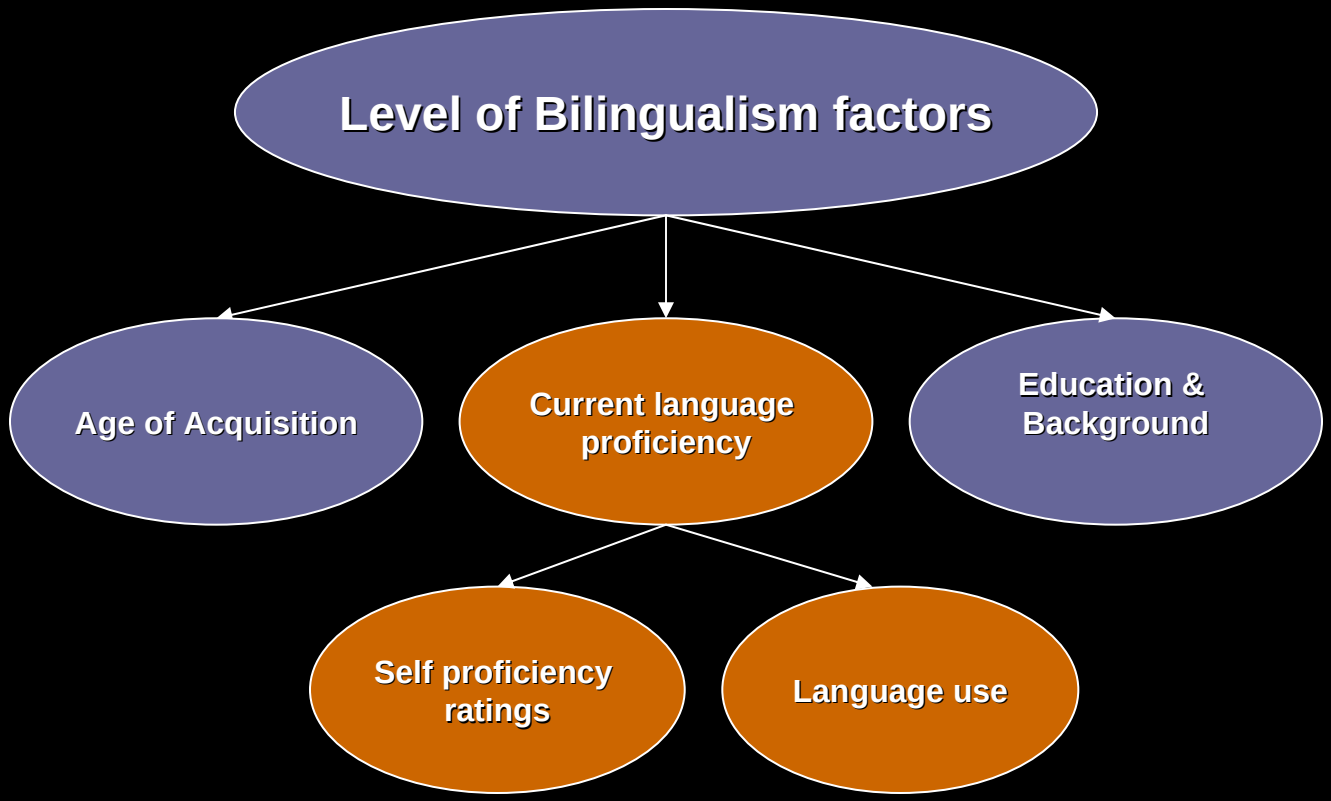
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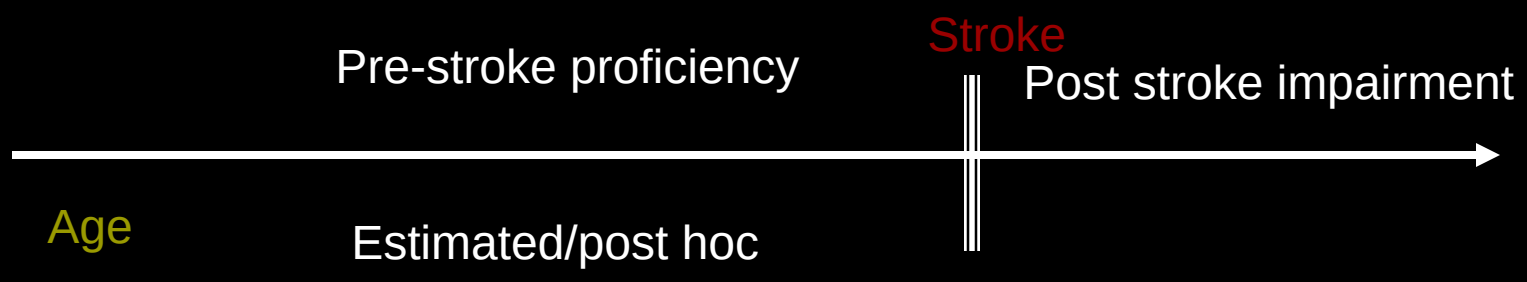
In Bilingual Aphasia

- Does current language proficiency also influence language processing skills?
- What are the neural correlates of bilingual semantic processing in aphasia patients?

Bilingual Aphasia



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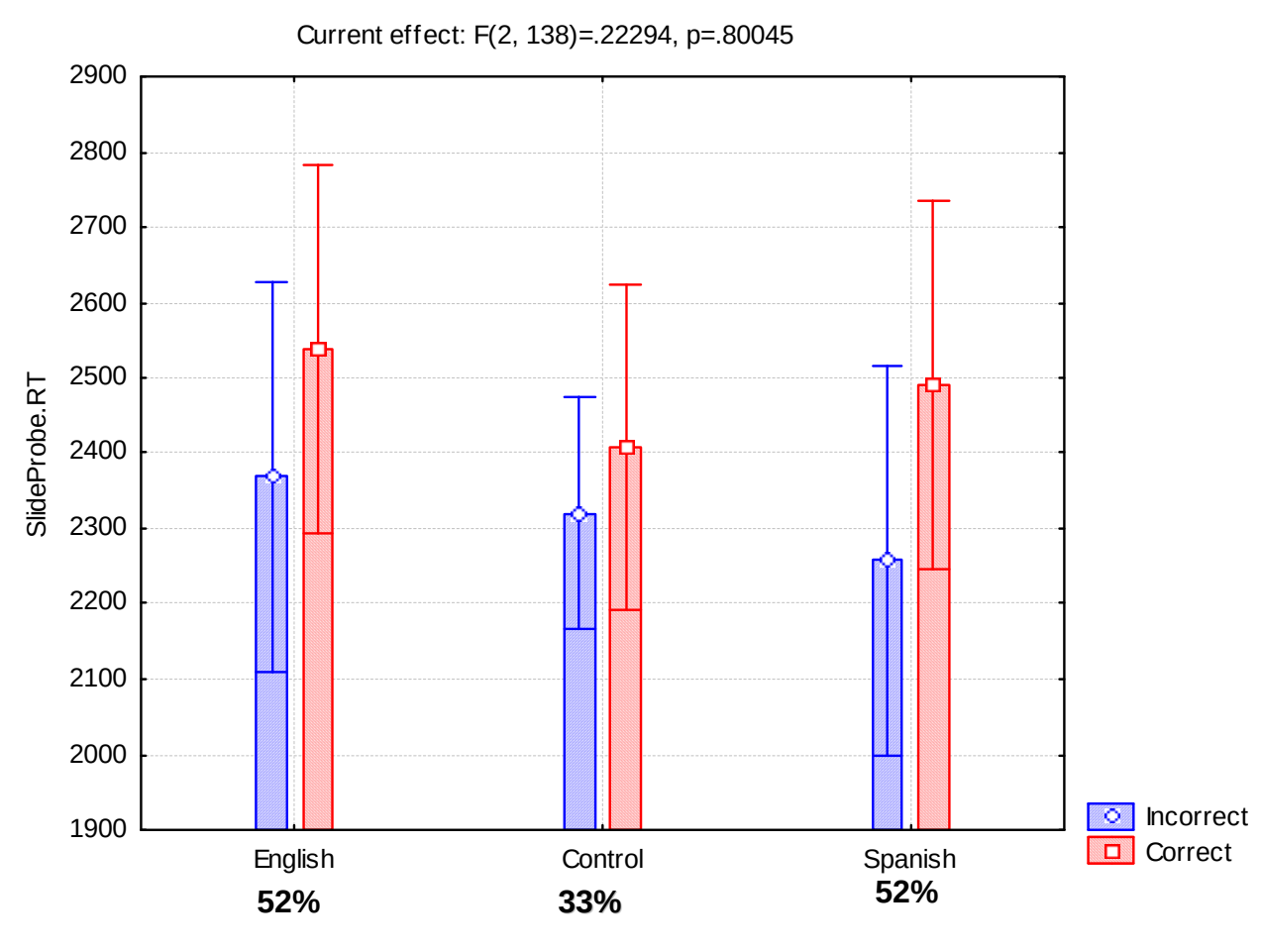
P1

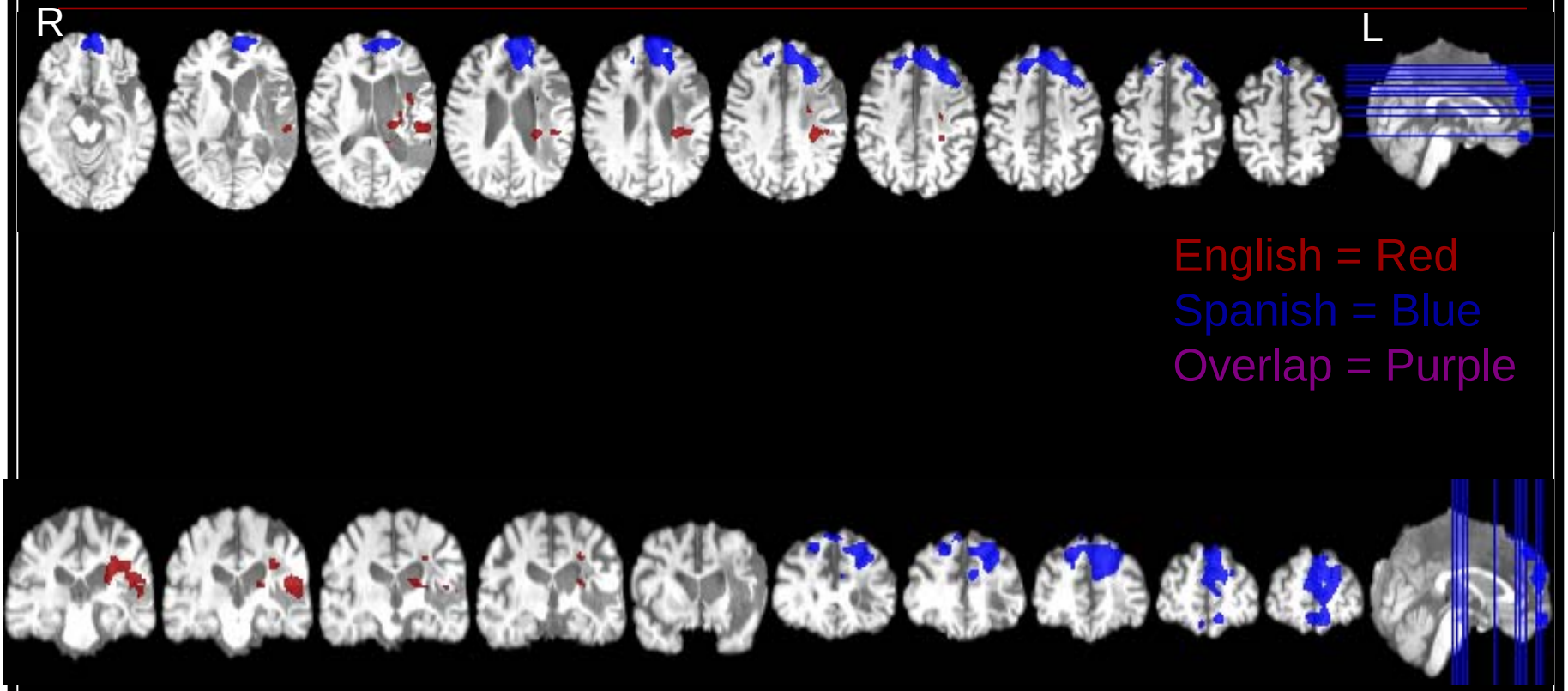
Sex	Age	MPO	Family / Social	Work	Education	Self-ratings (L1/L2) (1–7)	BNT
M	59	97	Both languages from birth -Prior to CVA, Spanish primarily with mother (bilingual) -100% English at home with spouse	Surveyor: 70% English 30% Spanish	Educated in English -No Spanish training -Read in English for leisure	English = 5 Spanish = 2	English = 19/60 Spanish 1/60

P1 – behavioral performance on task



P1 activation

Semantic > Size

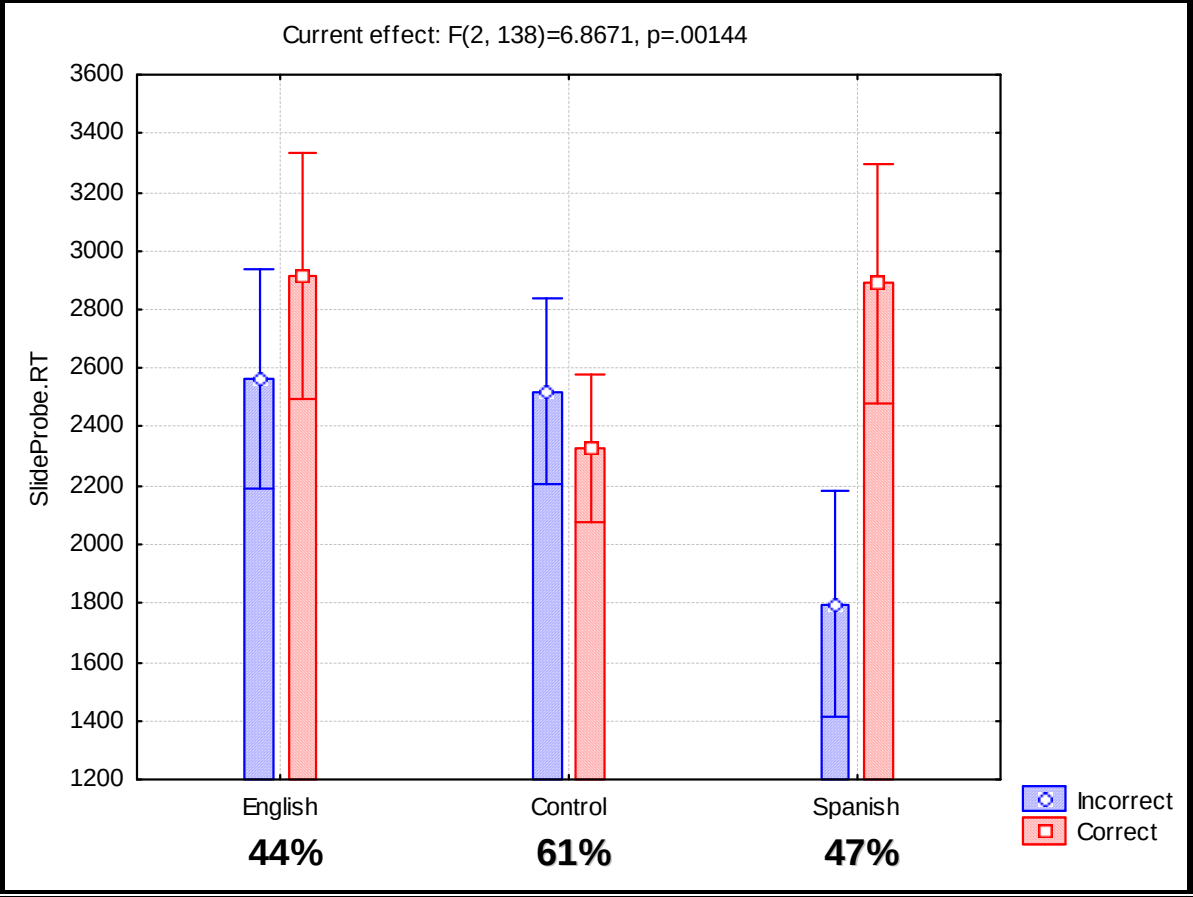


cluster threshold Z>2.3, p < .05

P2

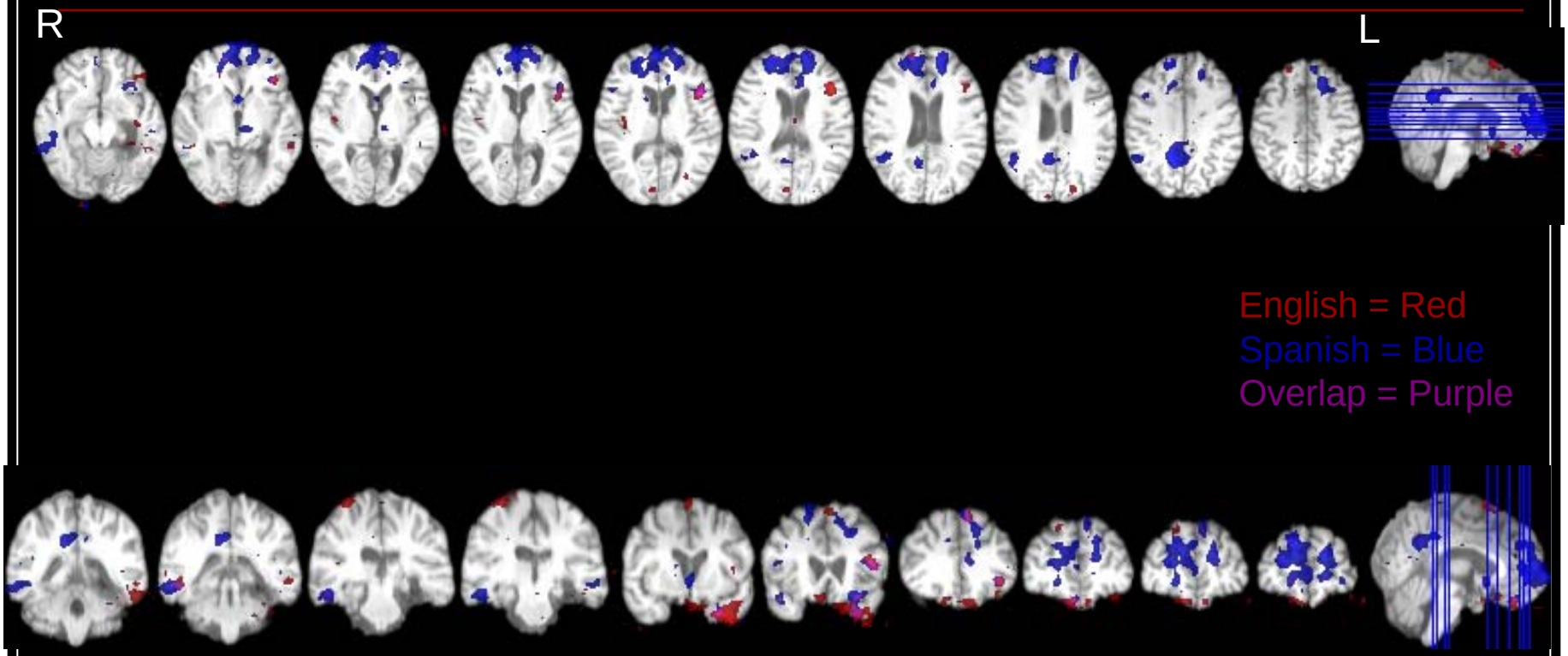
Sex	Age	MPO	Family / Social	Work	Education	Self-ratings (L1/L2) (1–7)	BNT
F	52	9	■Born in US ■Raised in bilingual environment ■Bilingual partner	Paralegal 75% English 25% Spanish	■Elementary education in English ■Middle School/College in both languages	English = 4.7 Spanish = 3.7	English = 4/60 Spanish = 3/60

P2-behavioral performance on task



P2 activation

Semantic > Size



cluster threshold Z>2.3, p < .05

Preliminary findings

- Different sites and lesion sizes

But:

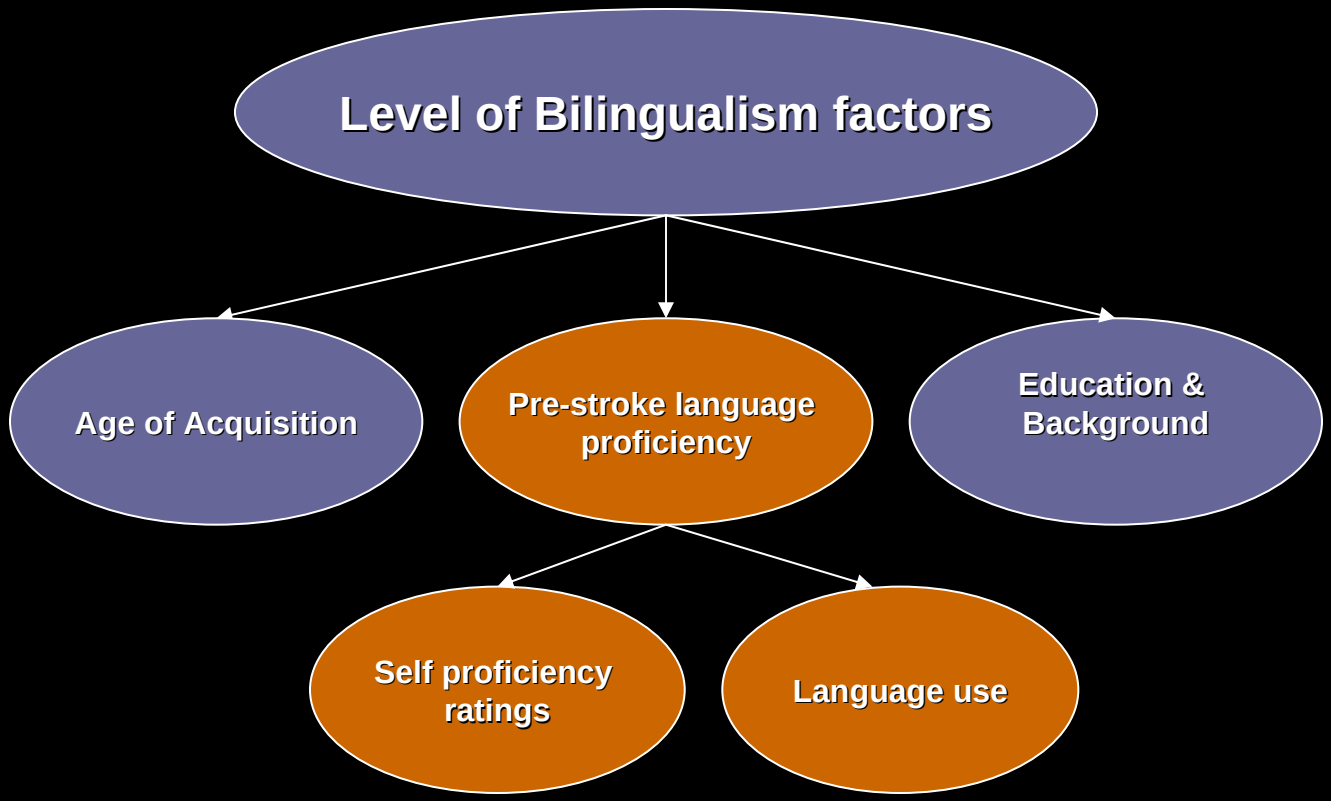
- Both patients more proficient in English prior to stroke

- 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.

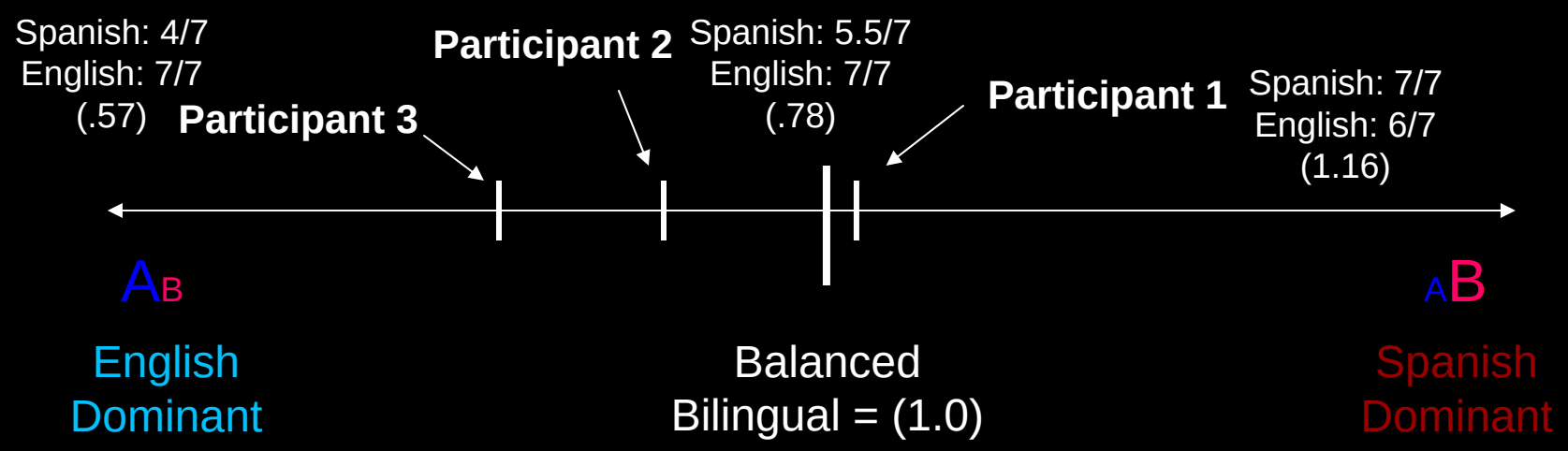
What are the factors that influence language rehabilitation?



Pt	Sex	Age	MPO	Family / Social	Work	Education	Self-ratings (L1/L2) (1–7)
1	F	53	9	Spanish only until 21 years -Prior to CVA, 100% English at home with -Spanish and English with grown children	Factory: 50% English 50% Spanish	-Educated in Spanish -Learned and used English	Speech: 6/7 Comp: 7/7
2	M	54	8	Both languages from birth -Prior to CVA, Spanish primarily with mother (bilingual) -100% English at home with spouse	Surveyor: 70% English 30% Spanish	Educated in English -No Spanish training -Read in English for leisure	Speech: 7/5 Comp: 7/6
3	F	53	9	-Both languages from birth -Prior to CVA, 80% English and 20% Spanish (with husband) at home	Retail: 70% English 30% Spanish	-Educated in English -No Spanish training -English only at work -Read in English for leisure	Speech: 7/3 Comp: 7/5

Edmonds & Kiran, (2006) *JSLHR*

Self Rated Pre- Morbid Language Proficiency



Edmonds & Kiran, (2006) *JSLHR*

Pre treatment BNT scores

	Participant 1		Participant 2		Participant 3	
	English	Spanish	English	Spanish	English	Spanish
Boston Naming Test (BNT) (N = 60)	41.7	40.0	**1.7**	0.0	**23.3**	**18.3**

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

Edmonds & Kiran, (2006) *JSLHR*

Stimuli

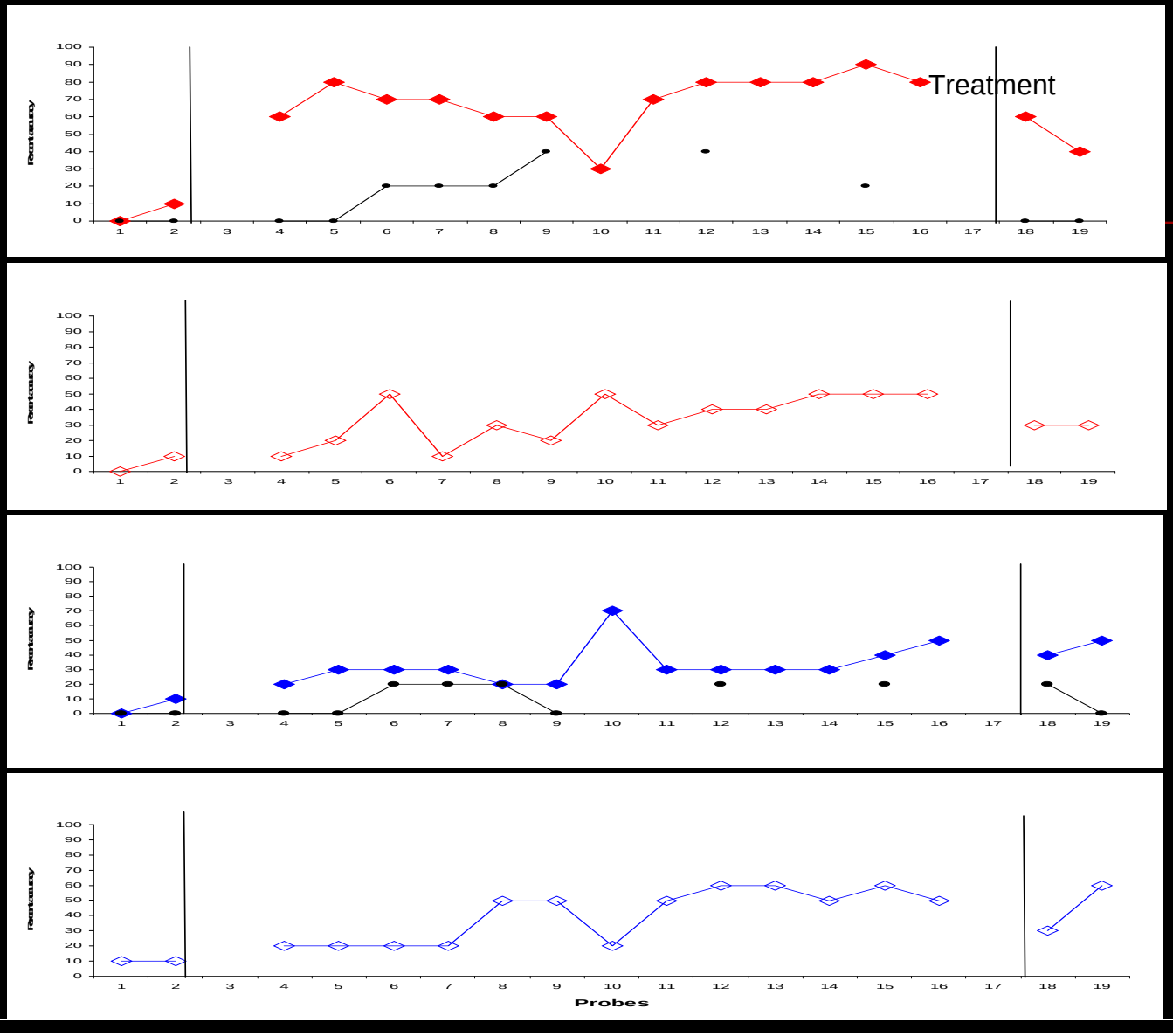
- For each participant, a different list of stimuli were developed
- Frequency of items matched within language and across languages for each participant
  - Matched semantically unrelated control set for English and Spanish (e.g., boat, *vaca*) (N=5 for each set)
  - No cognates (e.g., elephant/*elefante*) 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

Edmonds & Kiran, (2006) *JSLHR*



Apio

N=10

Repollo

N=10

Celery

N=10

Cabbage

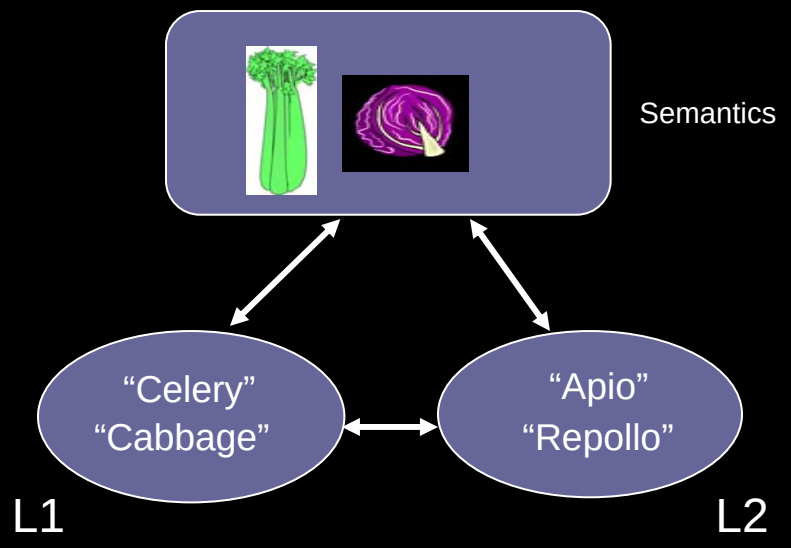
N=10

Participant 1 (equally proficient)

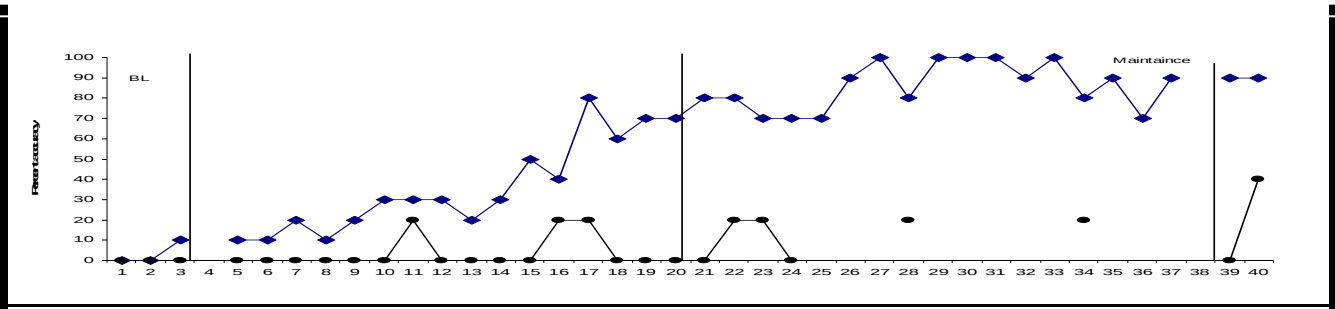
Edmonds & Kiran, (2006) *JSLHR*

Interpretation of Participant 1 (balanced) results

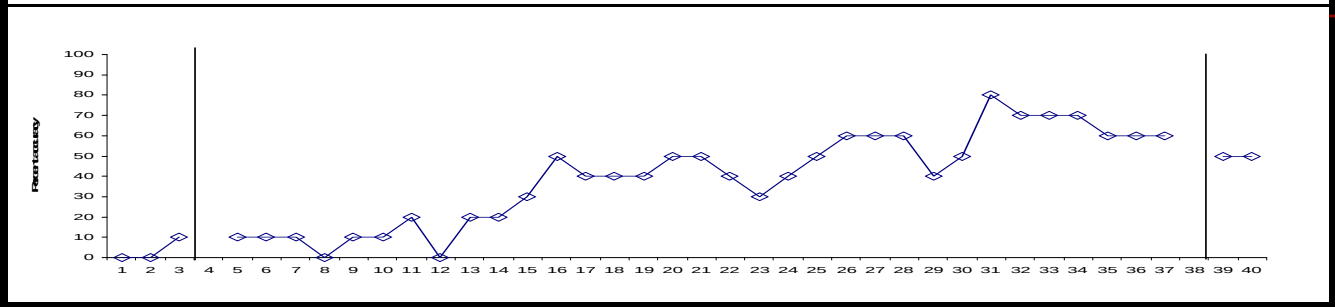
Spanish treatment



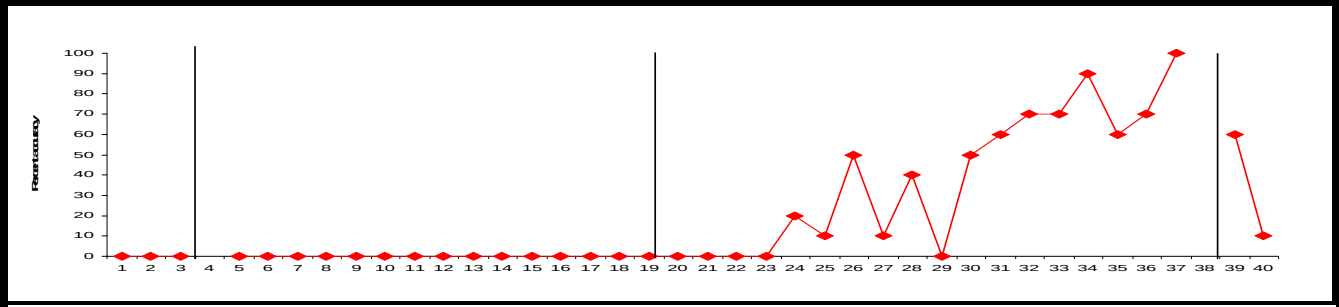
Edmonds & Kiran, (2006) *JSLHR*



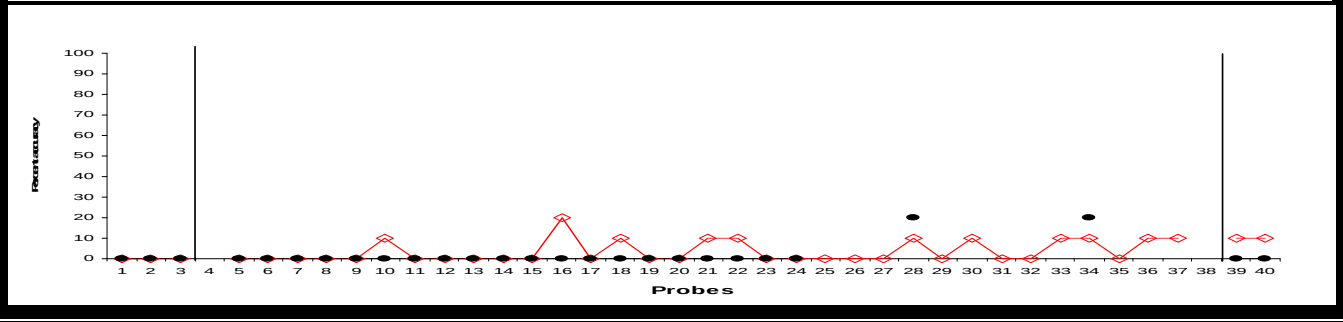
Apple



Orange



Naranja

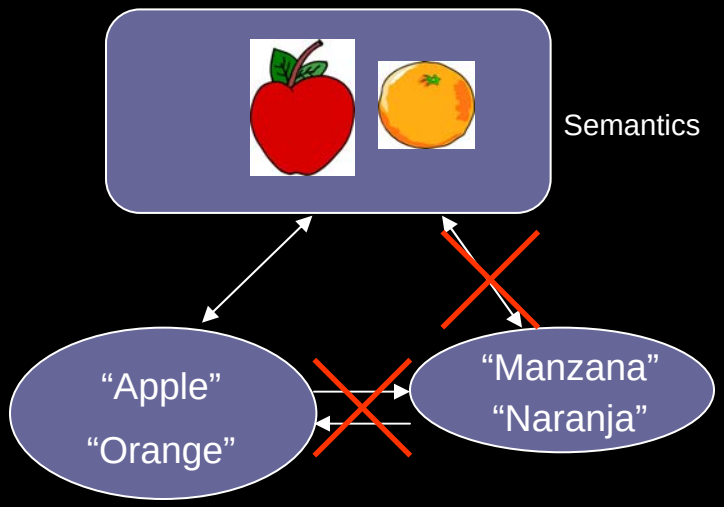


Manzana

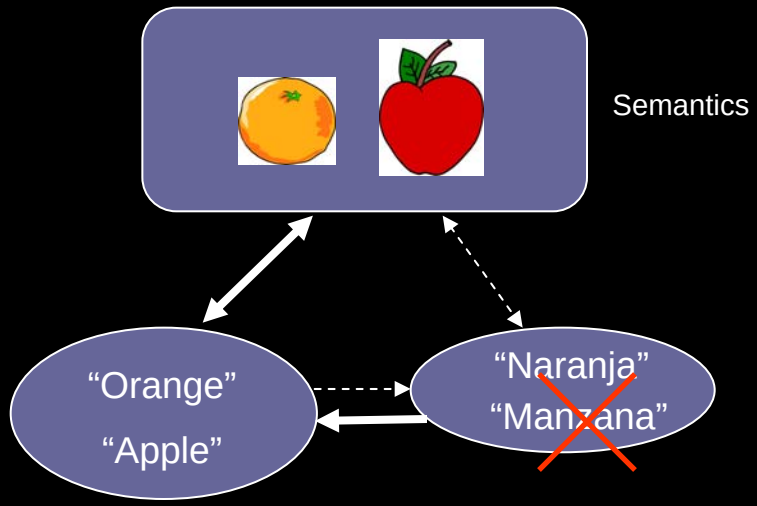
Edmonds & Kiran, (2006) *JSLHR*

Participant 2 (English dominant) results

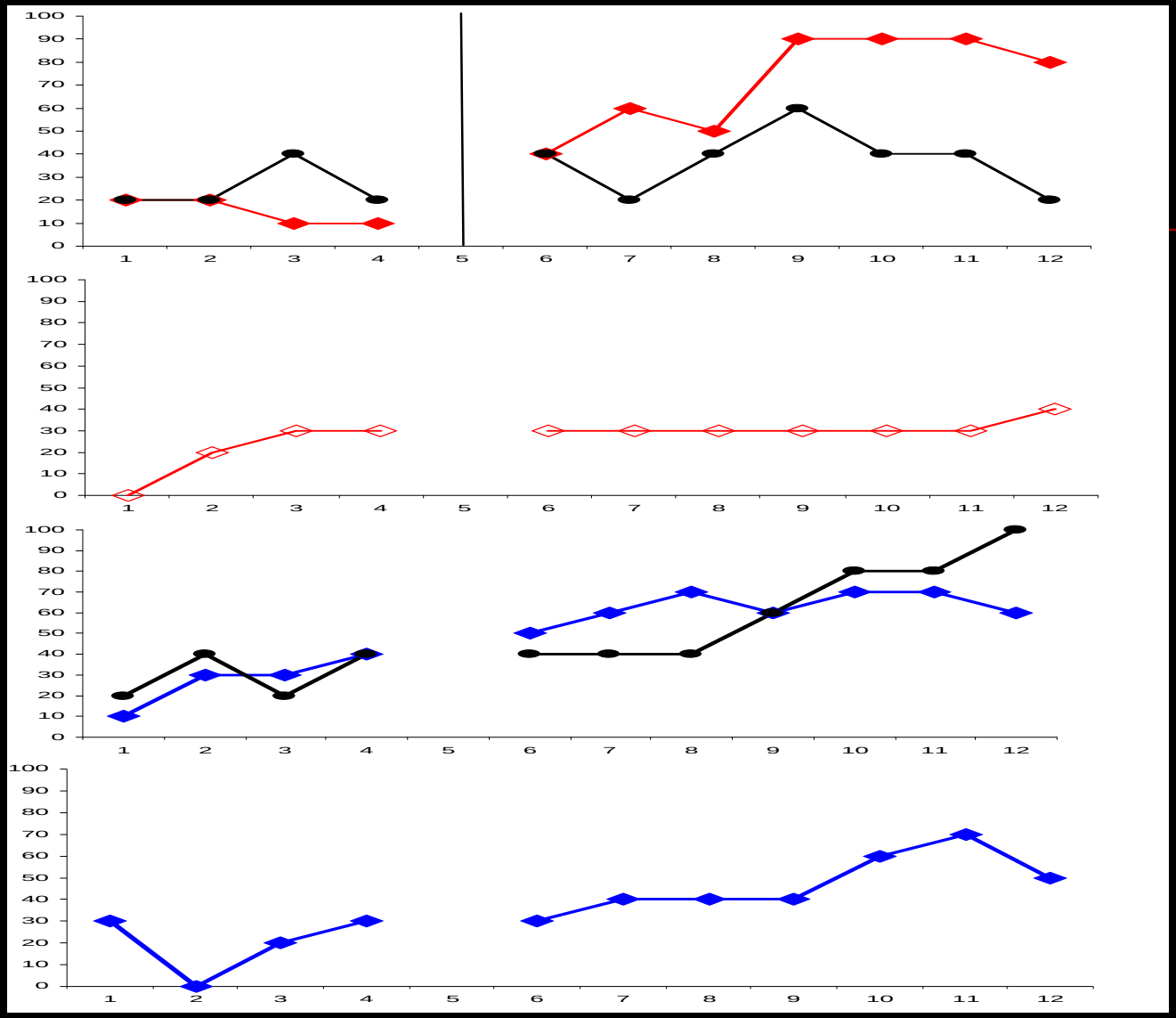
English (dominant language) treatment

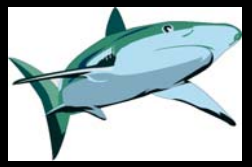


Spanish (non-dominant language) treatment



Edmonds & Kiran, (2006) *JSLHR*



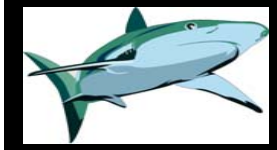


Tiburón

N=10

Ballena

N=10



Shark

N=10

Whale

N=10

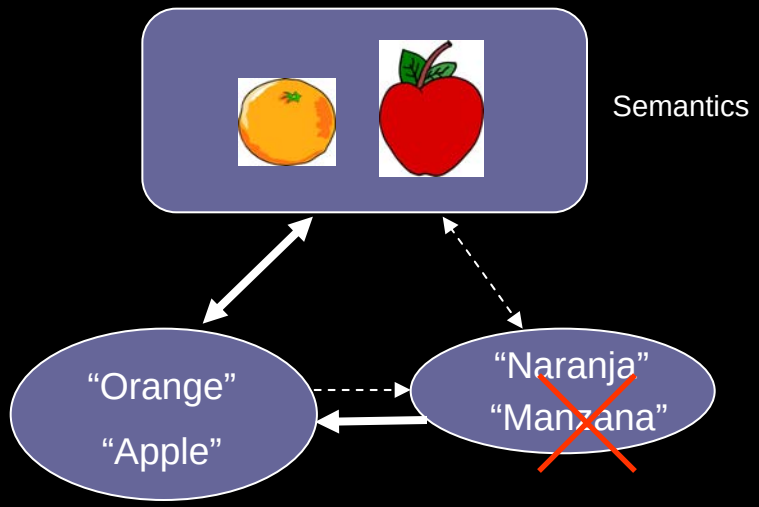
Participant 3 (English dominant) Results

Edmonds & Kiran, (2006) *JSLHR*

Participant 3 replicates findings of Participant 2 (both English dominant)

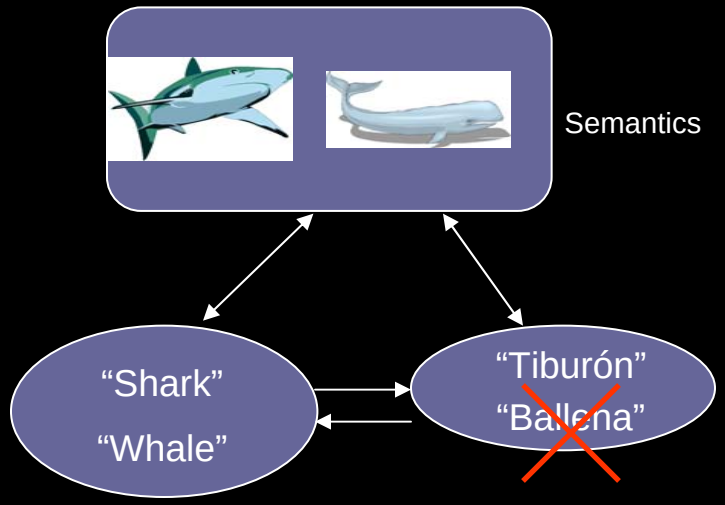
Participant 2

Spanish (non-dominant language) treatment



Participant 3

Spanish (non-dominant language) treatment



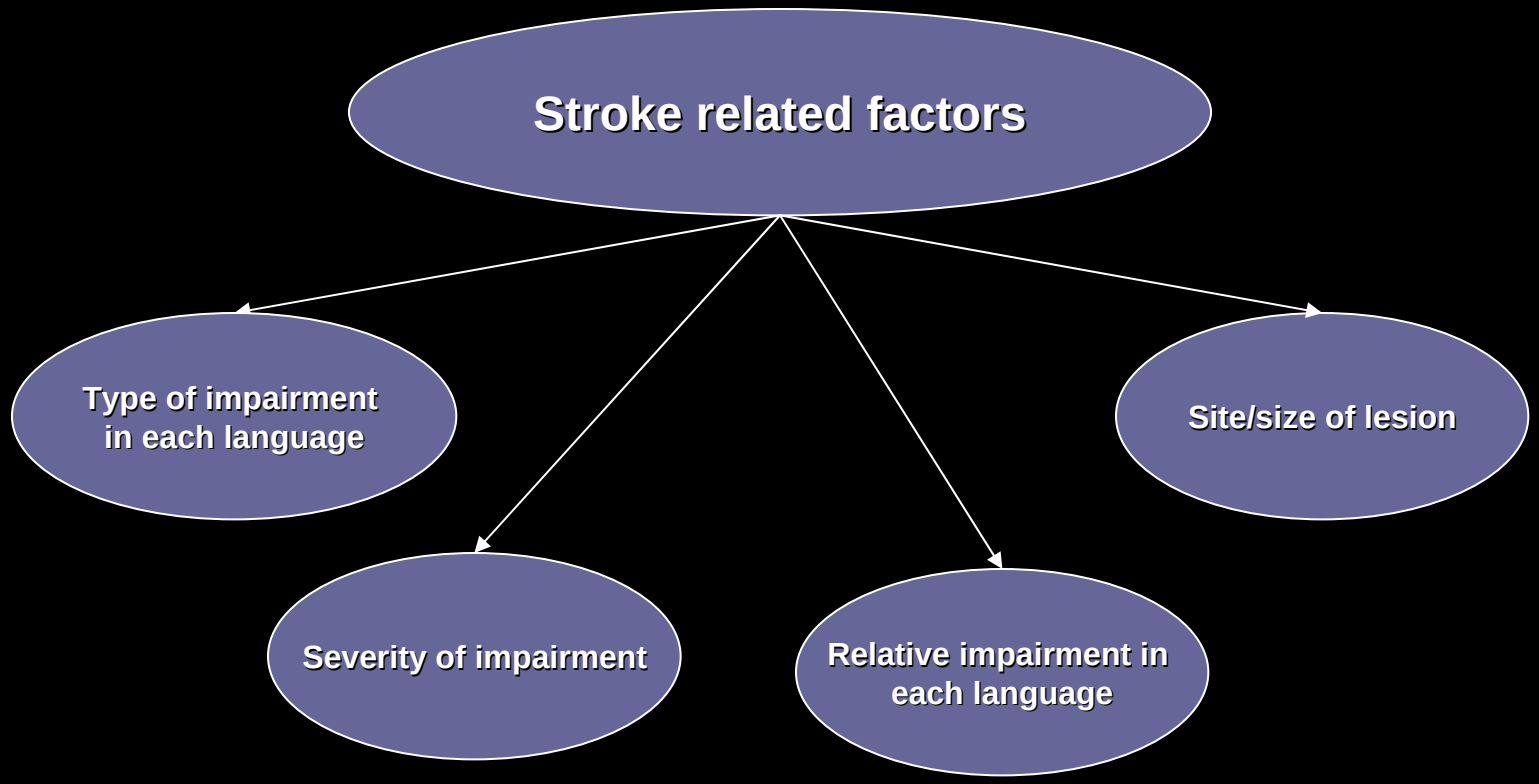
Edmonds & Kiran, (2006) *JSLHR*

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?

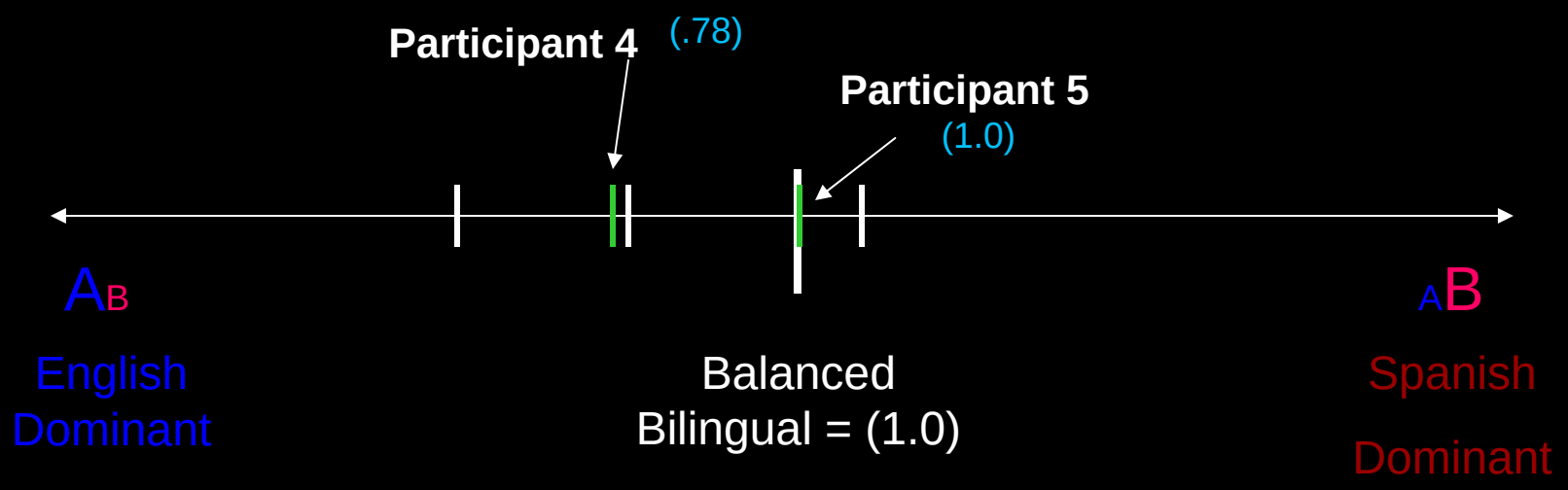
What are the factors that influence language recovery and rehabilitation?



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

Kiran, S. & Roberts, P. (accepted)

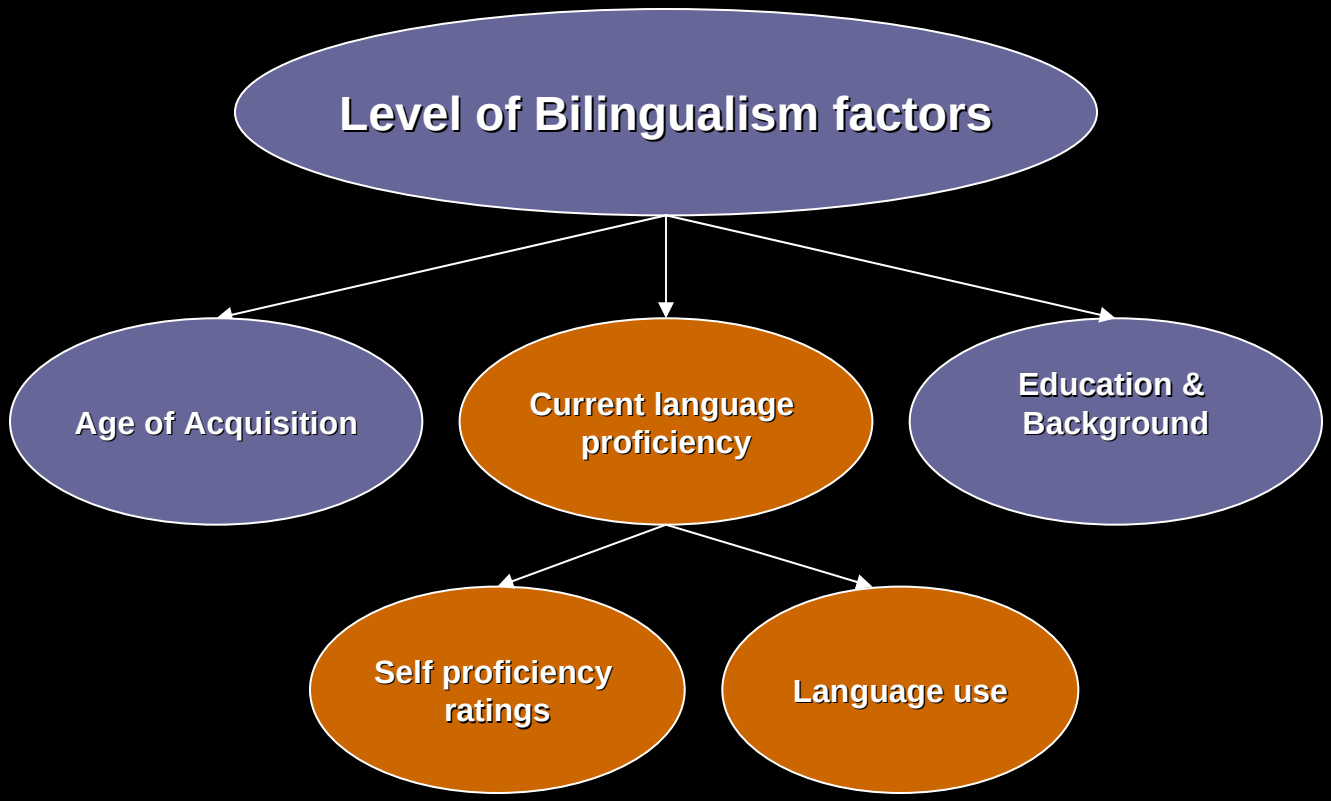
Self Rated Pre- Morbid Language Proficiency



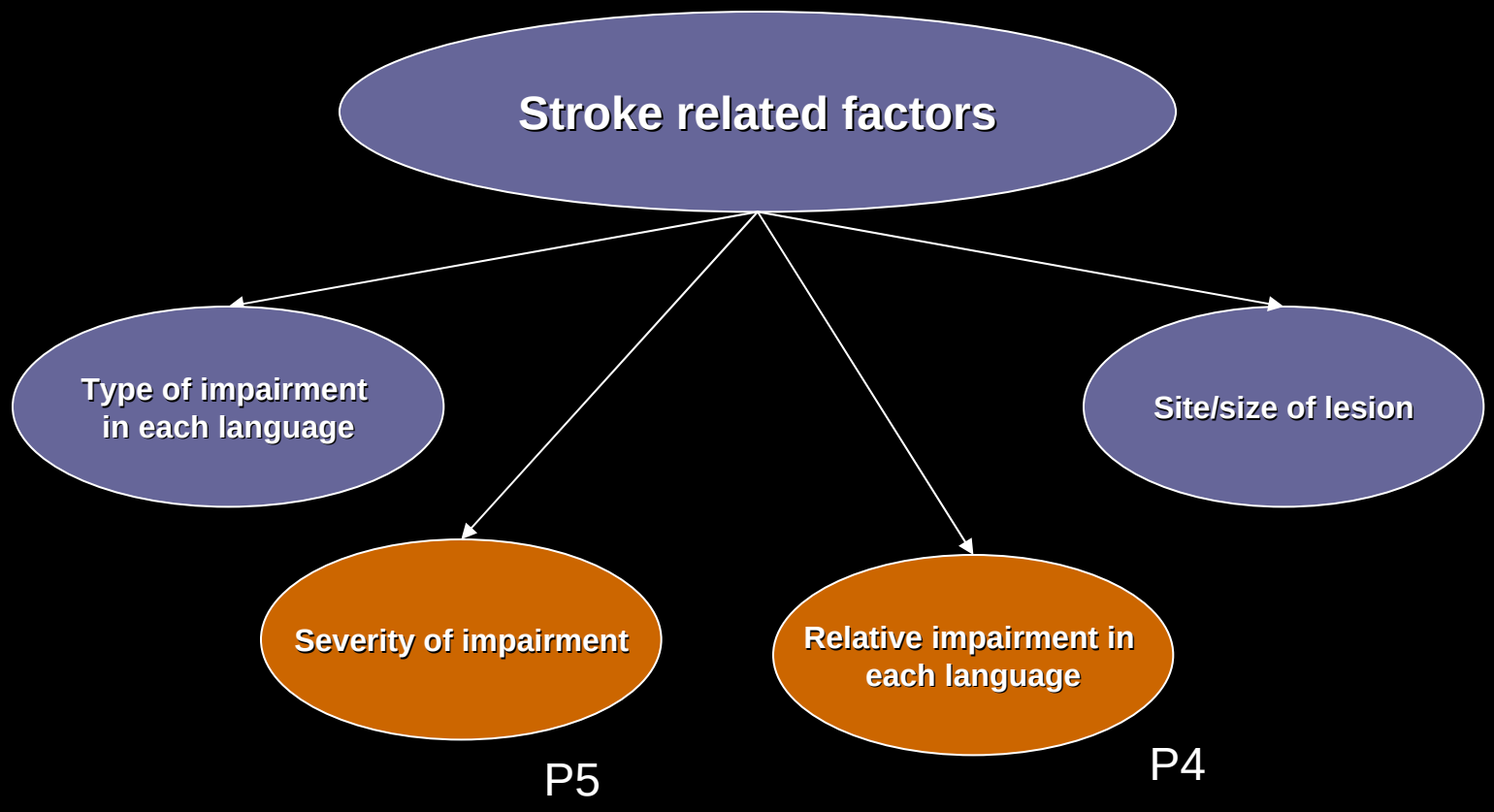
Kiran, S. & Roberts, P. (accepted)

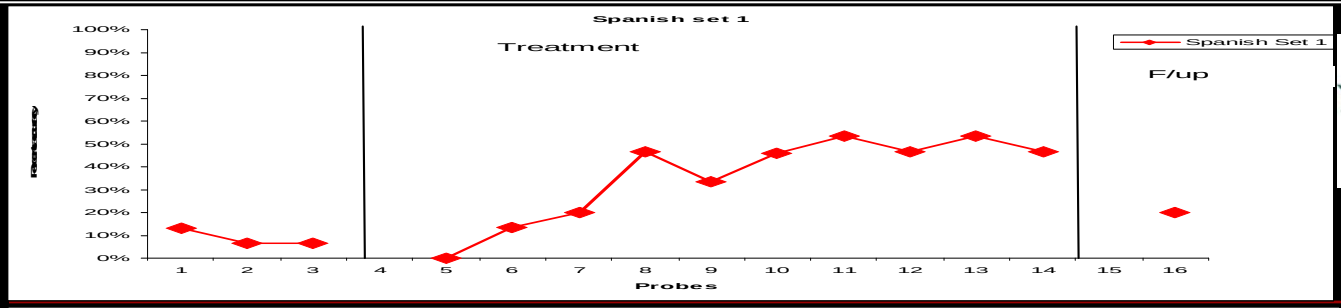
Pre treatment BNT scores

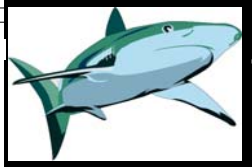
	Participant 4		Participant 5	
	English	Spanish	English	Spanish
Boston Naming Test (BNT) (N = 60)	34	6	**5**	3


Level of Bilingualism factors
Age of Acquisition
Current language proficiency
Education & Background
Self proficiency ratings
Language use

What are the factors that influence language recovery and rehabilitation?

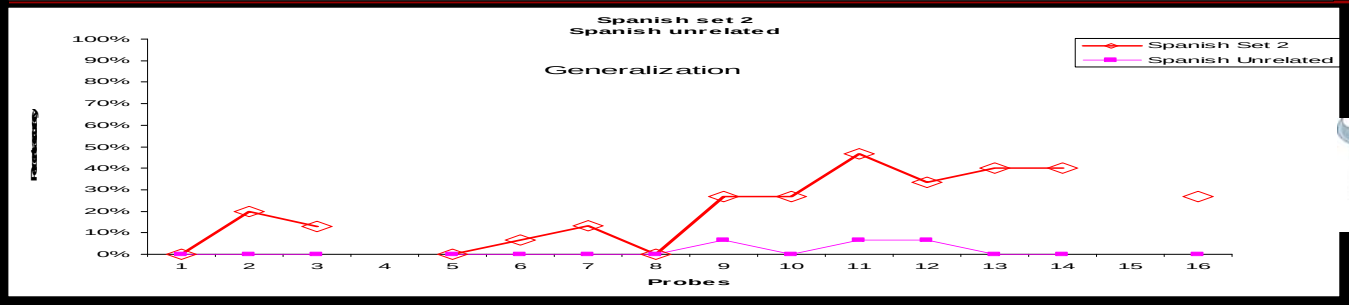






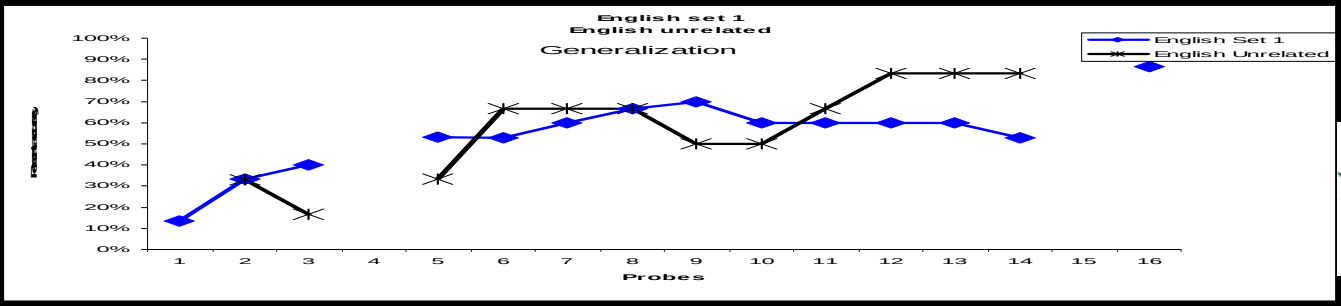
Tiburón

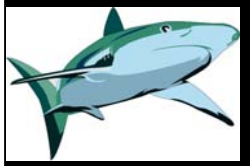
N=15



Ballena

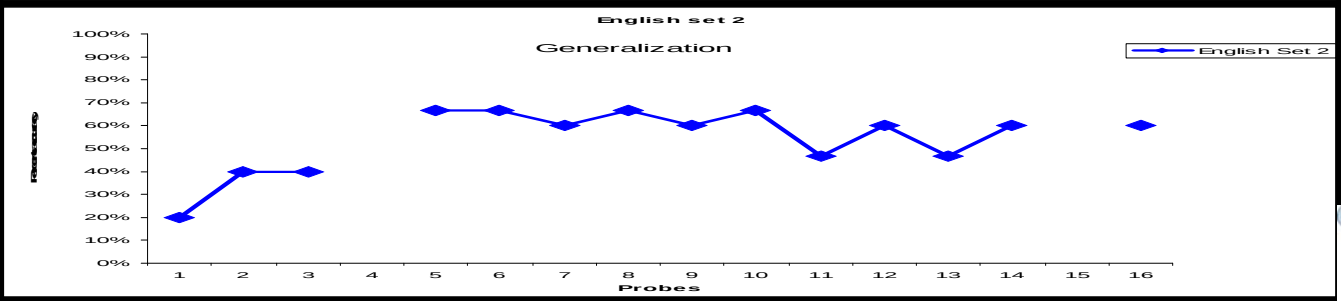
N=15

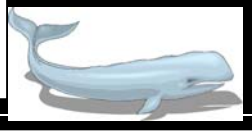




Shark

N=15





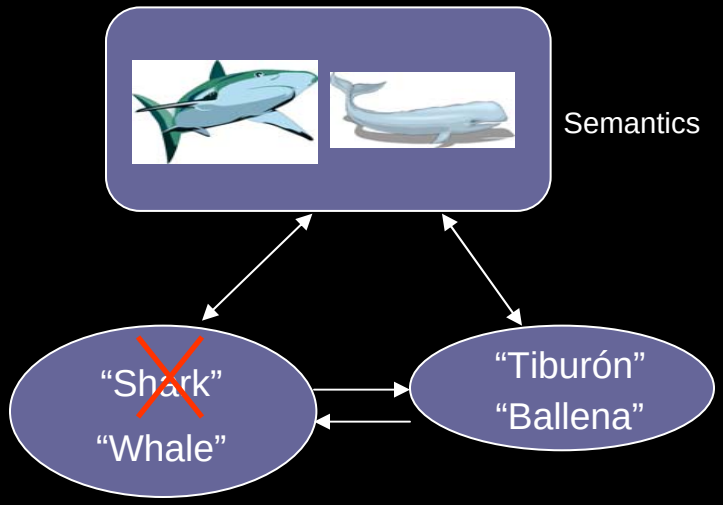
Whale

N=15

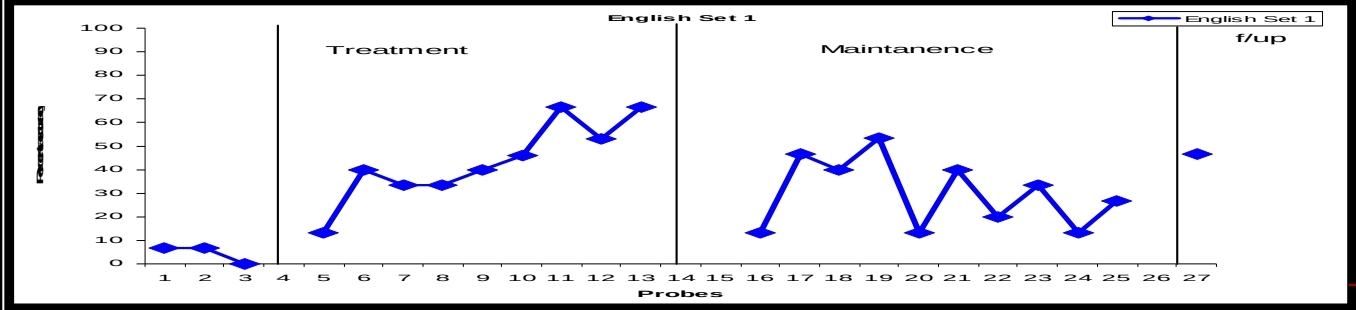
Kiran, S. & Roberts, P. (accepted)

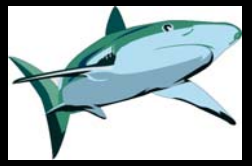
Results of P4

Spanish Treatment



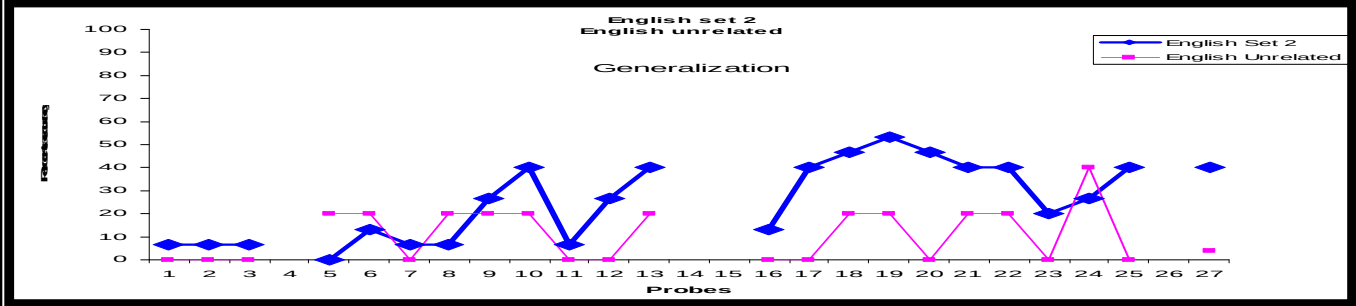
Kiran, S. & Roberts, P. (accepted)





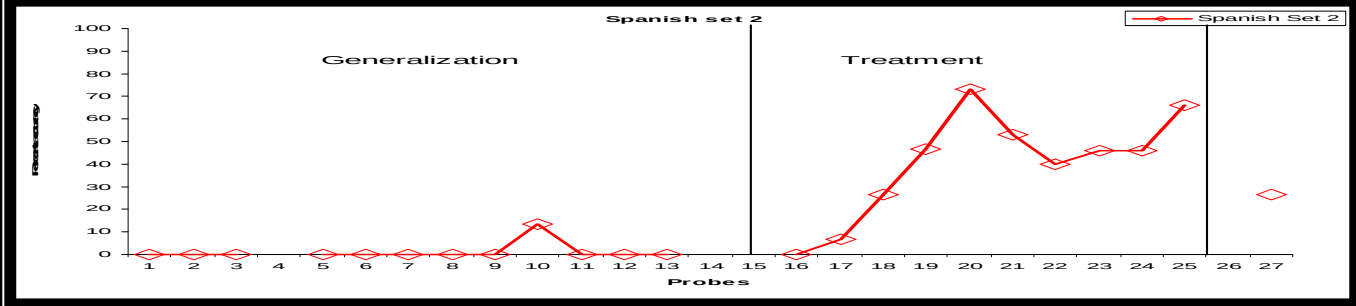
Shark

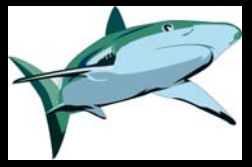
N=15



Whale

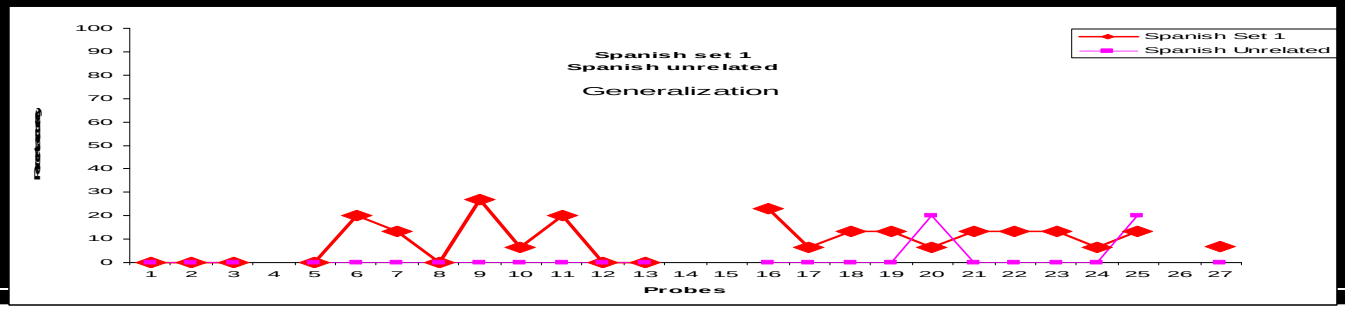
N=15

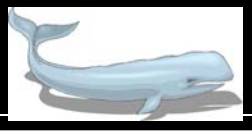




Tiburón

N=15





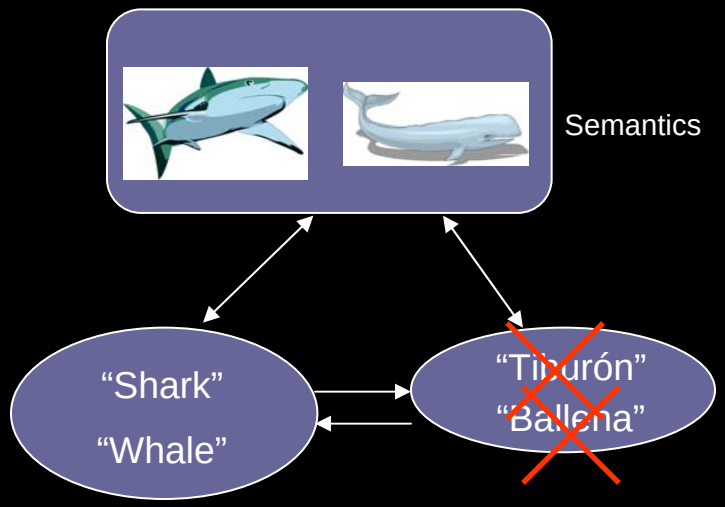
Ballena

N=15

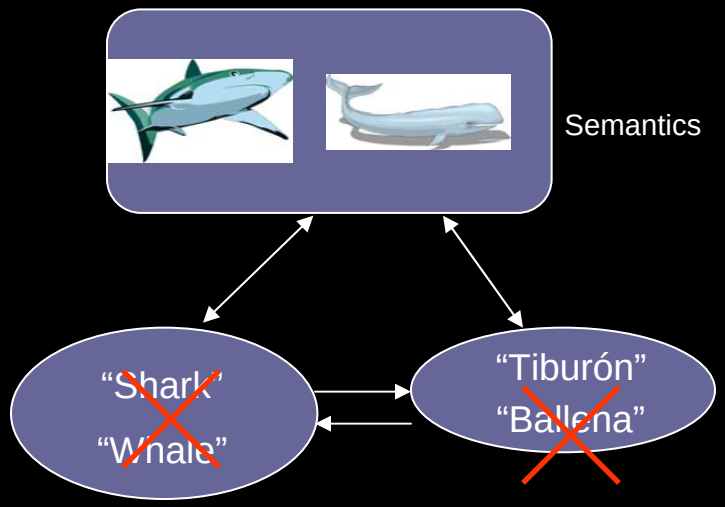
Kiran, S. & Roberts, P. (accepted)

Results of P5

English Treatment



Spanish Treatment



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

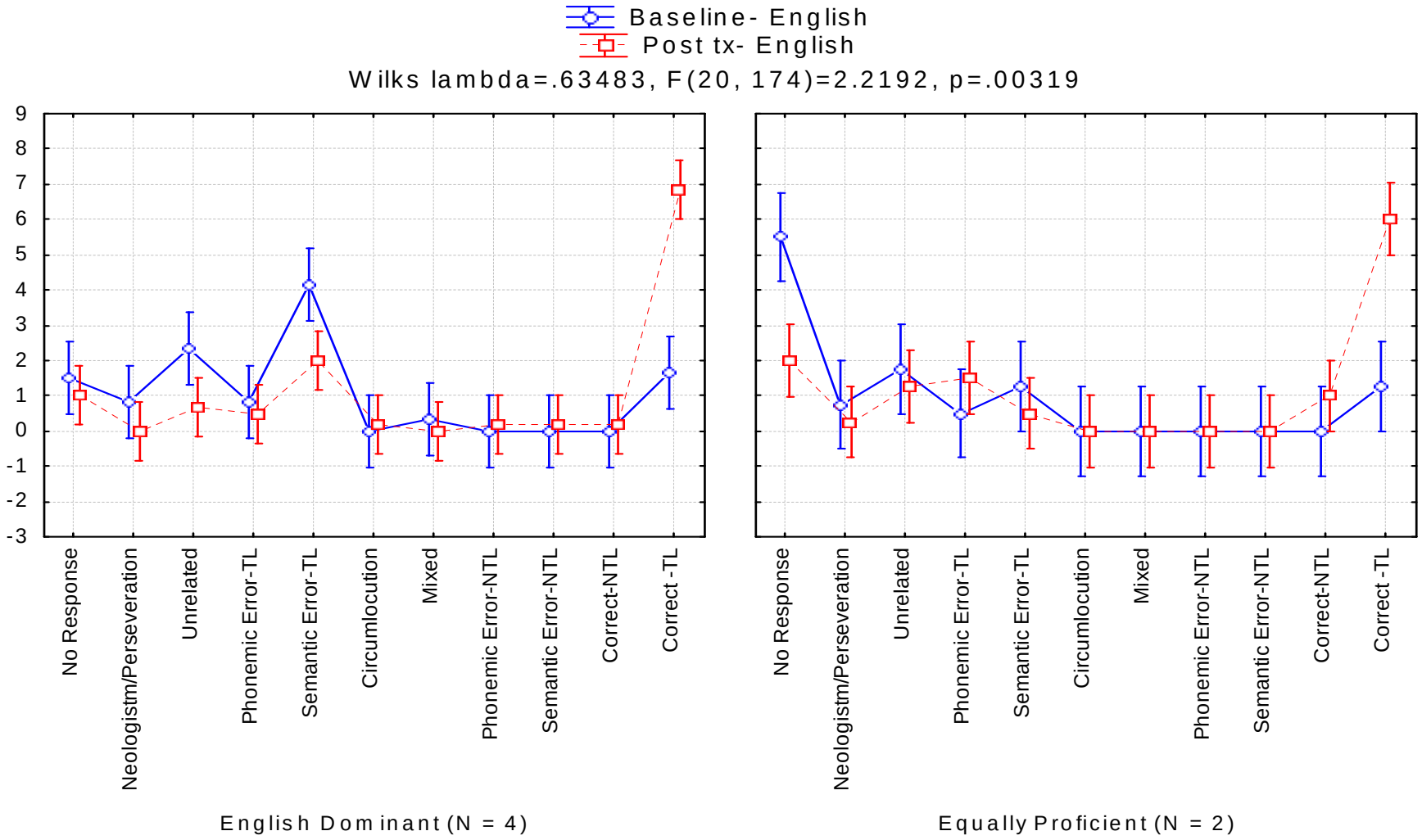
  - David Schnyer

- University of Florida
  - Lisa Edmonds

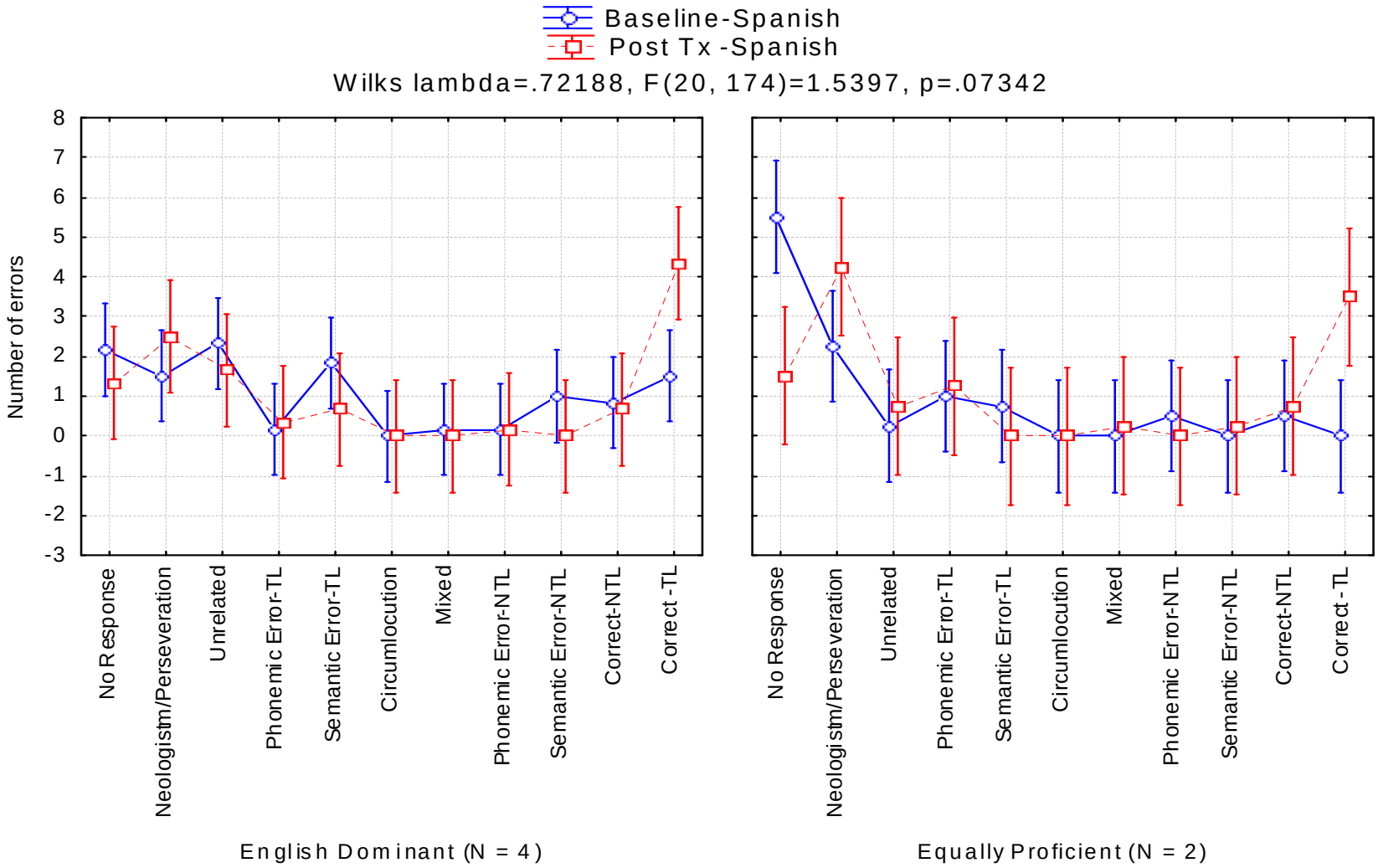
- UT- Southwestern
  - Mike Devous
- University of Ottawa
  - Patricia Roberts

- 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

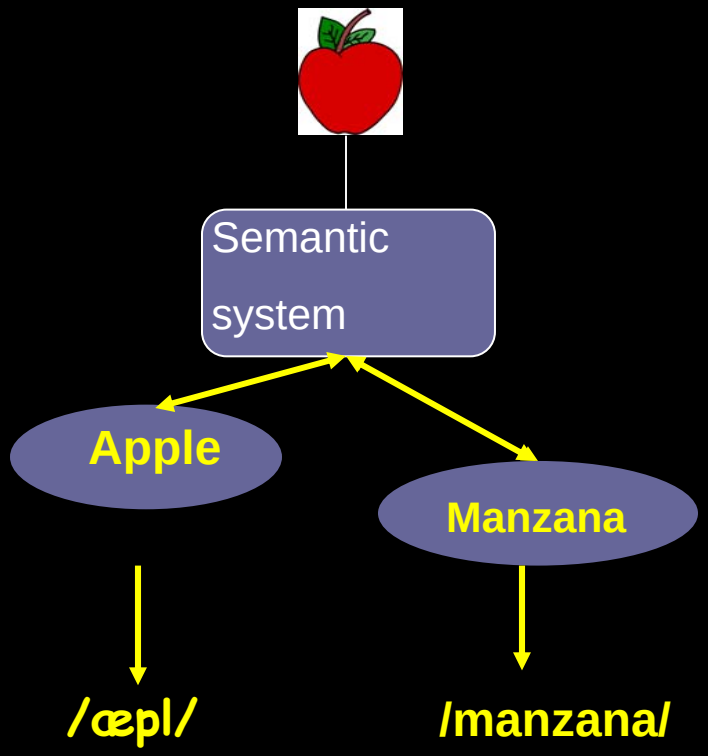
Pre post tx responses in English



Pre post tx responses in Spanish



Activating phonological representations



- 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
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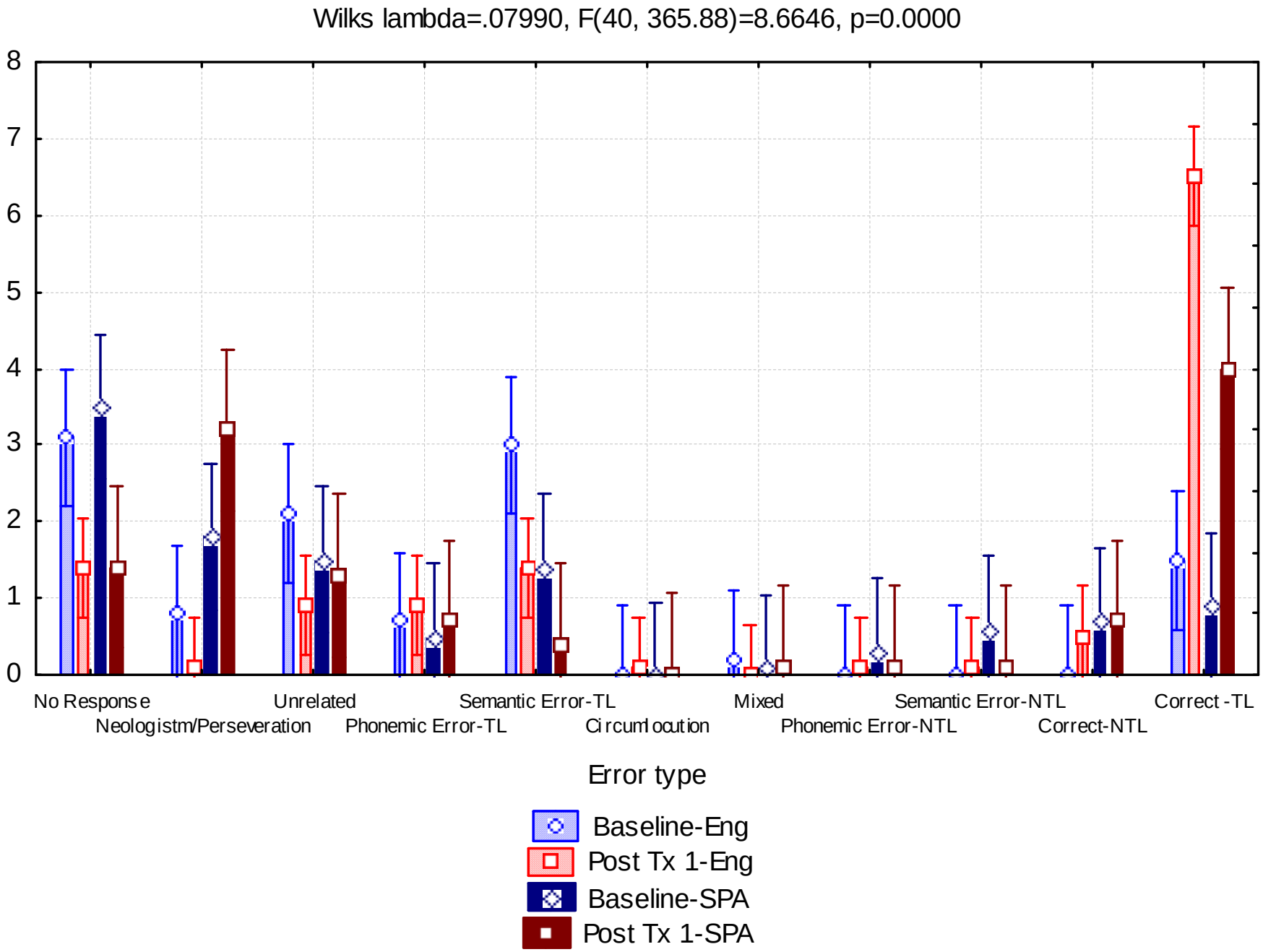
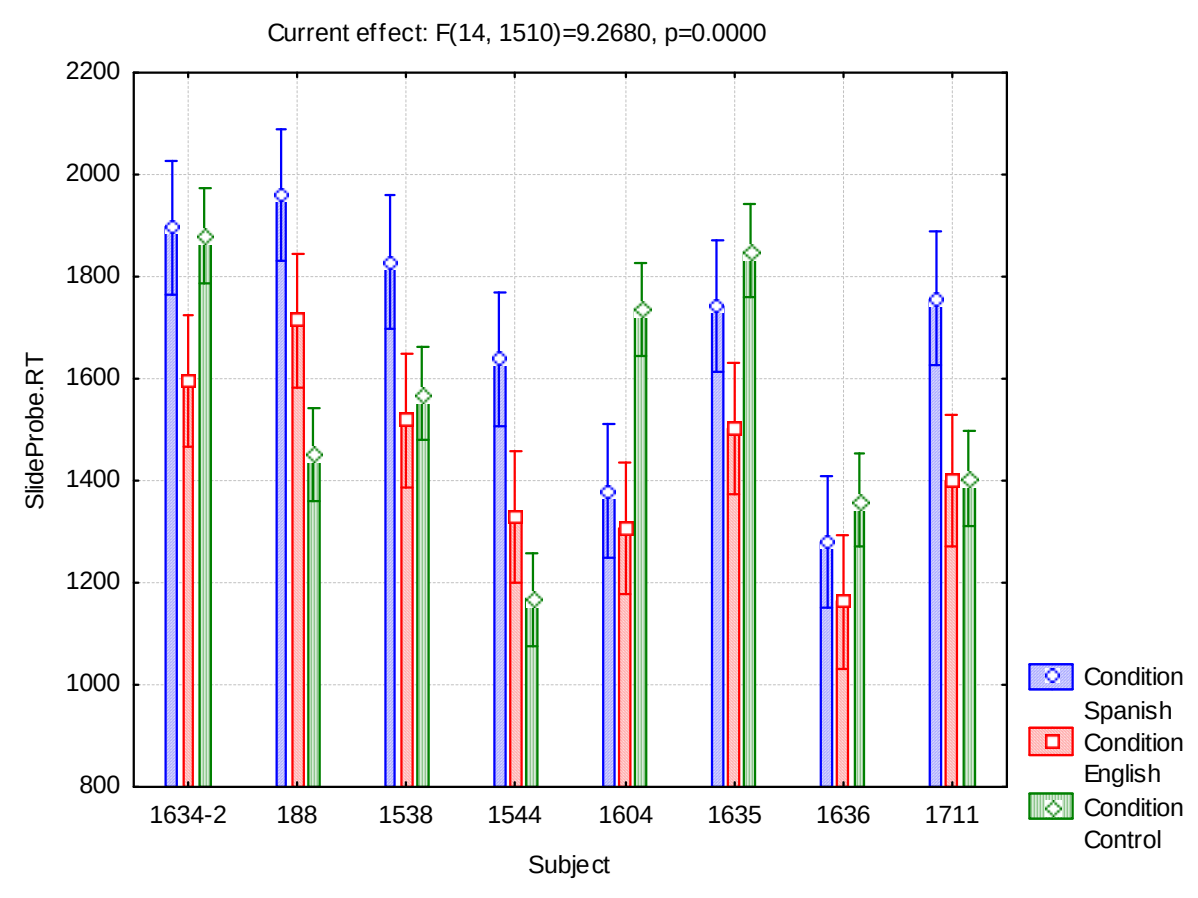
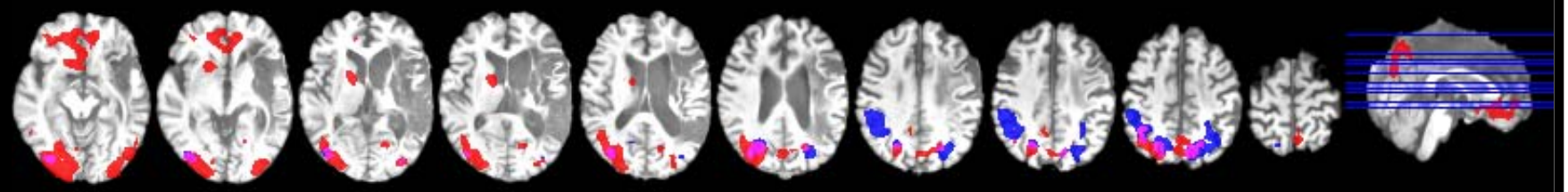

Wilks lambda=.07990, F(40, 365.88)=8.6646, p=0.0000
8
7
6
5
4
3
2
1
0
No Response
Neologistm/Perseveration
Unrelated
Phonemic Error-TL
Semantic Error-TL
Circumlocution
Mixed
Phonemic Error-NTL
Semantic Error-NTL
Correct-NTL
Correct -TL
Error type
Baseline-Eng
Post Tx 1-Eng
Baseline-SPA
Post Tx 1-SPA

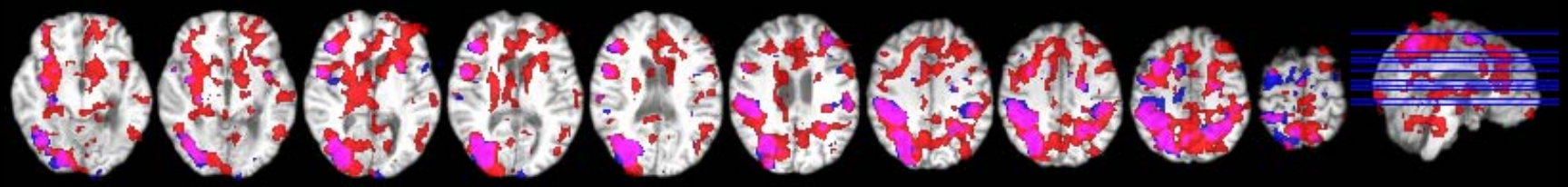
Subject x condition interaction in fMRI Spanish-English bilinguals

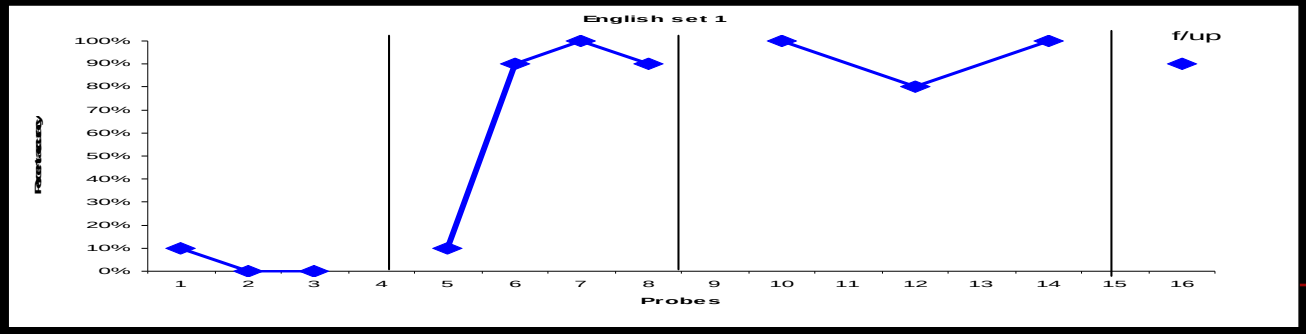


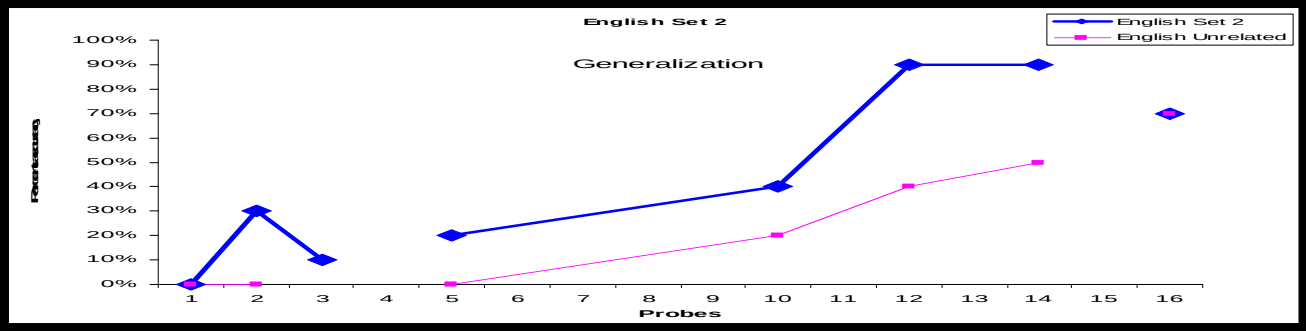
Size versus semantic comparison for P1



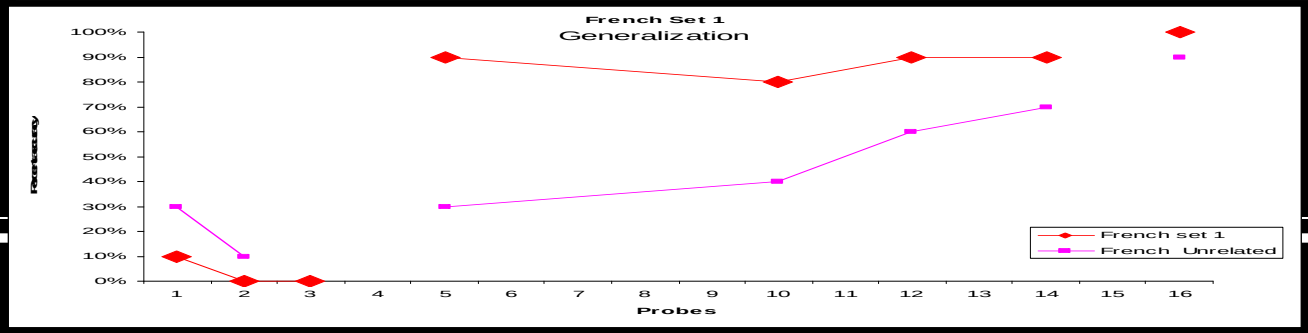
Size versus semantic comparison for P2




English set 1
f/up
Frequency
Probes


English Set 2
English Set 2
English Unrelated
Generalization
Frequency
Probes


French set 2
Treatment
Maintenance
Frequency
Probes


French Set 1
Generalization
French set 1
French Unrelated
Frequency
Probes

	Participant 1				Participant 2				Participant 3			
	English		Spanish		English		Spanish		English		Spanish	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Boston Naming Test (BNT)	41.7	48.3	40.0	55.0	**1.7**	**35.0**	0.0	1.67	**23.3**	**33.3**	**18.3**	**30.0**
Bilingual Aphasia Test (BAT)												
Pointing (%)	100	100	100	100	**50.0**	**100**	**30.0**	**60.0**	100	100	100	100
Semi-complex commands (%)	**80.0**	**100**	**60.0**	**100**	8.3	25.0	0.0	25.0	**50.0**	**100**	90.0	90.0
Verbal auditory discrimination (%)	83.3	83.3	**66.7**	**100**	61.1	72.2	50.0	50.0	83.0	89.0	94.0	89.0
Judgment of words/nonwords (%)	**56.7**	**90.0**	**66.7**	**100**	20.0	60.0	0.0	0.0	90.0	97.0	97.0	93.0
Naming (%)	60.0	66.7	93.3	100	**0.0**	**42.9**	0.0	DNT	88.0	95.0	74.0	79.0
Word Repetition (%)	93.3	96.7	96.7	96.7	76.7	73.3	66.7	DNT	57.0	77.0	57.0	77.0
Series (automatics) (%)	66.7	66.7	**66.7**	**100**	0.0	0.0	0.0	0.0	33.0	33.0	33.0	33.0
Semantic Categories (%)	100	80.0	**100**	**80.0**	**60.0**	**80.0**	100	60.0	**100**	**60.0**	**80.0**	**60.0**
Semantic opposites (%)	**20.0**	**40.0**	**10.0**	**50.0**	**0.0**	**70.0**	10.0	10.0	30.0	20.0	30.0	10.0
Semantic Acceptability (%)	100	100	90.0	100	70.0	60.0	50.0	40.0	90.0	100	**80.0**	**100**
Synonyms (%)	80.0	80.0	**60.0**	**80.0**	**20.0**	**100**	20.0	0.0	20.0	0.0	**40.0**	**60.0**
Antonyms I (%)	80.0	80.0	**100**	**60.0**	**20.0**	**60.0**	**0.0**	**40.0**	**40.0**	**60.0**	40.0	40.0
Antonyms II (%)	**60.0**	**100**	80.0	80.0	**20.0**	**40.0**	**60.0**	**0.0**	**40.0**	**0.0**	**80.0**	**40.0**
Reading words (%)	80.0	70.0	90.0	100	0.0	0.0	0.0	0.0	90.0	90.0	0.0	10.0
Reading sentences (%)	**20.0**	**50.0**	**40.0**	**70.0**	0.0	16.7	0.0	DNT	0.0	0.0	0.0	0.0
Bilingual Aphasia Test – Part C												
Recognition of words (Spanish to English) (%)	100	100	n/a	n/a	**20.0**	**100**	n/a	n/a	100	100	n/a	n/a
Recognition of words (English to Spanish) (%)	100	100	n/a	n/a	n/a	10.0	n/a	n/a	100	80	n/a	n/a
Translation of words (Spanish to English) (%)	50.0	60.0	n/a	n/a	0.0	0.0	n/a	n/a	**10.0**	**40.0**	n/a	n/a
Translation of words (English to Spanish) (%)	60.0	60.0	n/a	n/a	0.0	0.0	n/a	n/a	**20.0**	**50.0**	n/a	n/a

	P1					P2			
	PRE-TX		POST-TX			PRE-TX		POST-TX	
	E	S	E	S		E	S	E	S
Task	%	%	%	%		%	%	%	%
Semicomplex commands (10 points)	90	70	100	60		50	60	3	600
Complex commands (20 points)	100	55	55	60		15	5	2	55
Semantic Categories (5 points)	80	40	80	80		20	0	6	400
Synonyms (5 points)	100	80	100	60		20	0	0	0
Antonyms I (5 points)	100	60	100	40		20	0	2	00
Antonyms II (5 points)	40	40	40	40		40	40	2	400
Grammaticality judgment (10 points)	50	70	70	50		50	60	5	400
Semantic Acceptability (10 points)	40	30	100	80		40	50	8	600
Repetition (30 points)	77	67	77	87		13	37	3	377
Judgment of words/nonwords (30 points)	90	73	97	90		70	60	6	737
Series (automatics) (3 points)	33	NA	0	0		0	0	3	673
Naming (19 points)	100	26	100	32		25	25	5	250
Semantic opposites (10 points)	40	NA	30	10		0	0	6	100
Reading words (10 points)	90	80	100	80		90	40	1	1000

Schematic of treatment for each participant

Pre –treatment assessment:

Western Aphasia Battery, BNT, Bilingual Aphasia Test

No feedback provided

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

Session 2: Testing & Training

Week 1

Week 2

Week 3

Week 4

No feedback provided regarding accuracy

Session 1: Training

Session 2: Testing & Training

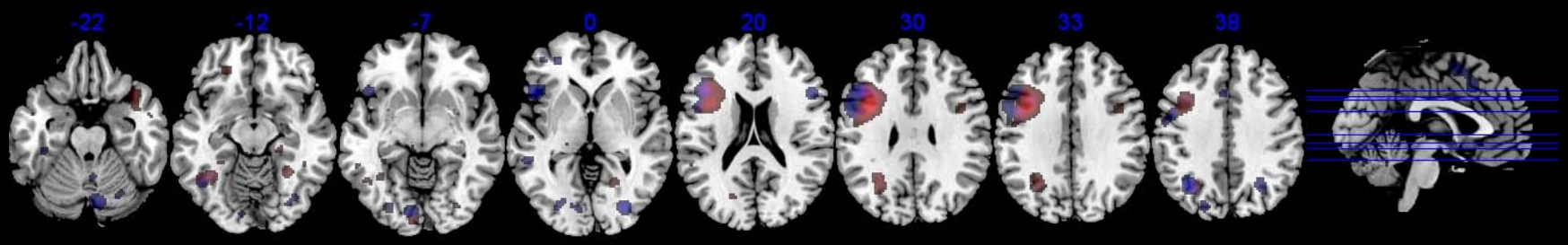
Until 80% accuracy achieved on items trained

Post –treatment assessment:

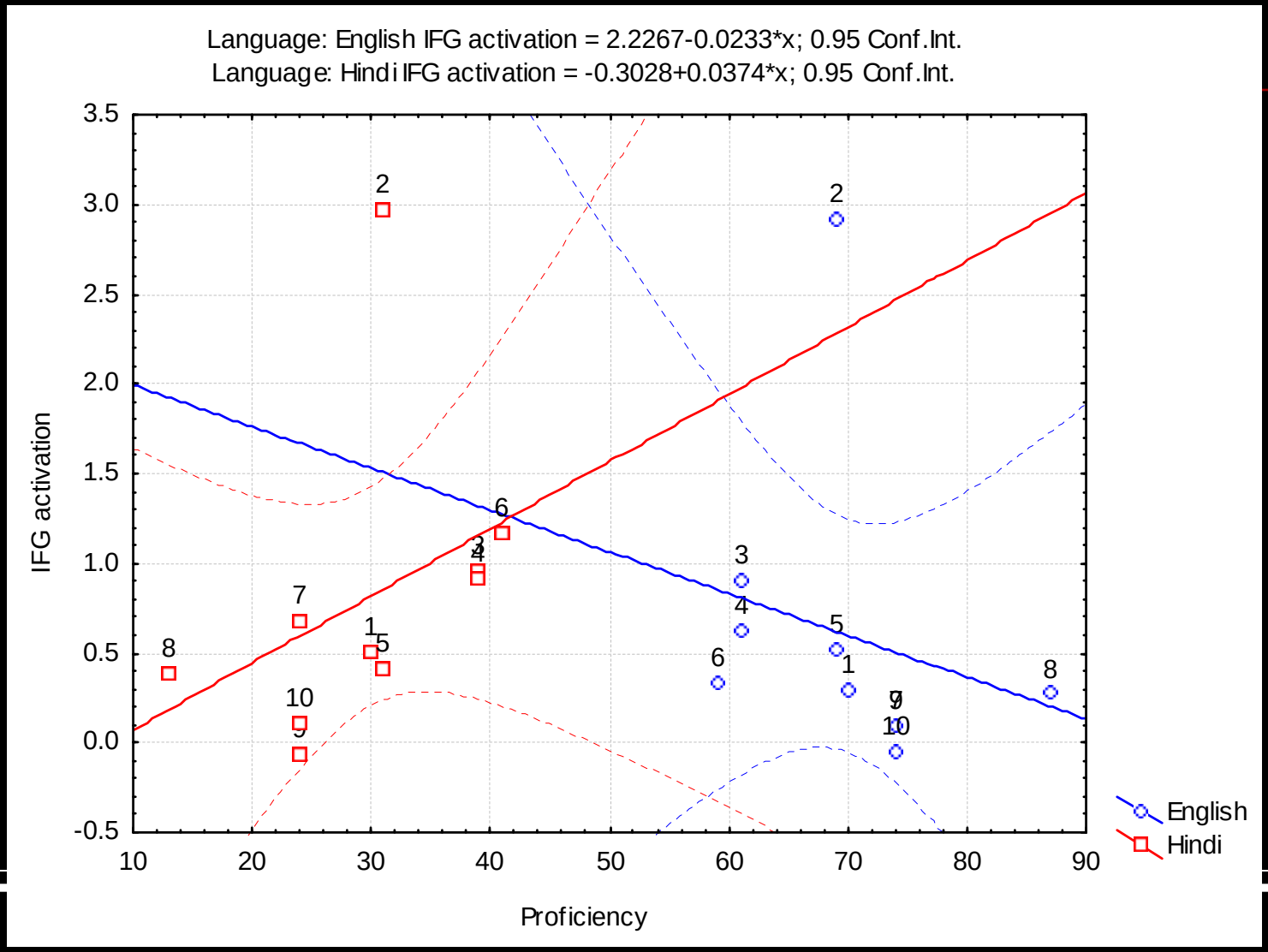
Standardized language tests

Edmonds & Kiran, (2006) *JSLHR*

Author	Languages	Proficiency	L2 acquisition	Task	Baseline
Chee et al., 2001	L1=English L2=Mandarin L1=Mandarin L2=English	High High	Early bilinguals Late bilinguals	Semantic Judgment	Size judgment
Ding et al., 2003	L1=Chinese L2=English	High	Late bilinguals	Semantic and orthographic Judgment	Asterix viewing
Luke et al., 2006	L1=Mandarin L2=English	Moderate	Late bilinguals	Syntactic and semantic judgment	Font size judgment
Perani et al., 1996	L1=Italian; L2=English	LowS	Late bilinguals	Listening to stories	Backward Japanese/infrequent vowel sounds
Perani et al., 1998	L1=Italian L2=English L1=Spanish L2=Catalan	High	I= Late bilinguals II=Early bilinguals	Listening to stories	Backward Japanese/infrequent vowel sounds
Shu et al., 2007	L1=Korean L2=English	Moderate	Late bilinguals	Sentence comprehension	Rest
Tham et al., 2005	L1=Mandarin L2=English	High	Early bilinguals	Homophone matching	Non Homophone matching
Yokoyama et al., 2006	L1=Japanese L2=English	Moderate	Late bilinguals	Sentence comprehension	Rest
Chee et al., 1999	L1=Mandarin L2=English	I=High II=High	Group I=Early Group II=Late	Word generation	Fixation
De Bleser et al., 2003	L1=Dutch L2=French	High	Late bilinguals	Word Naming	Fixation
Golestani et al., 2006	L1=French L2=English	Moderate	Late bilinguals	Sentence generation	Silence
Klein et al., 1995	L1=English L2=French	High	Late bilinguals	Synonym/rhyme generation	Word repetition
Klein et al., 1999	L1=MandarinL2=English	High	Late bilinguals	Noun/verb generation	Word repetition
Meschyan & Hernandez et al., 2006	L1=Spanish, L2=English	High	Early bilinguals	Word naming	Rest



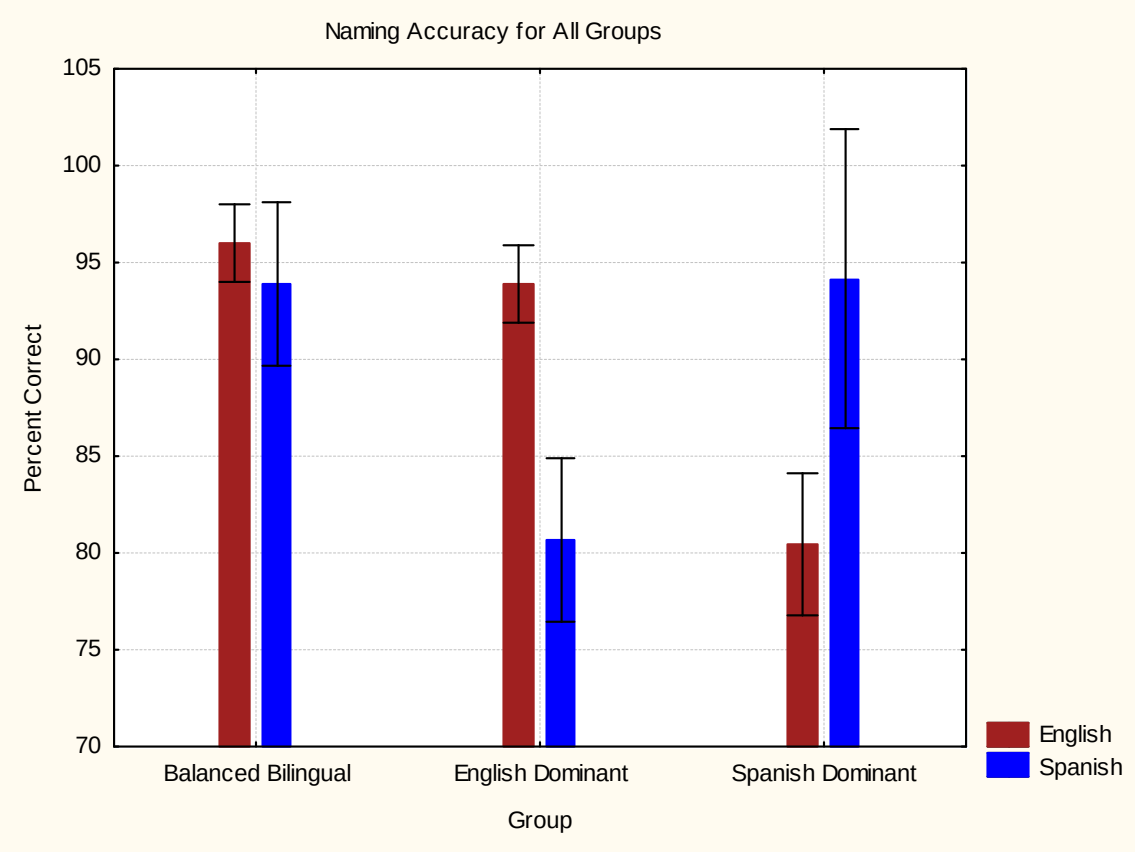
- Results of the ALE subtraction meta-analysis between high and low proficiency studies. The analysis demonstrated a primarily left-lateralized network, with activation seen in frontal region and temporal regions.


Language: English IFG activation = 2.2267-0.0233*x; 0.95 Conf.Int.
Language: Hindi IFG activation = -0.3028+0.0374*x; 0.95 Conf.Int.
IFG activation
Proficiency
English
Hindi

Picture naming in English and Spanish

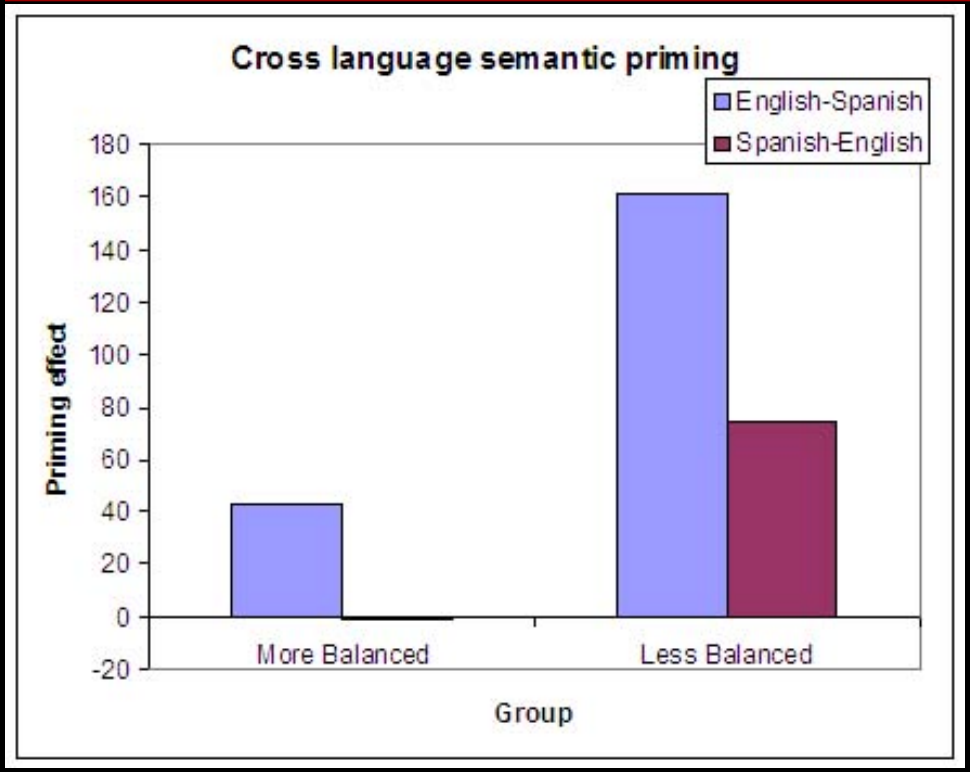
N = 23

	AoA	Speak	Comp
Eng	3.26	6.65	6.74
Spa	0.65	6.56	6.83



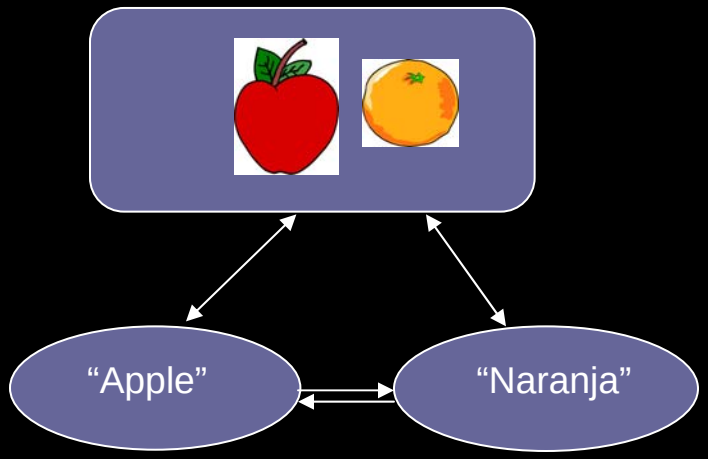
Edmonds & Kiran, (2004) *Aphasiology*

Cross language priming



N = 24

	AoA
Eng	3.0
Spa	0



Kiran & Lebel, (2007) *Clinical Linguistics and Phonetics*