Linguistic characteristics affect literacy acquisition and verbal short-term memory of Chinese characters

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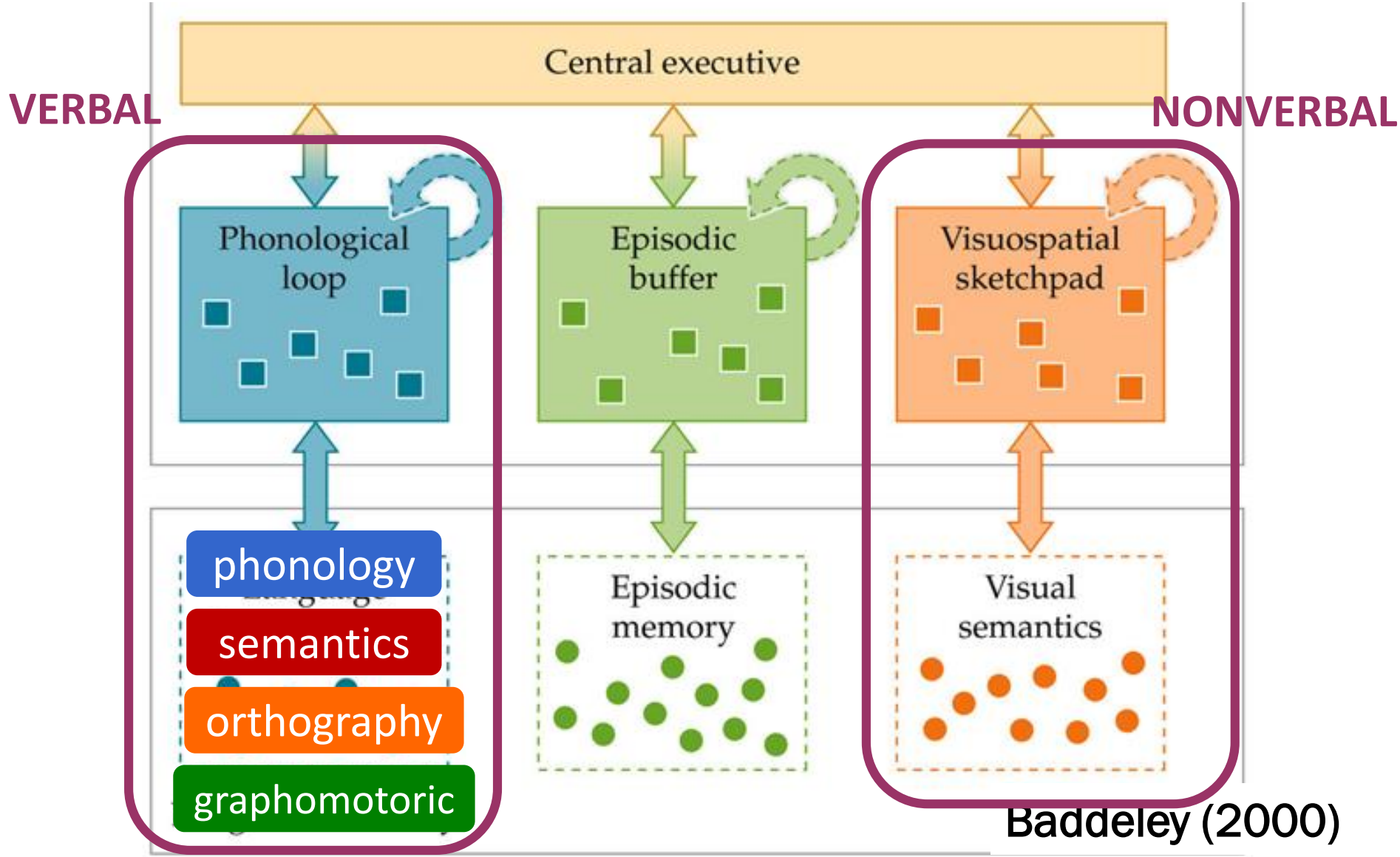
TAIWAN

A Model of STM



Baddeley (2000)

Findings of Alphabetic Languages

- ***phonological similarity effect*** (Conrad, 1964)

wart taut caught **<** rough dough cough **=** full pea sigh

  - *word length effect* (Conrad, 1968)

  - *articulatory suppression* (Baddeley & Hitch, 1974)

- Contribution from **word forms** to verbal STM

fry cry dry **<** guy sigh pie

Kk Cc Zz **<** Dd Hh Rr

(Logie et al., 2000)

Dissociable Verbal and Non-verbal STM

Verbal STM

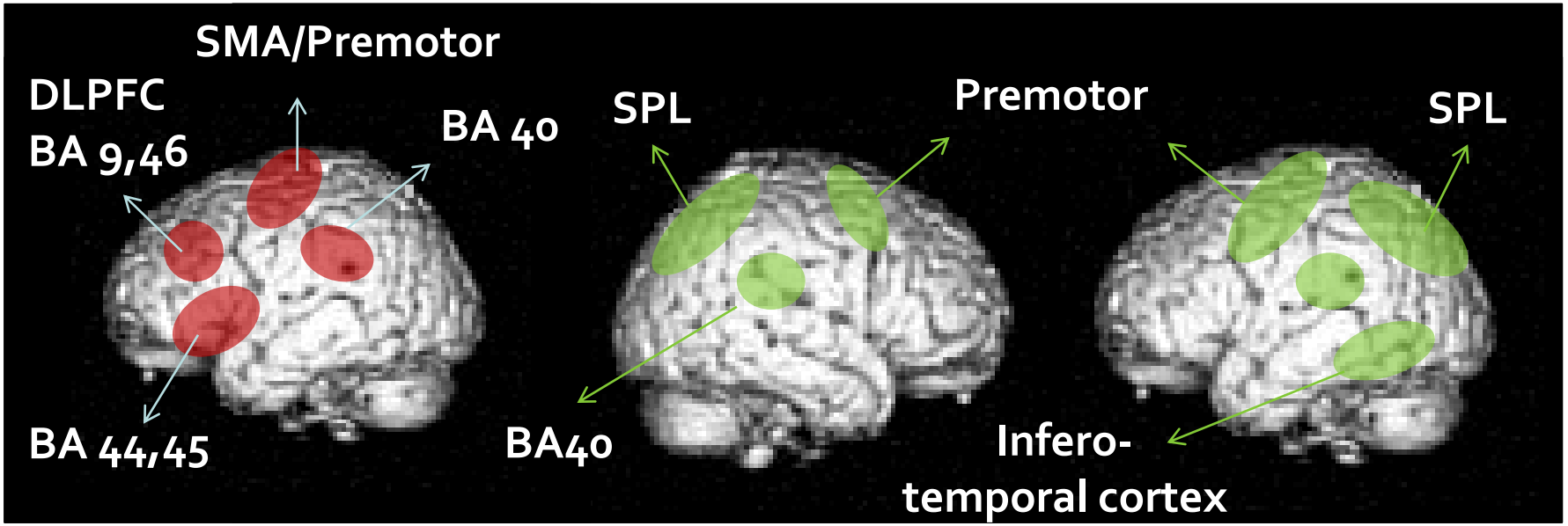
→ **left-lateralized**

(Fiez et al., 1996; Smith et al., 1995)

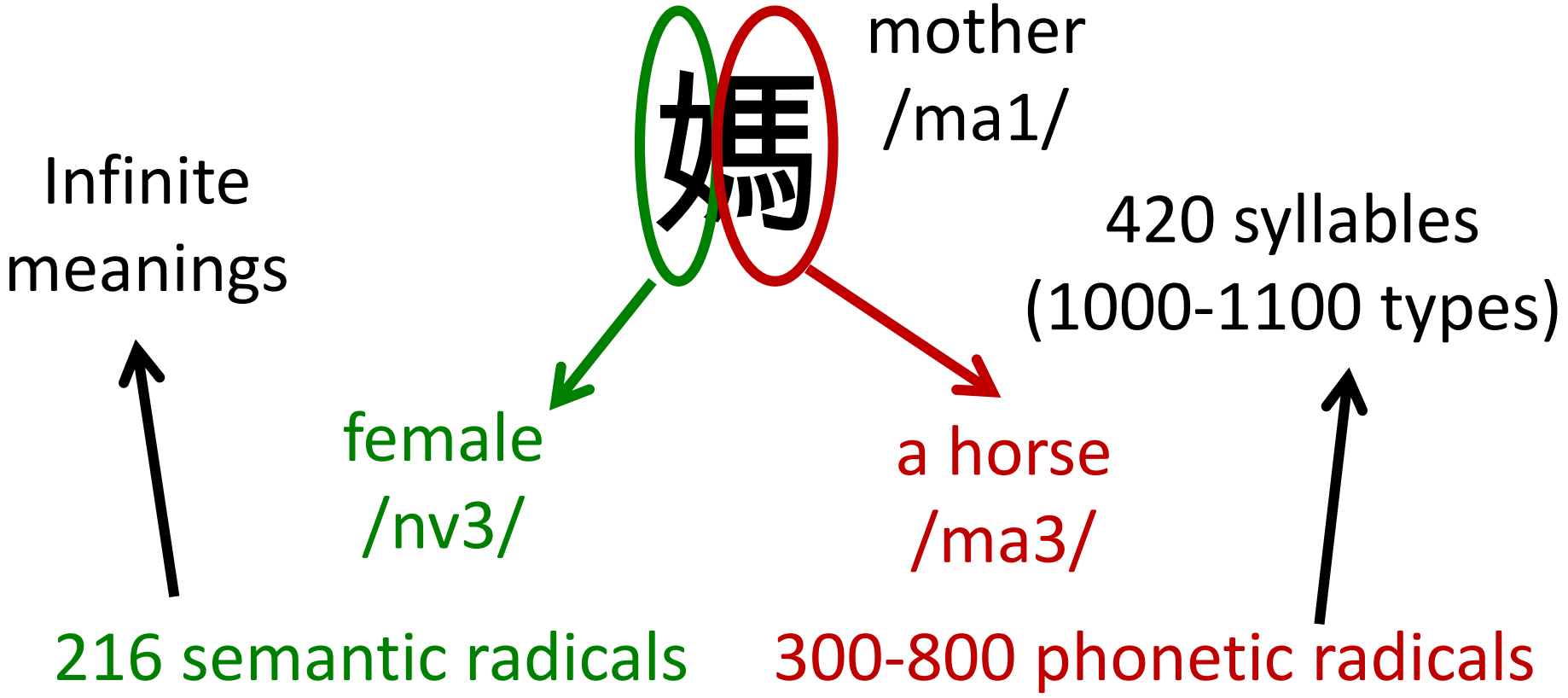
Visuo-spatial STM

→ **Right-lateralized or bilateral**

(Awh et al., 1996; Smith et al., 1995; Smith et al., 1998)



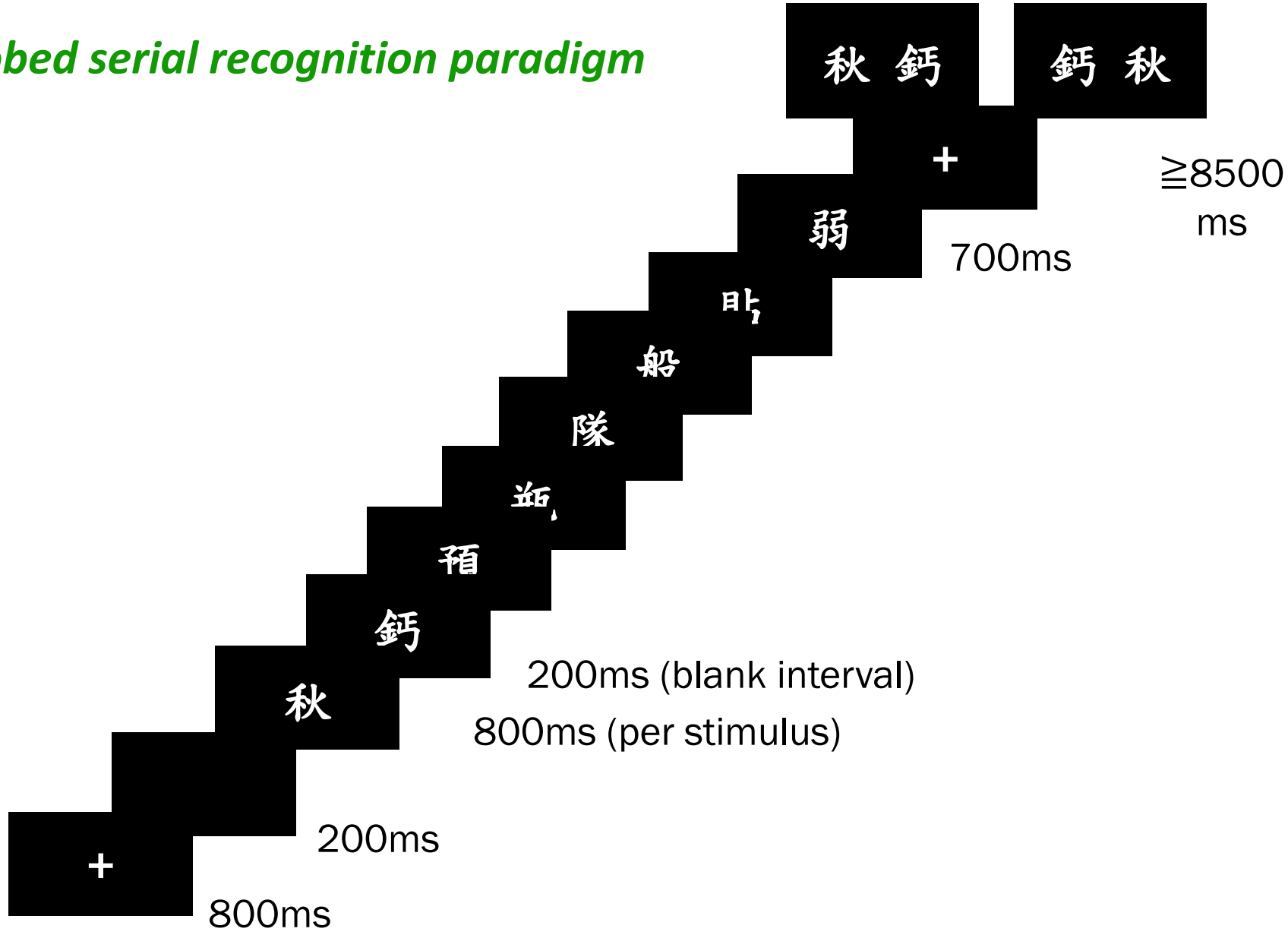
- But there are many homophones in Chinese
- The majority (~80%) of Chinese characters are semantic-phonetic compounds (phonograms)
- Chinese readers are sensitive to the sub-lexical phonological information

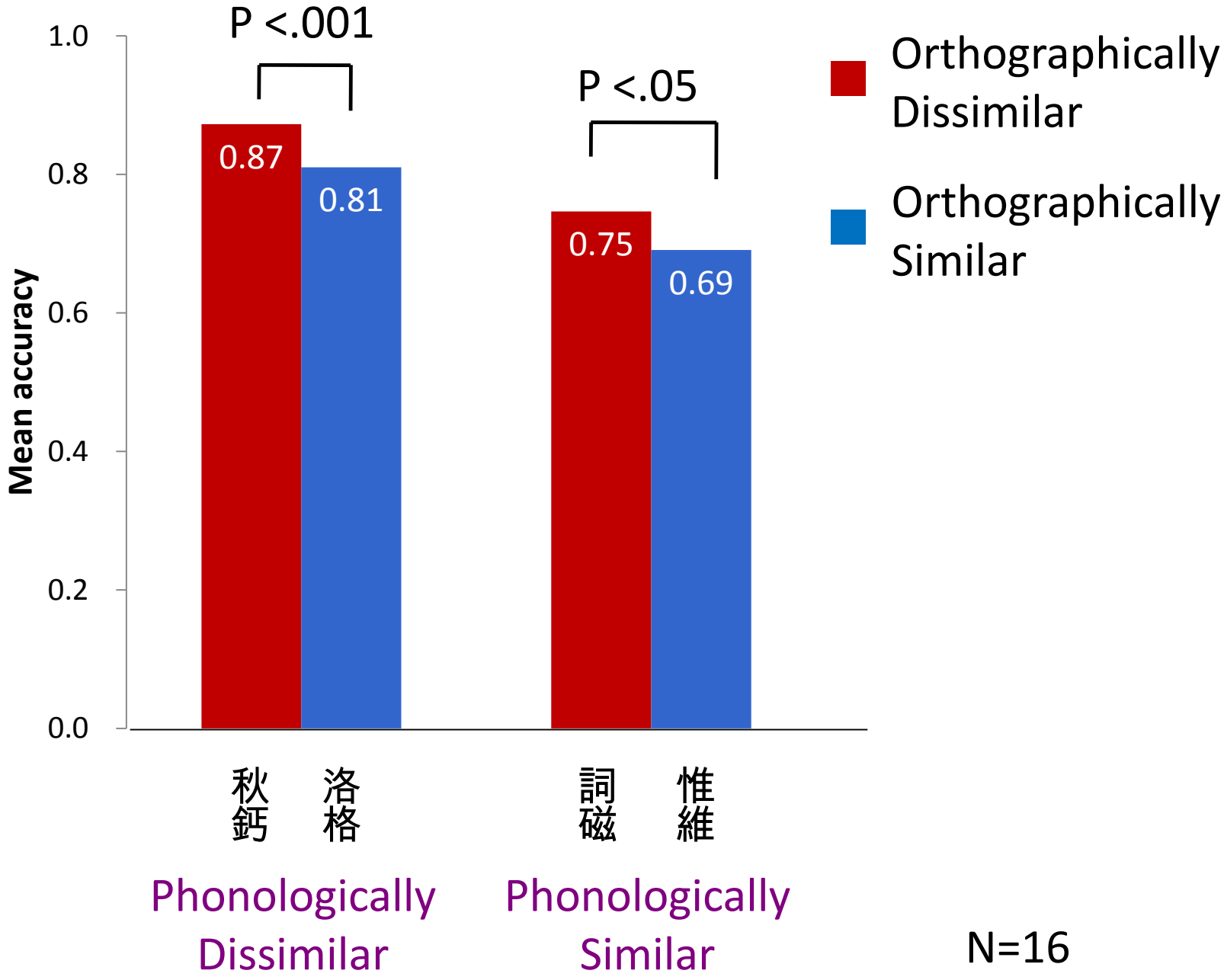


Orthographic Similarity Effect

	Phonologically dissimilar (PD)				Phonologically similar (PS)			
OD	秋 *chiou1*	鈣 *gai4*	預 *yu4*	瓶 *ping2*	詞 *tszi2*	磁 *tszi2*	韌 *ren4*	任 *ren4*
	隊 *duei4*	般 *ban1*	貼 *tie1*	弱 *ruo4*	租 *tzu1*	豬 *tzhu1*	殿 *dian4*	建 *jian4*
OS	洛 *luo4*	格 *ge2*	海 *hai3*	梅 *mei2*	惟 *wei2*	維 *wei2*	惘 *wang3*	網 *wang3*
	愧 *kuei4*	槐 *huai2*	泊 *bo2*	怕 *pa4*	校 *shiau4*	絞 *jiau3*	枕 *jen3*	忱 *chen2*

Probed serial recognition paradigm

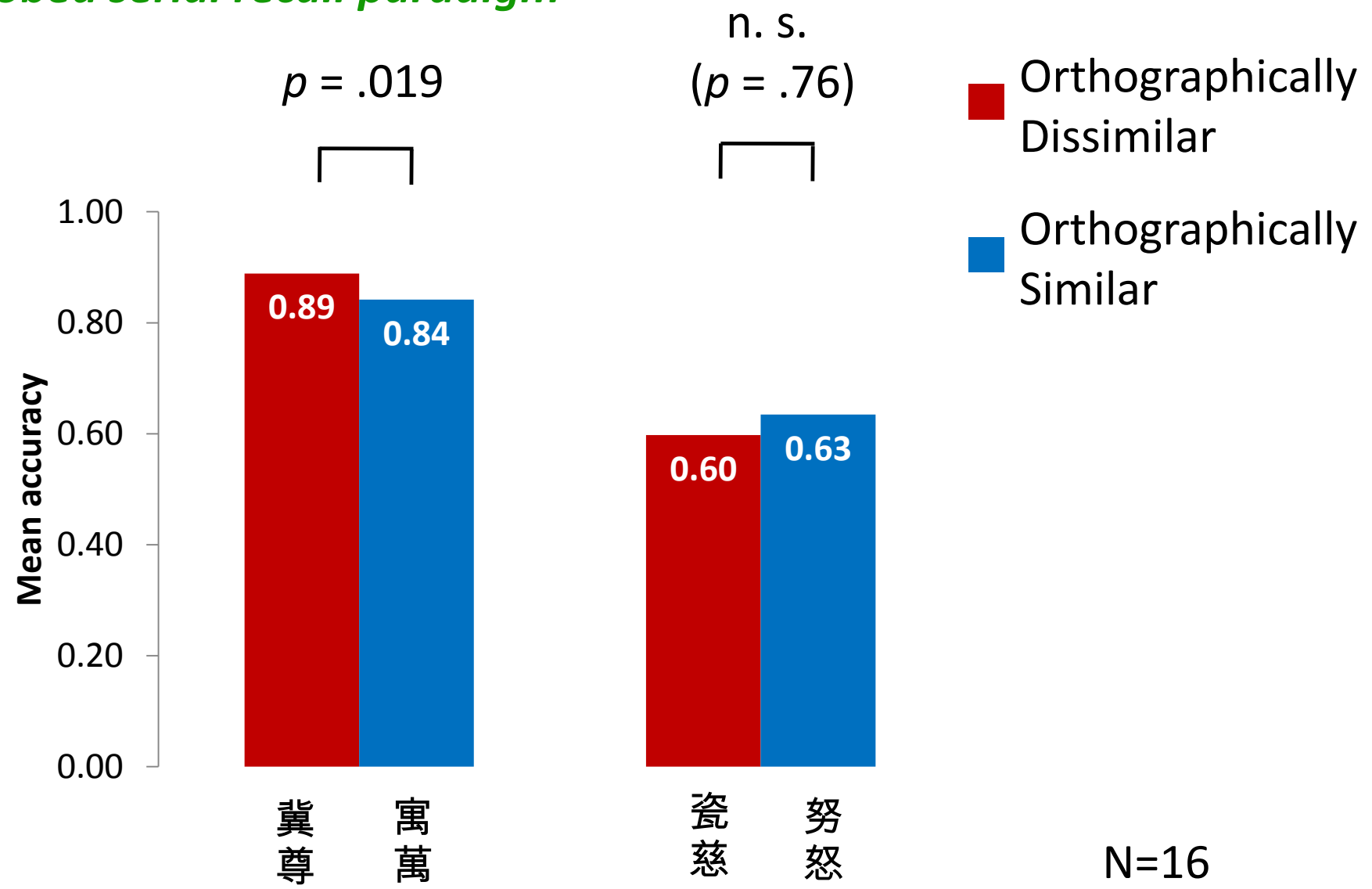



P <.001
P <.05
1.0
0.8
0.6
0.4
0.2
0.0
Mean accuracy
0.87
0.81
0.75
0.69
Orthographically Dissimilar
Orthographically Similar
秋 洛
鈣 格
詞 惟
磁 維
Phonologically Dissimilar
Phonologically Similar
N=16

OSE in Vertical Characters?

	Phonologically dissimilar				Phonologically similar			
OD	筒 *tong3*	尊 *zun1*	暈 *yun1*	冀 *ji4*	勢 *shi4*	誓 *shi4*	鶯 *ying1*	膺 *ying1*
	察 *cha2*	興 *xing1*	辜 *gu1*	紫 *zi3*	愚 *yu2*	輿 *yu2*	瓷 *ci2*	慈 *ci2*
OS	墊 *dian4*	摯 *zhi4*	萬 *wan4*	寓 *yu4*	努 *nu3*	怒 *nu4*	籃 *lan2*	藍 *lan2*
	疊 *die2*	壘 *lei3*	豎 *shu4*	登 *deng1*	翠 *cui4*	萃 *cui4*	幕 *mu4*	慕 *mu4*

Probed serial recall paradigm



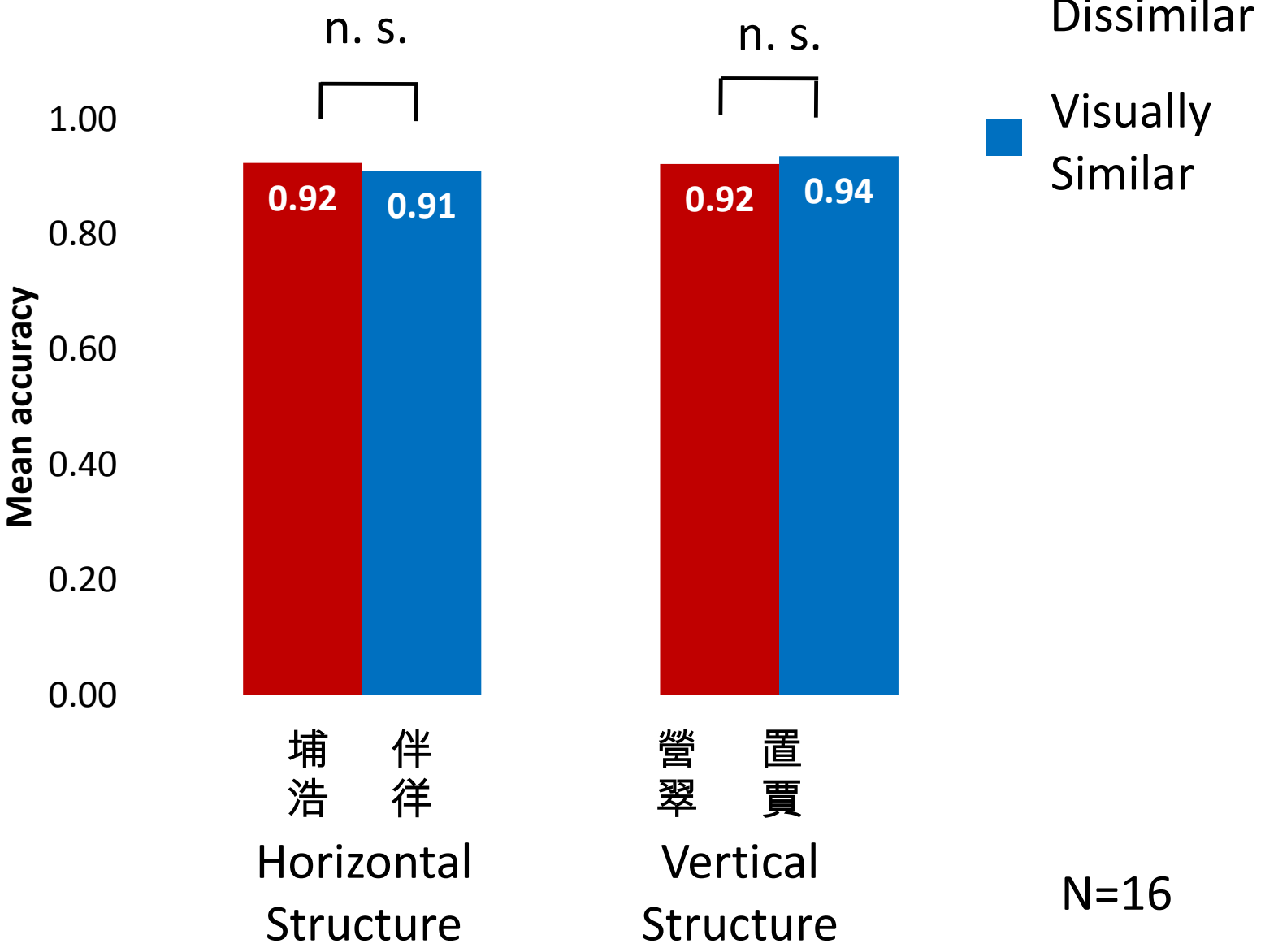
N=16

Visual Similarity Effect?

	Horizontal				Vertical			
VD	陌	缸	浩	埔	營	岳	翠	宵
	mo4	*gang1*	*hau4*	*pu3*	*ying2*	*yue4*	*tsuei4*	*shiau1*
	舒	絃	訝	稅	富	晃	亮	姿
	shu1	*shian2*	*ya4*	*shuei4*	*fu4*	*huang4*	*liang4*	*tzi1*
	Rating score: 1.75				**Rating score: 2.13**			
VS	伴	徉	凋	洞	笑	芙	查	香
	ban4	*yang2*	*diau1*	*dung4*	*shiau4*	*fu2*	*cha2*	*shiang1*
	暢	惕	項	填	賈	置	育	盲
	chang4	*ti4*	*shiang4*	*tian2*	*jia3*	*jri4*	*yu4*	*mang2*
	Rating score: 3.38				**Rating score: 3.25**			

5-points rating (1: most dissimilar, 5: most similar)

Probed serial recall paradigm



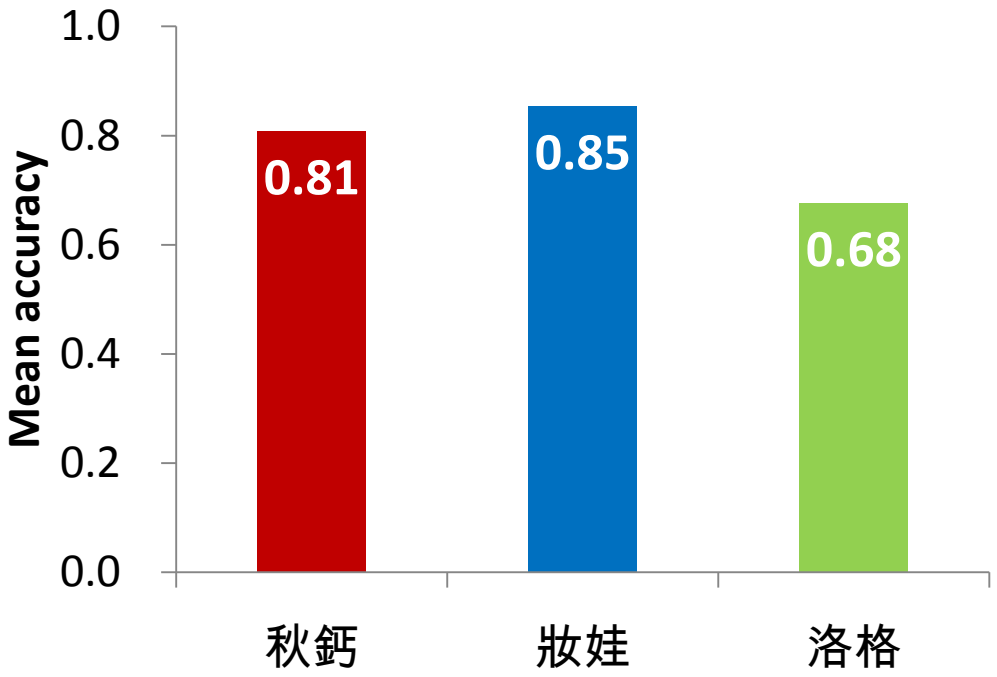
N=16

RDPD	秋 *chiou1*	鈣 *gai4*	預 *yu4*	瓶 *ping2*	隊 *duei4*	般 *ban1*	貼 *tie1*	弱 *ruo4*
RSPD	妝 *juang1*	娃 *wa2*	酒 *jiou3*	配 *pei4*	除 *chu2*	斜 *shie2*	綠 *liu4*	剝 *bo1*
RSPS	洛 *Luo4*	格 *ge2*	海 *hai3*	梅 *mei2*	愧 *kuei4*	槐 *huai2*	泊 *bo2*	怕 *pa4*

1.96	2.08
2.12	2.30
3.35	3.82

Chinese readers Foreigners

Ratings of Visual Similarity (1-5)



N=16

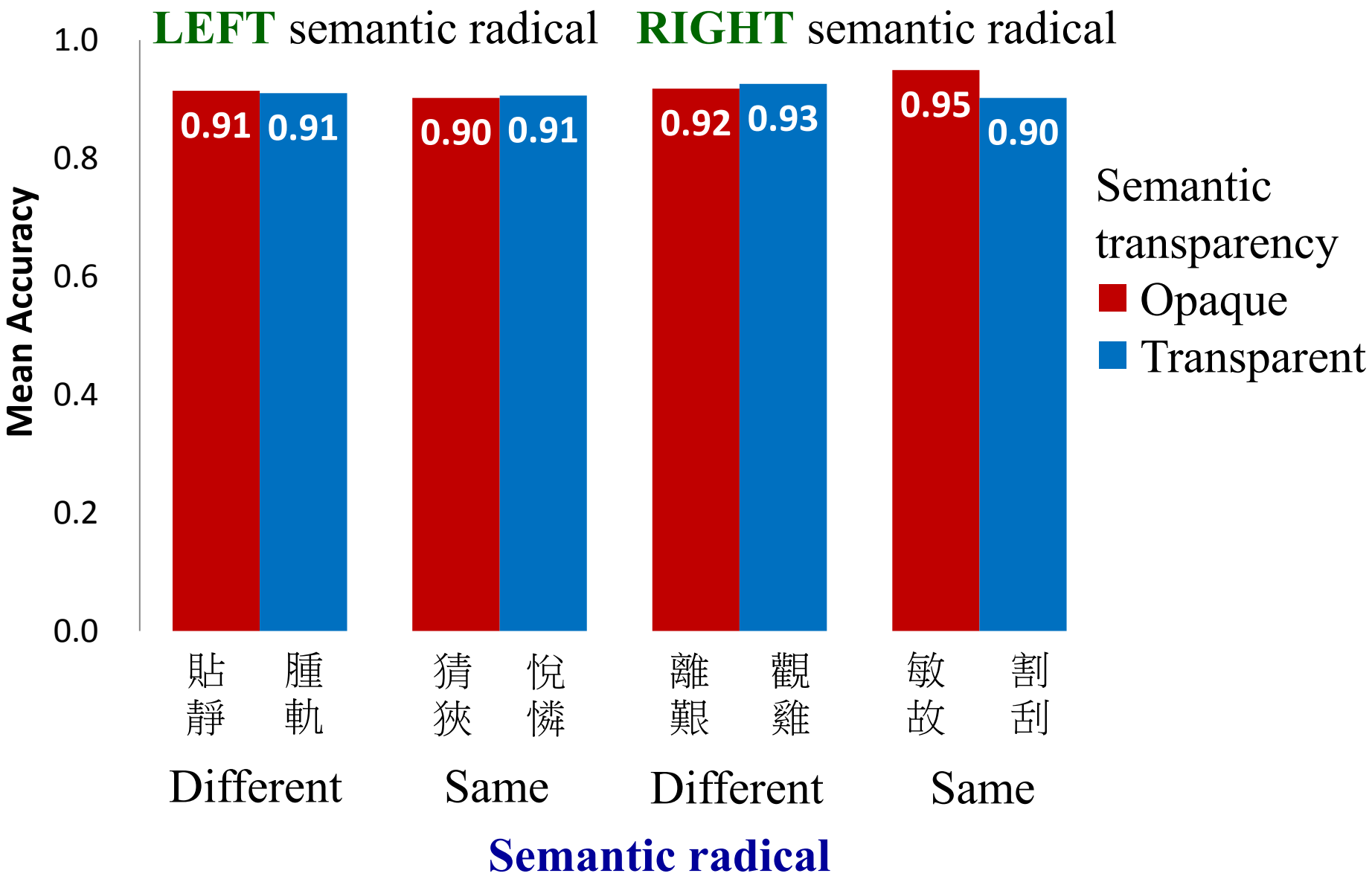
OSE from Semantic Radicals?

		Semantic Transparency			
		Opaque		Transparent	
Semantic radical	Different	貼 /tie1/ Stick (shellfish)	靜 /jing1/ Quiet (blue)	鍋 /guo1/ Pot (metal)	詞 /tsu2/ Words (speech)
	Same	猜 /cai1/ Guess (dog)	狹 /xia2/ Narrow (dog)	悅 /yue4/ Happy (heart)	憐 /lian2/ Pity (heart)

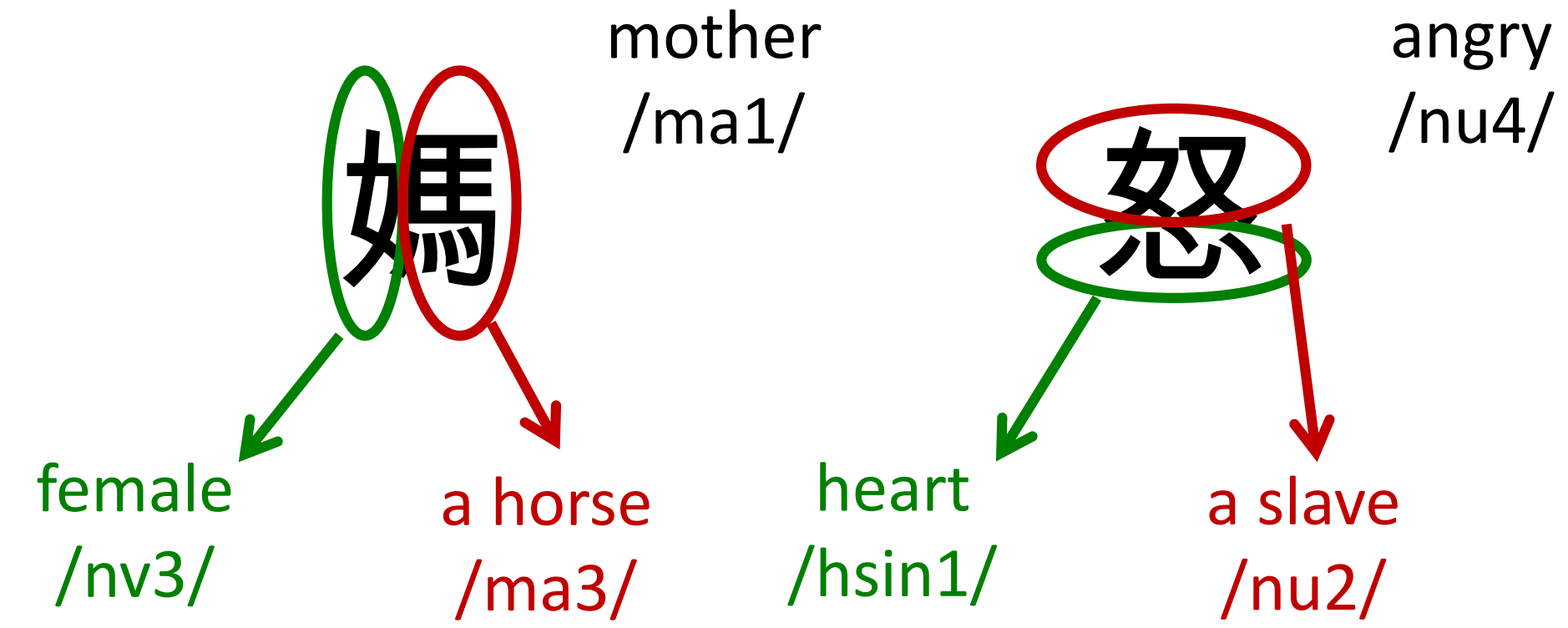
OSE from Semantic Radicals?

		Semantic Transparency			
		Opaque		Transparent	
Semantic radical	Different	離 /li2/ Leave (bird)	副 /fu4/ Secondary (knife)	觀 /guan1/ Watch (see)	雞 /ji1/ Chicken (bird)
	Same	敏 /min3/ Quick (beat)	故 /gu2/ Old (beat)	戰 /zhan4/ War (weapon)	戳 /chuo1/ Poke (weapon)

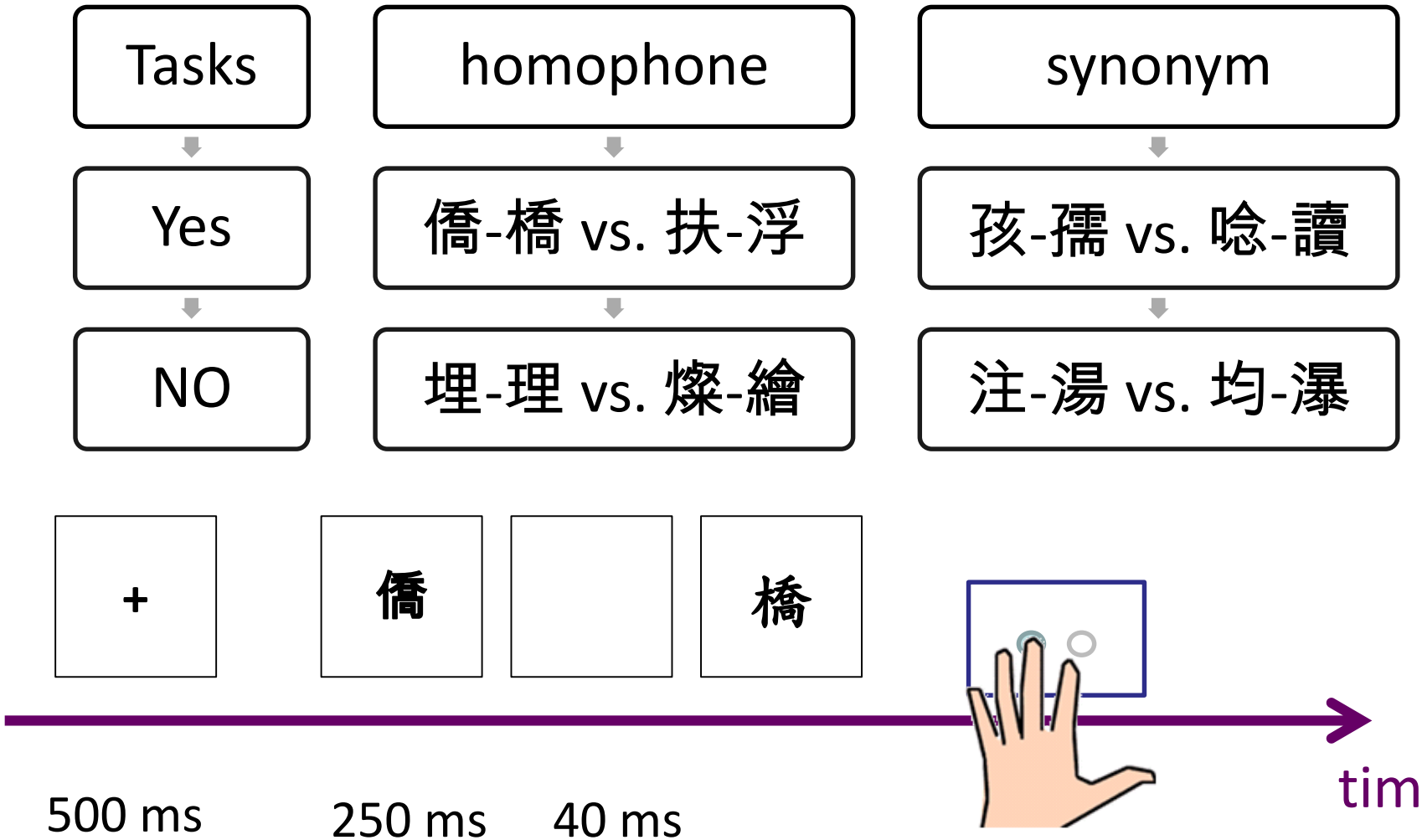
Probed serial recall paradigm



- STM of Chinese characters is worse when sharing
  - phonology
  - phonetic (but not semantic) radicals in the same position within a character, especially in horizontal characters

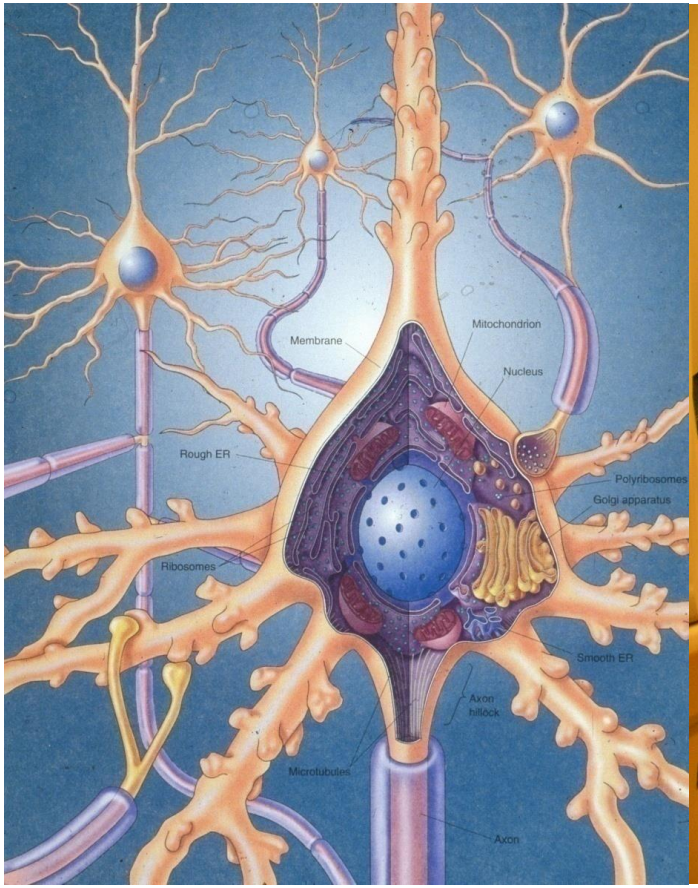


- Temporal dynamics of phonetic and semantic radicals (an MEG study)

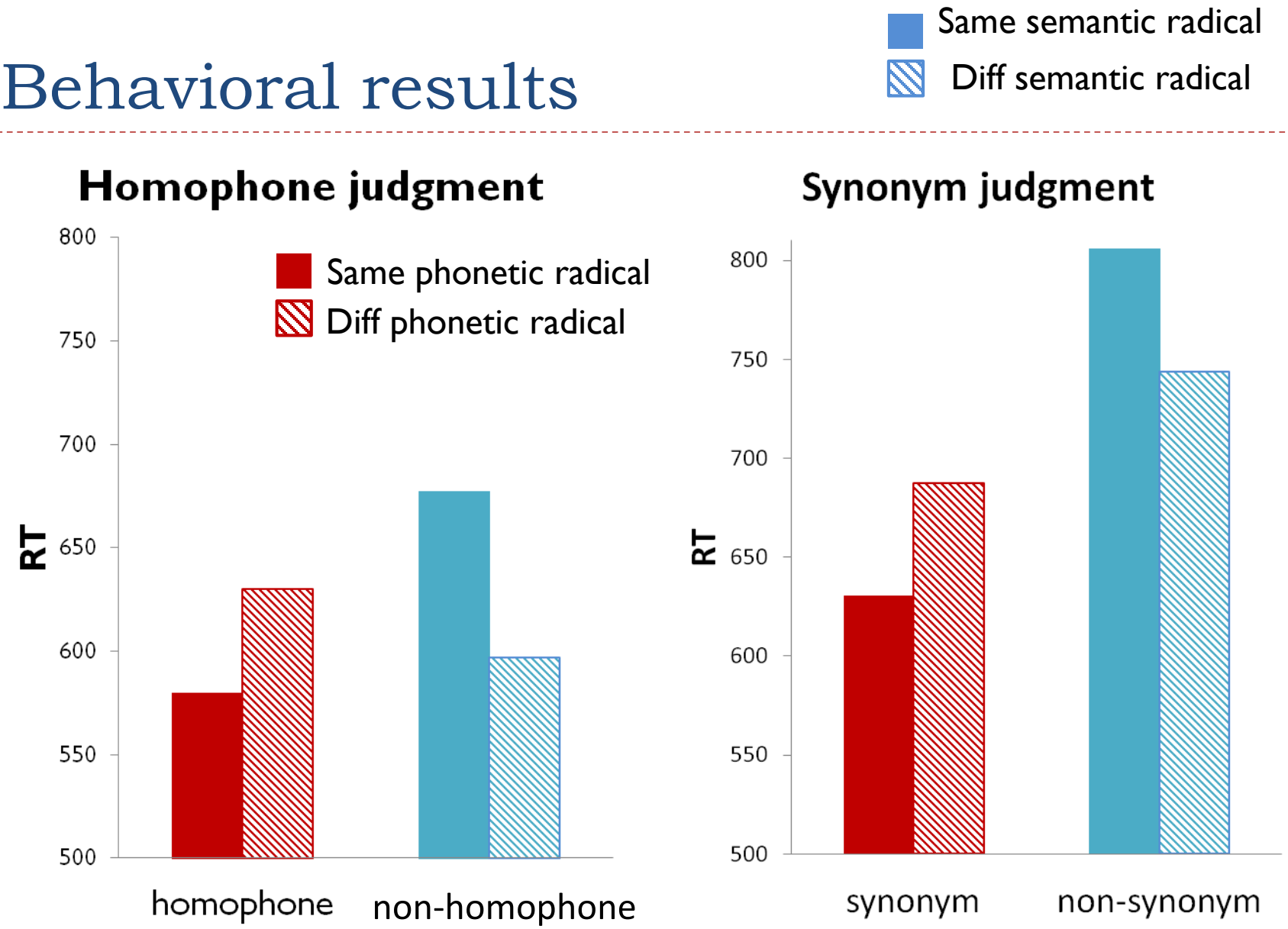


Hung et al. (2013)

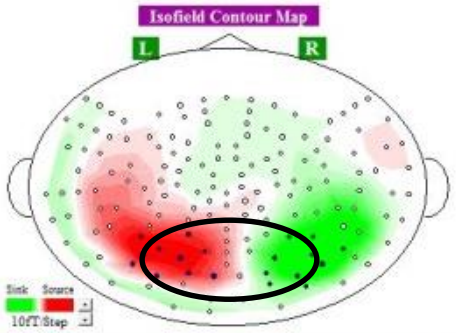
➢ MegnetoEncephaloGrphy

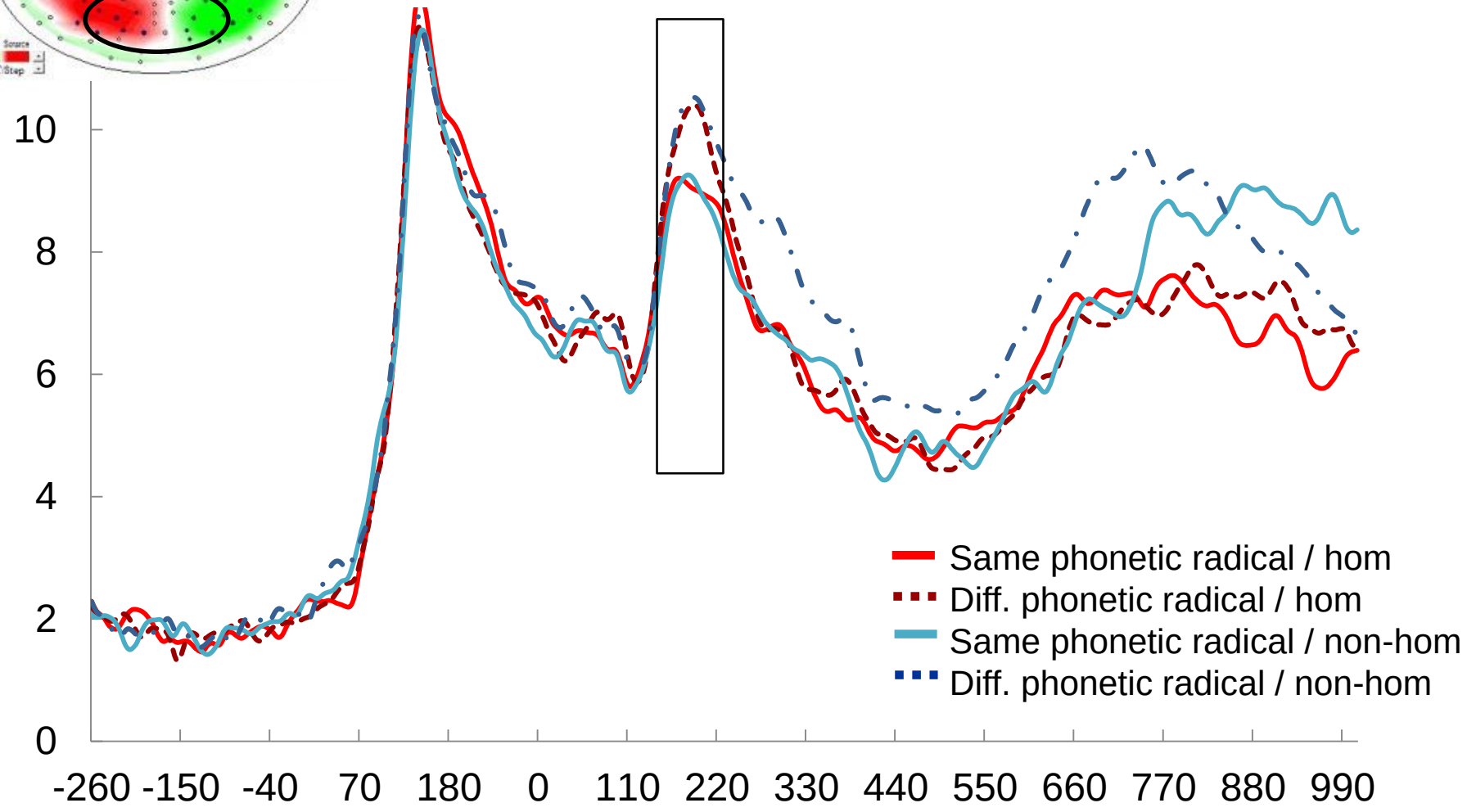


Behavioral results

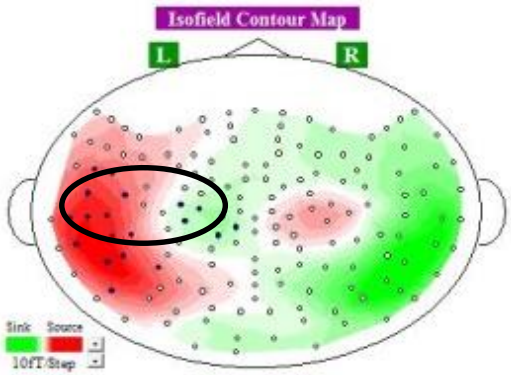


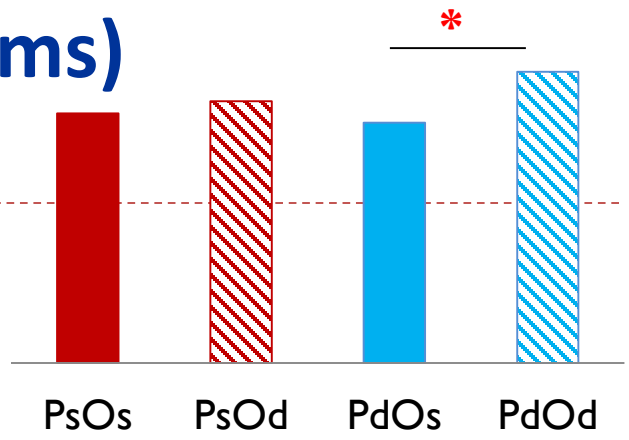
M170 (130 – 230 ms)

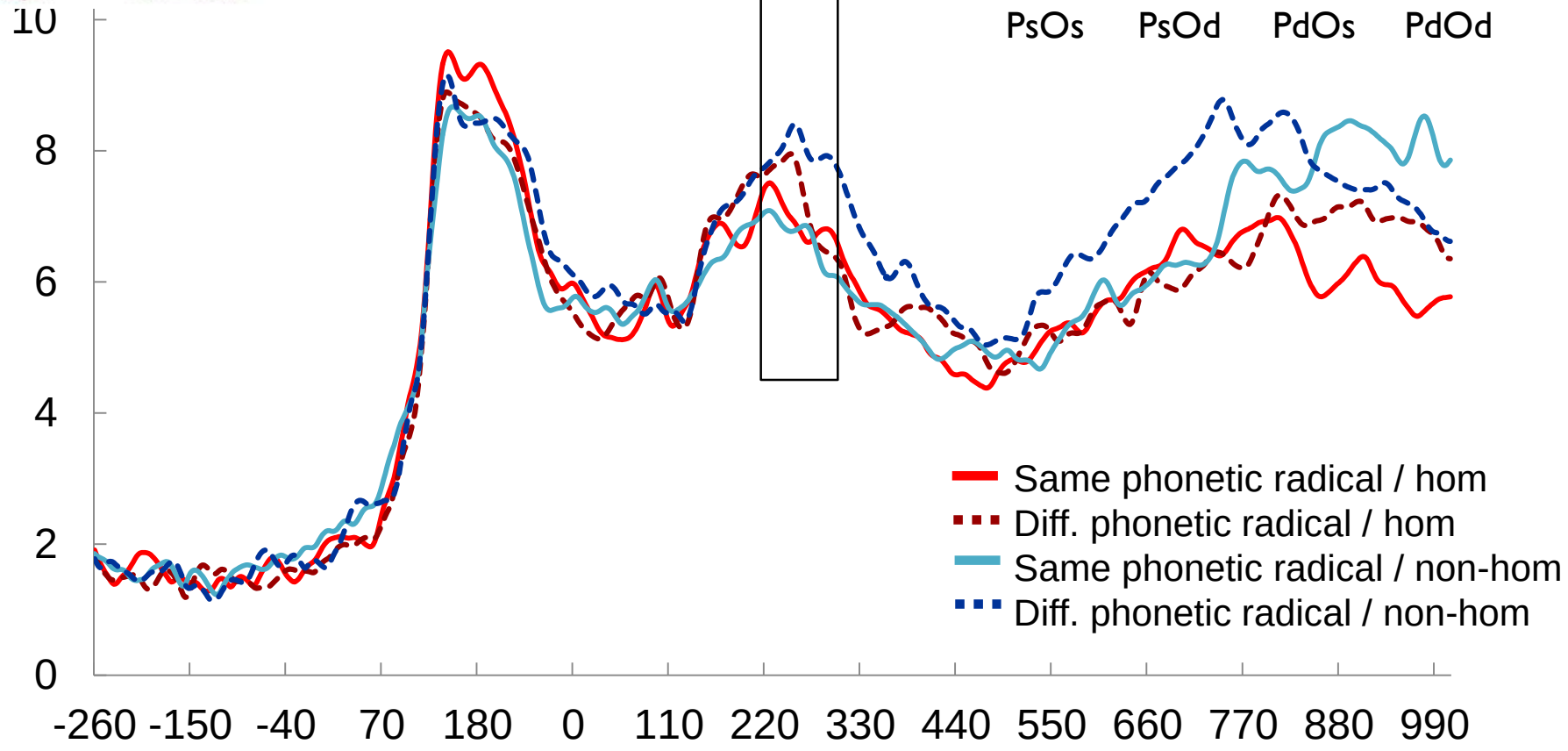


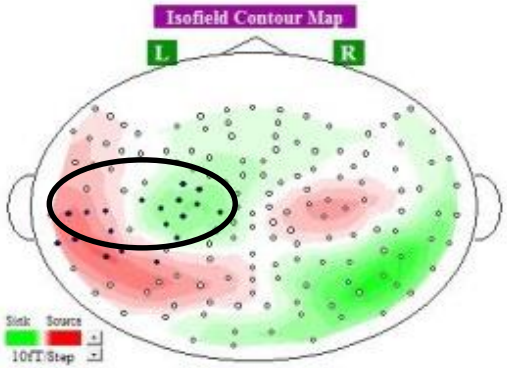


M250 (230 – 300 ms)

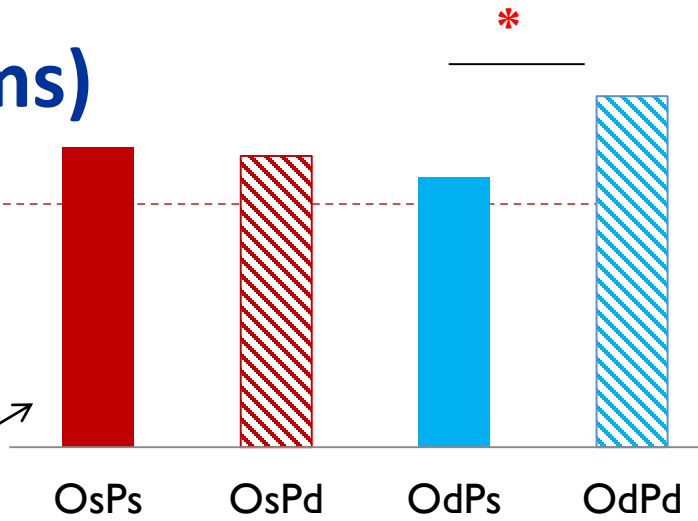


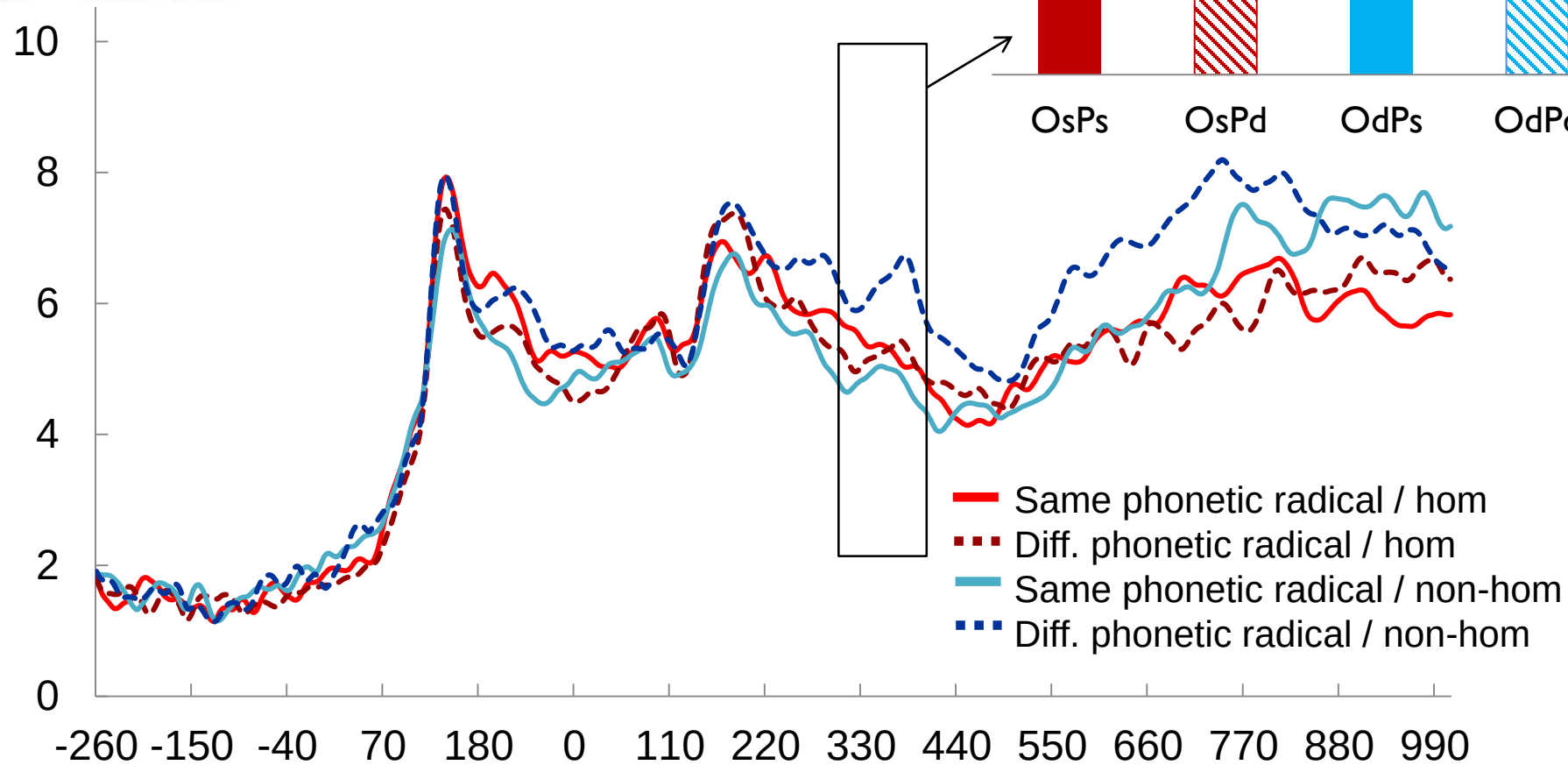




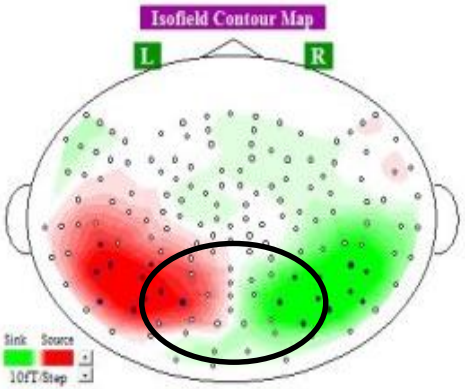


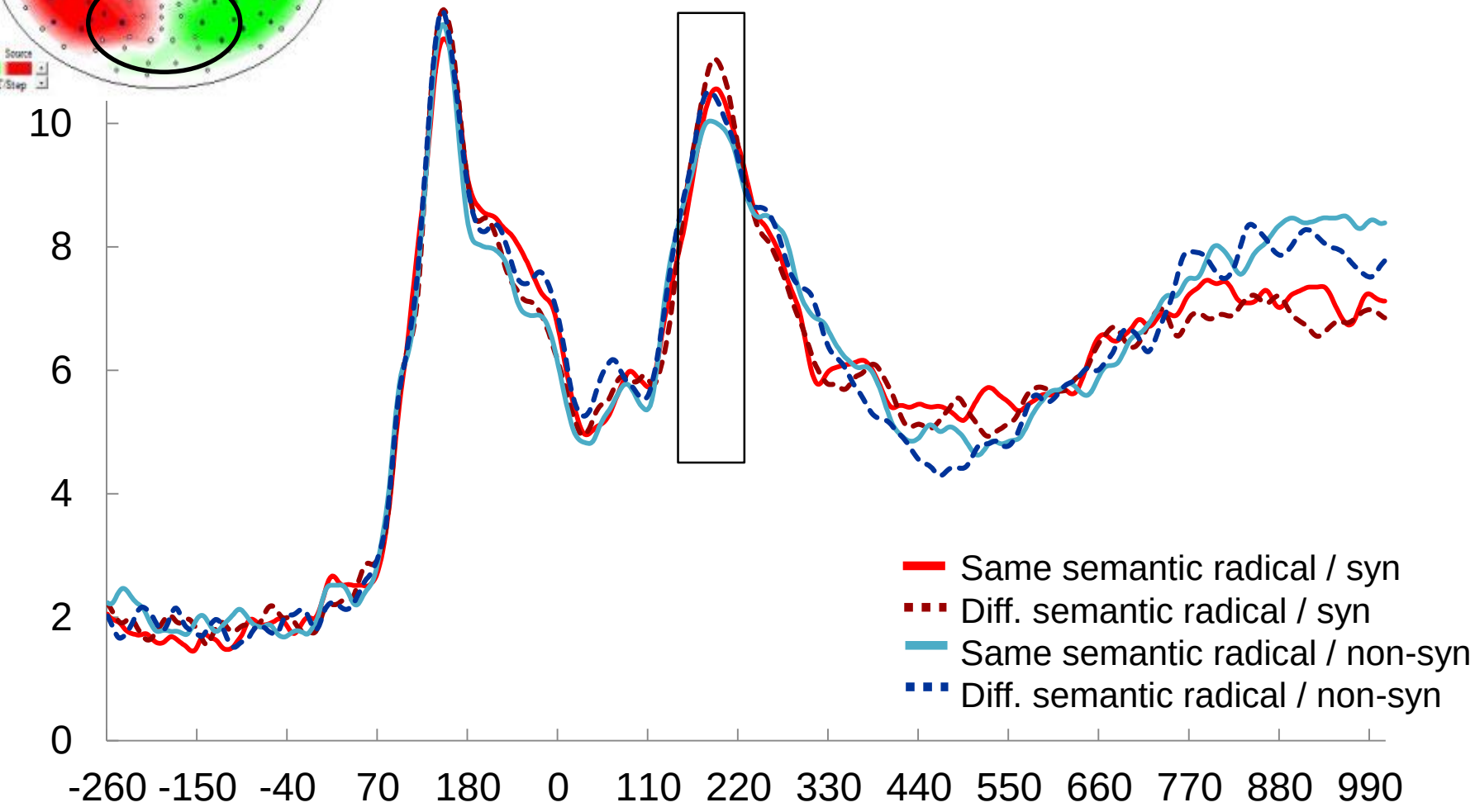
M350 (300 – 400 ms)

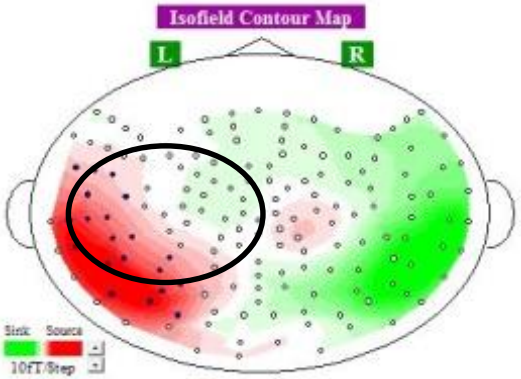




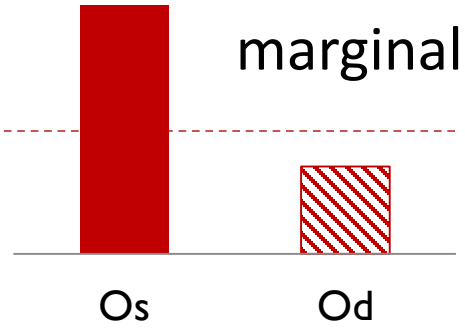
M170 (130 – 230 ms)

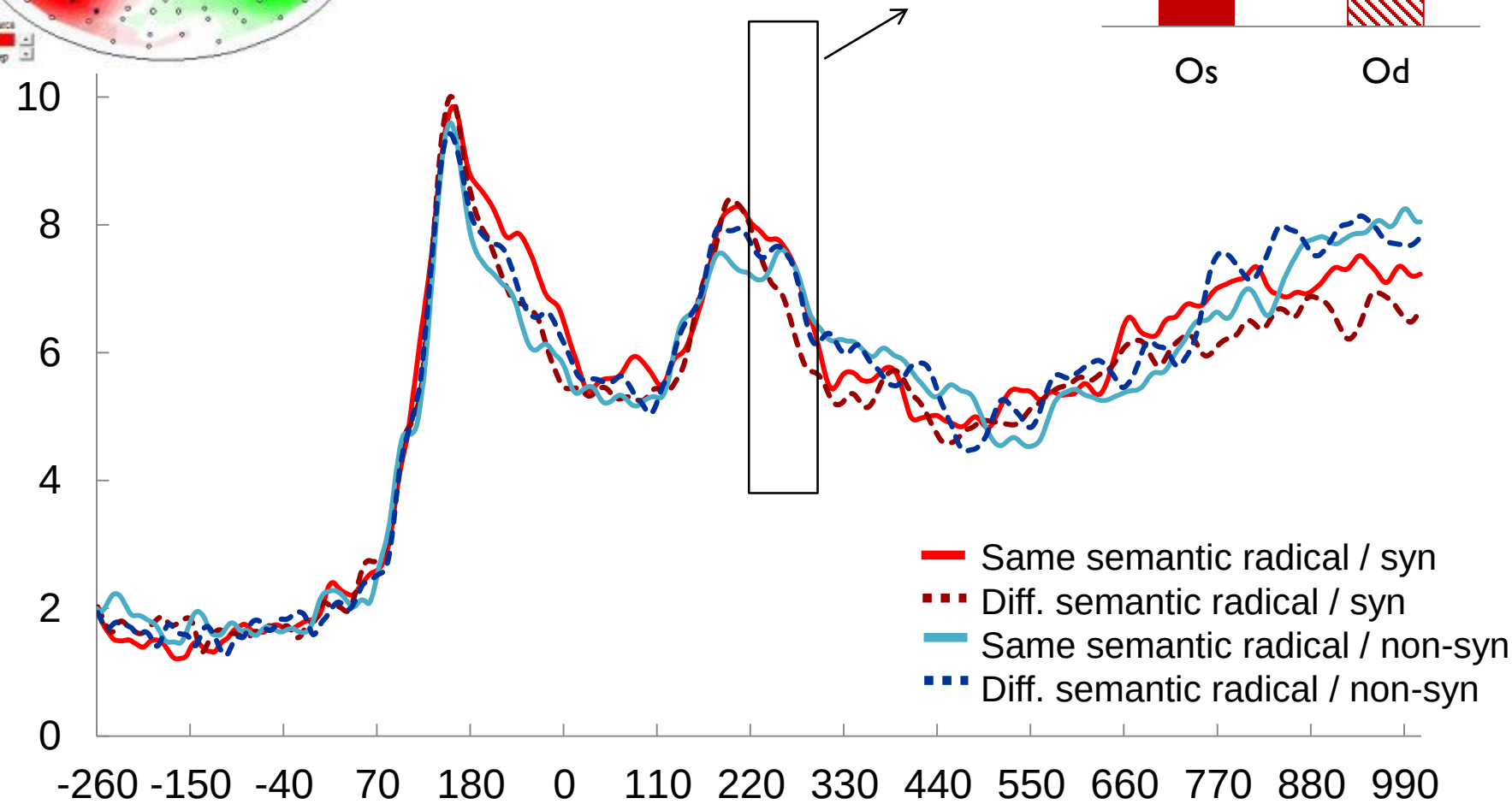


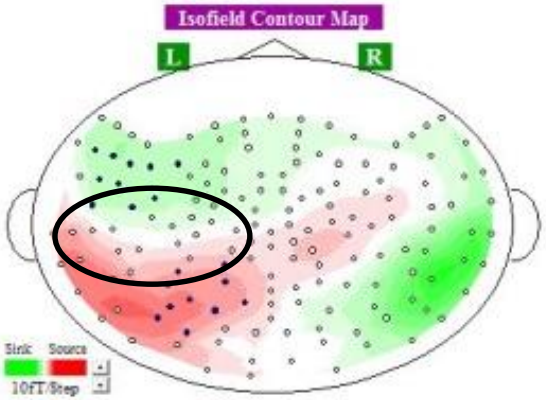




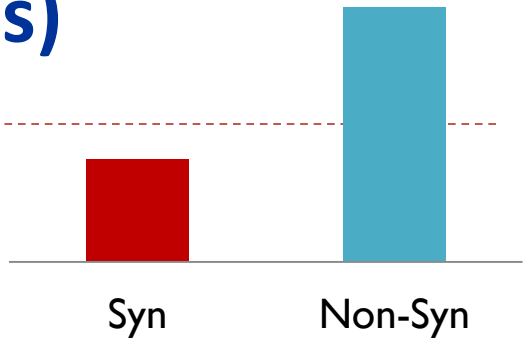
M250 (230 – 300 ms)

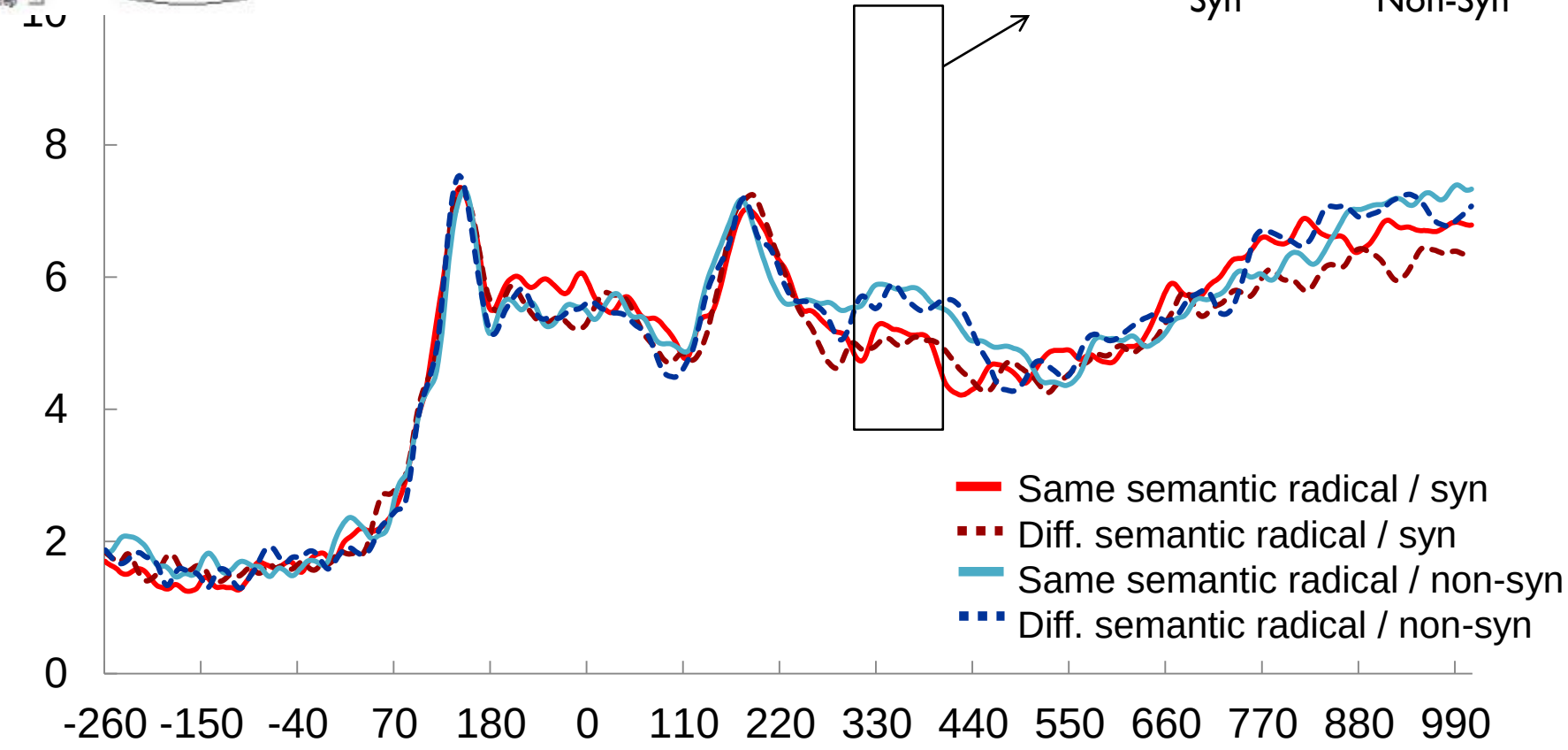






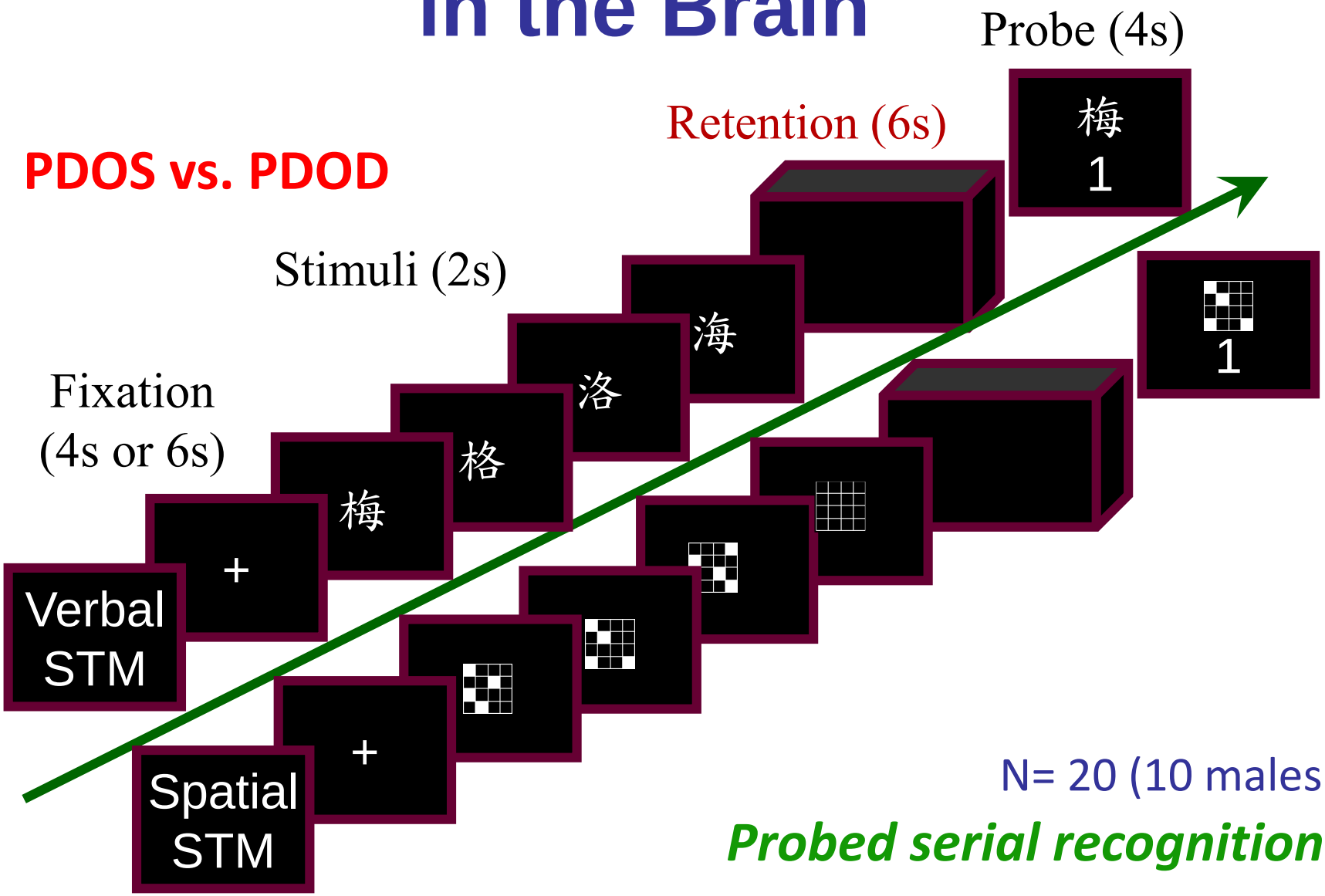
M350 (300 – 400 ms)





- Phonetic radicals play a dominant role in early lexical access and phonological computation
- The graphic form of semantic radicals provides further constraints on lexical access before the activation of character meaning

Orthographic Similarity Effect in the Brain

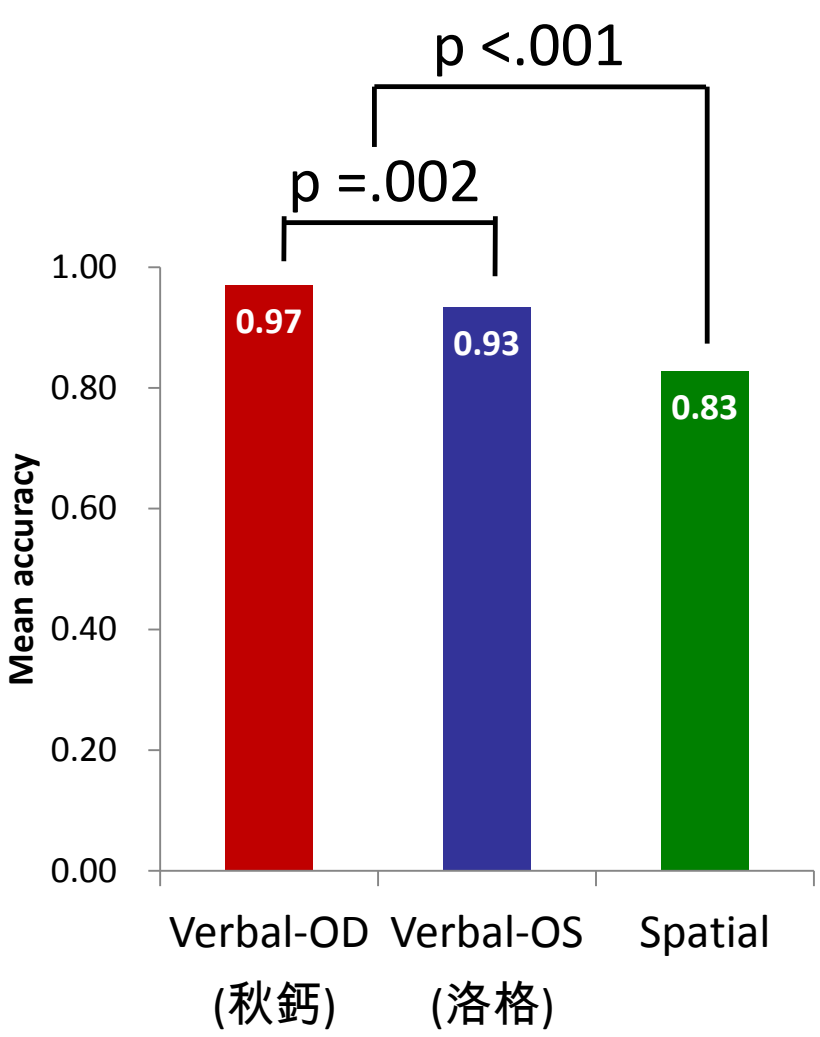


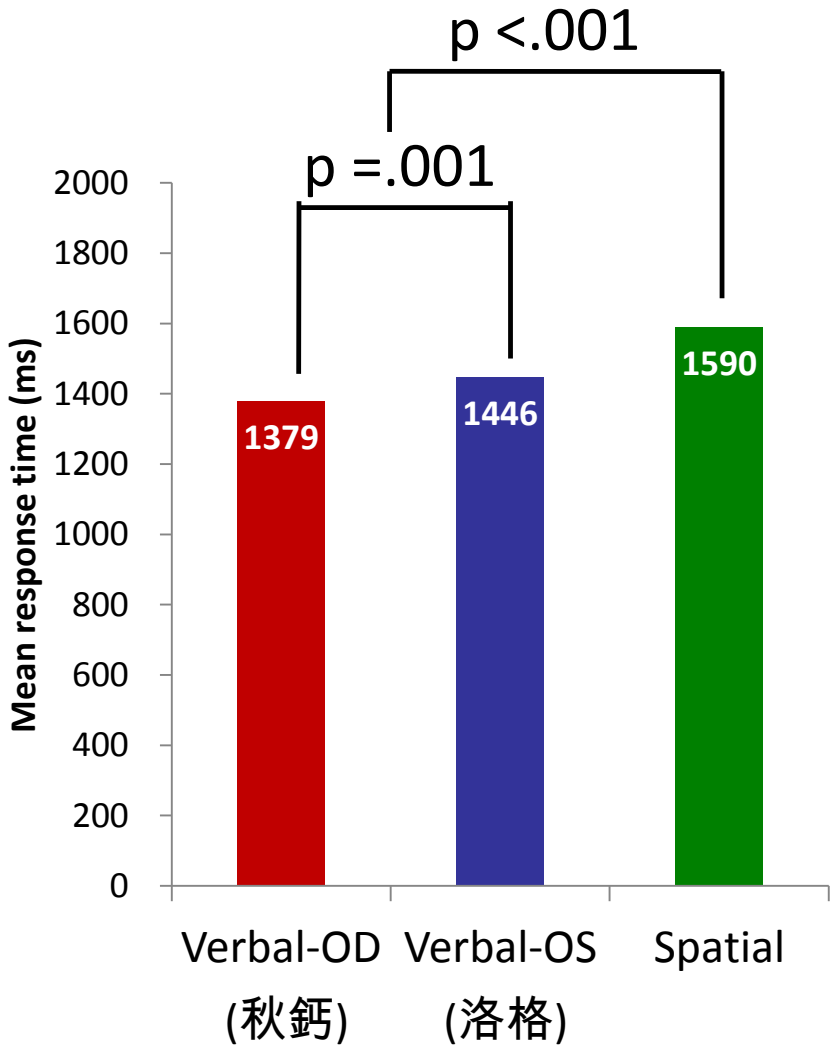
N= 20 (10 males)

Probed serial recognition

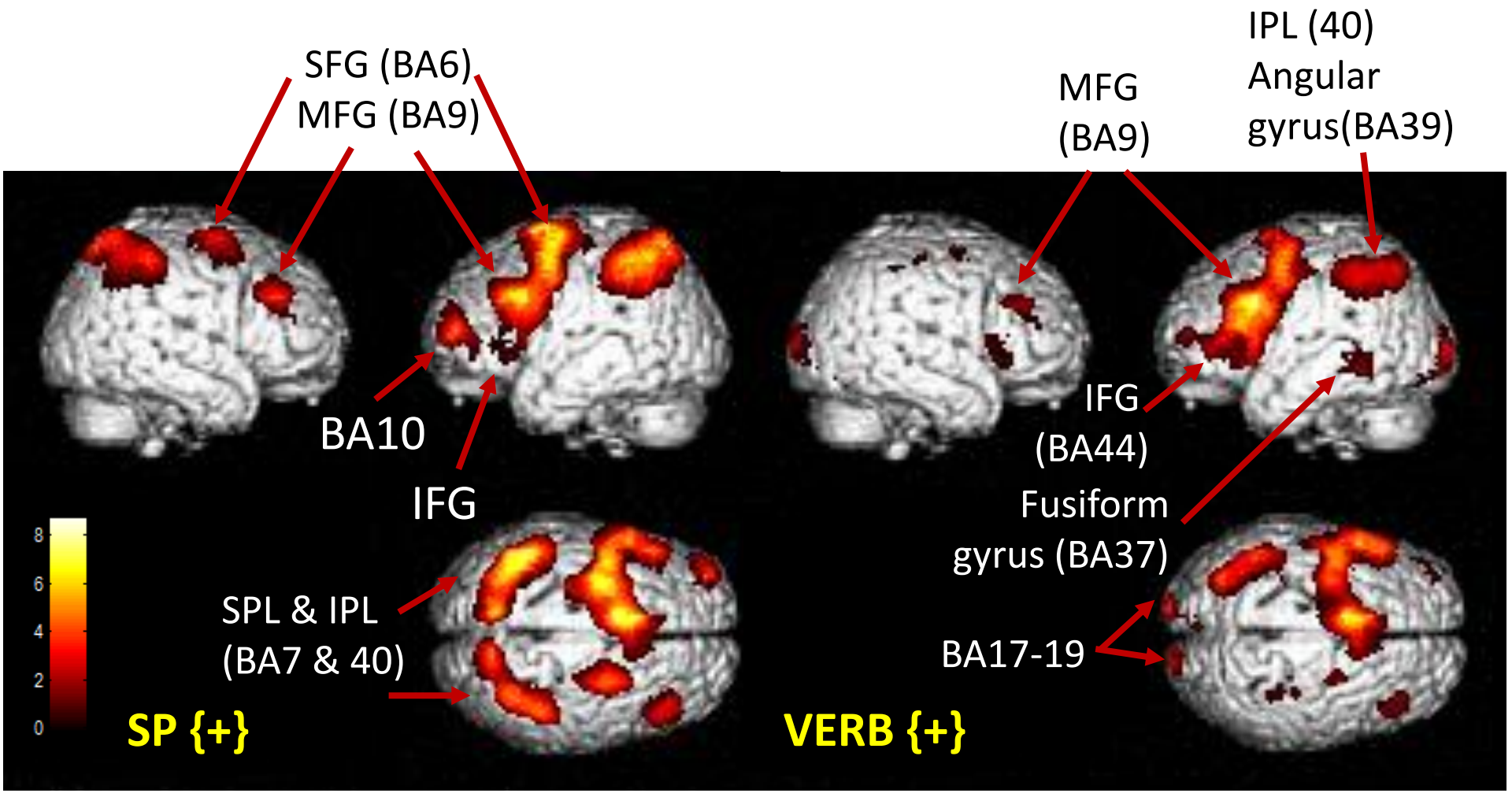
Behavioral data

N=20



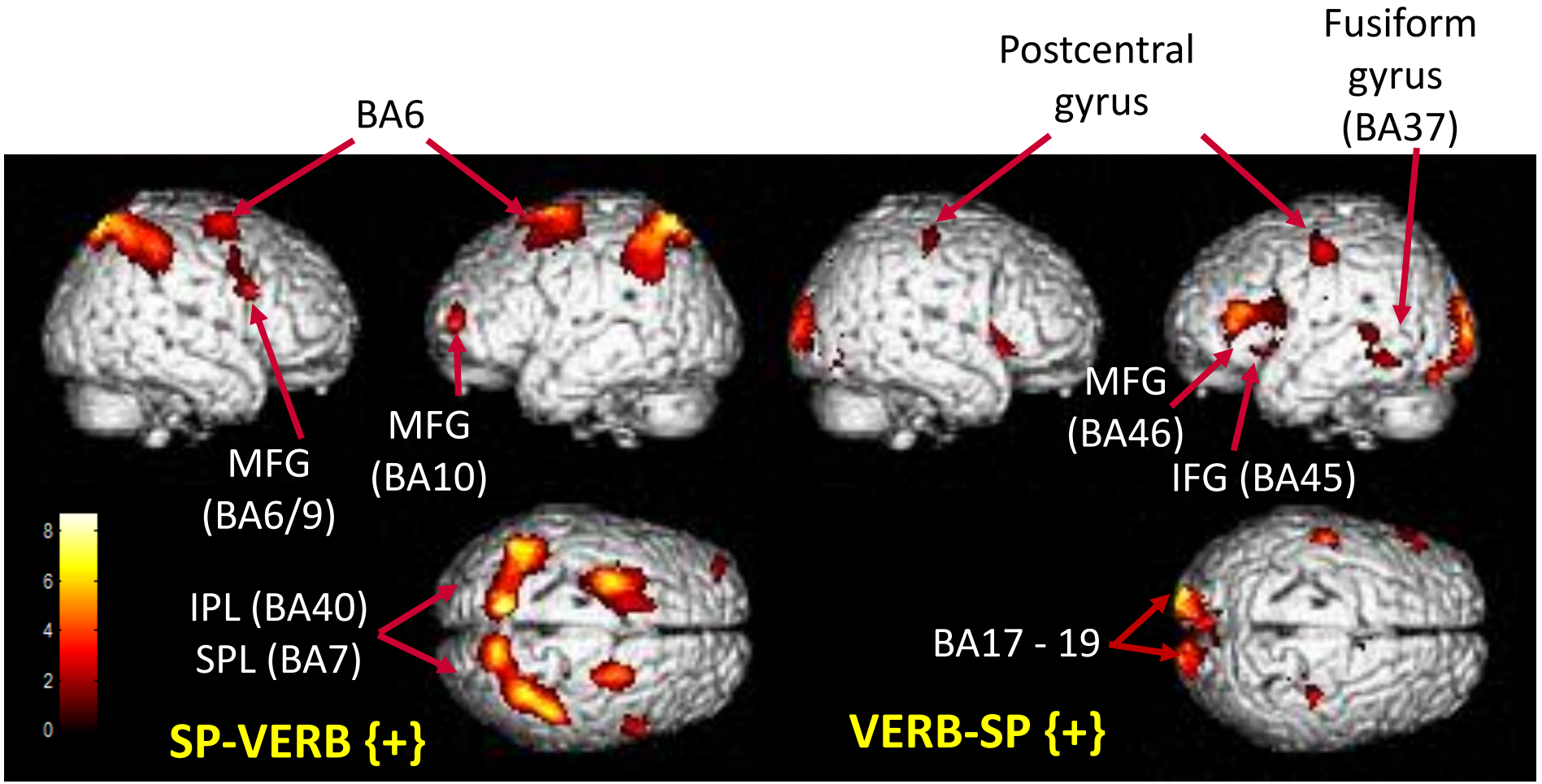


Networks of Spatial & Verbal STM



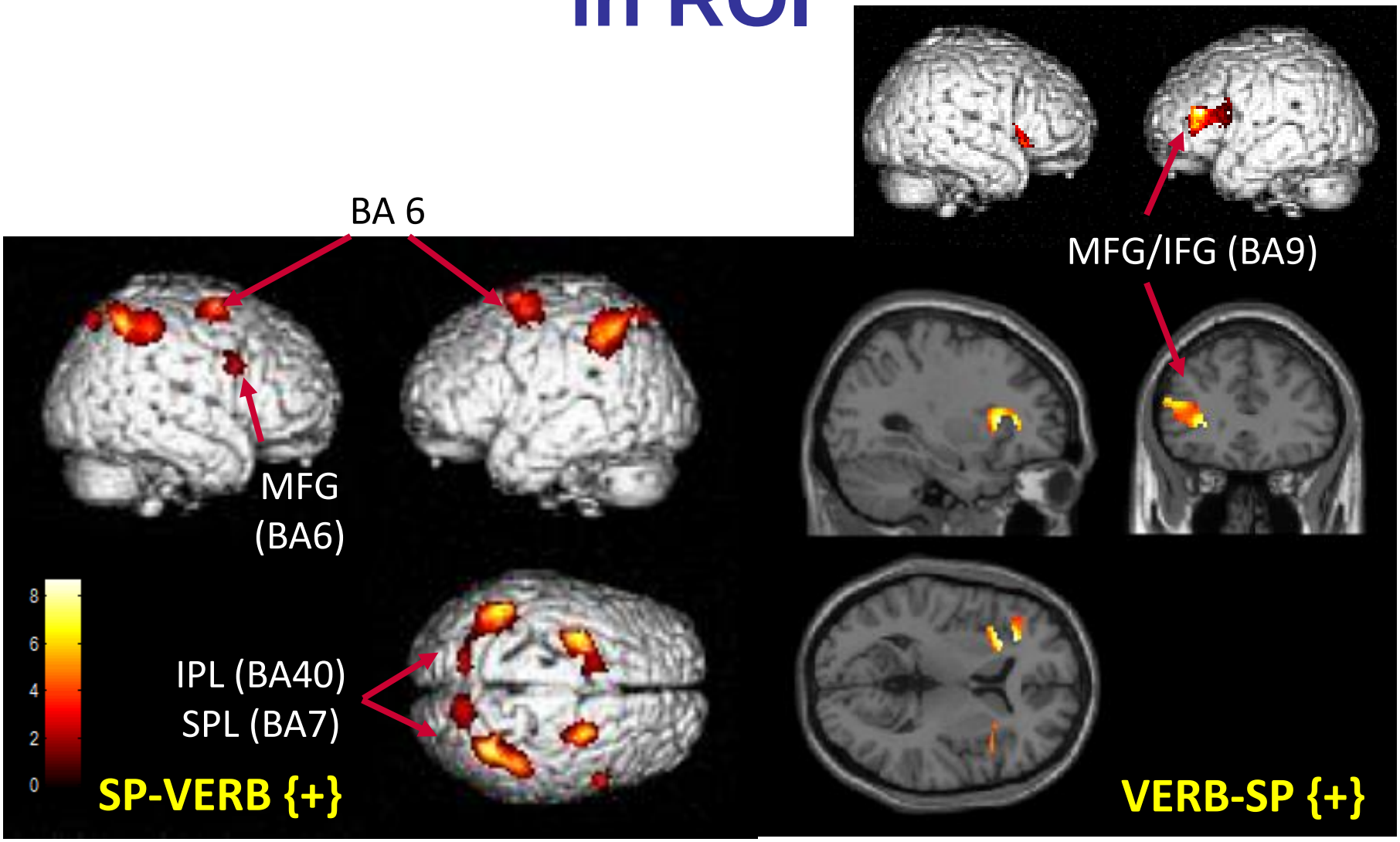
Uncorrected p=.001, Spatial extent $p<FDR_{.05}$

Regions of Interest



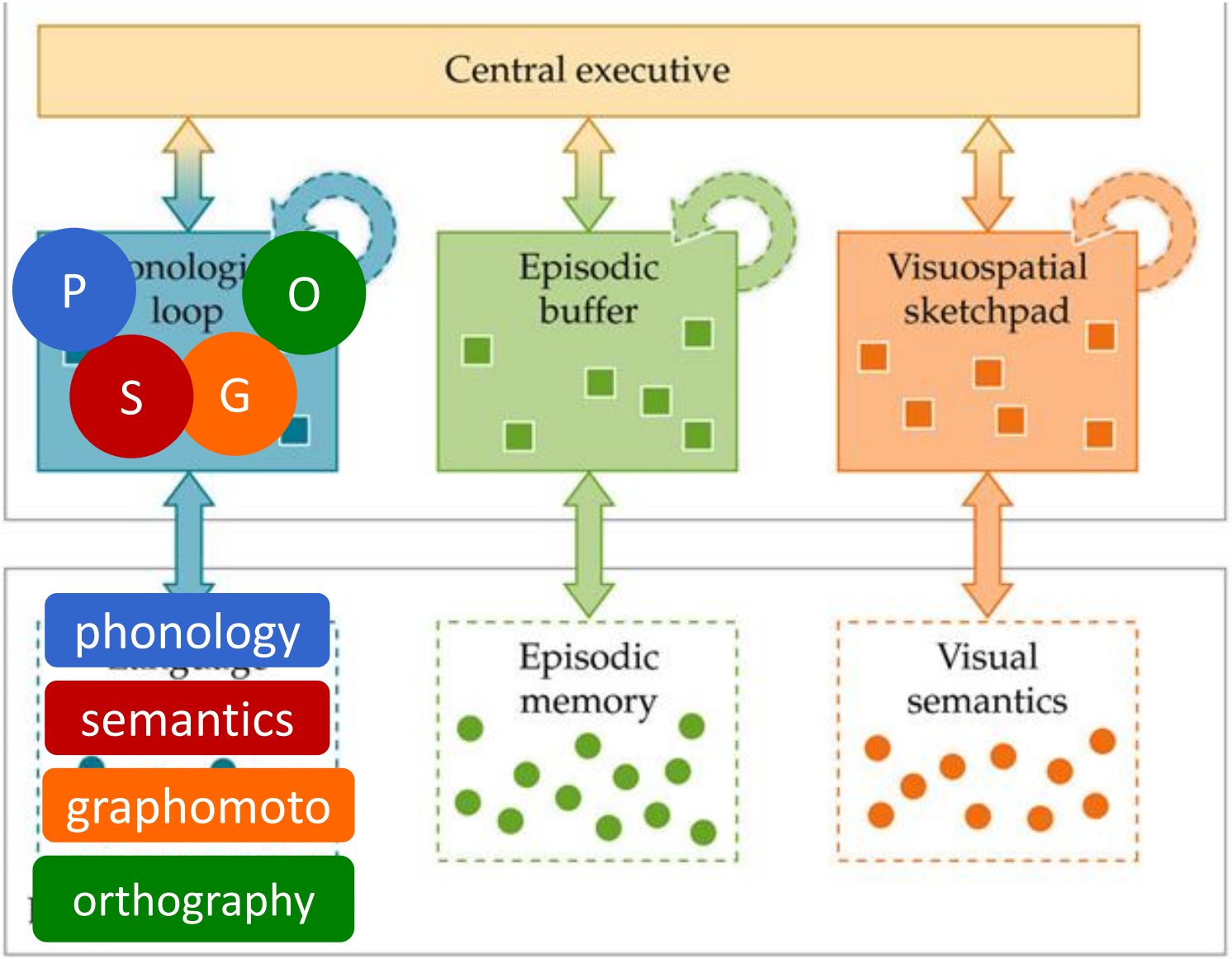
p=.01

Orthographic Similarity Effect in ROI

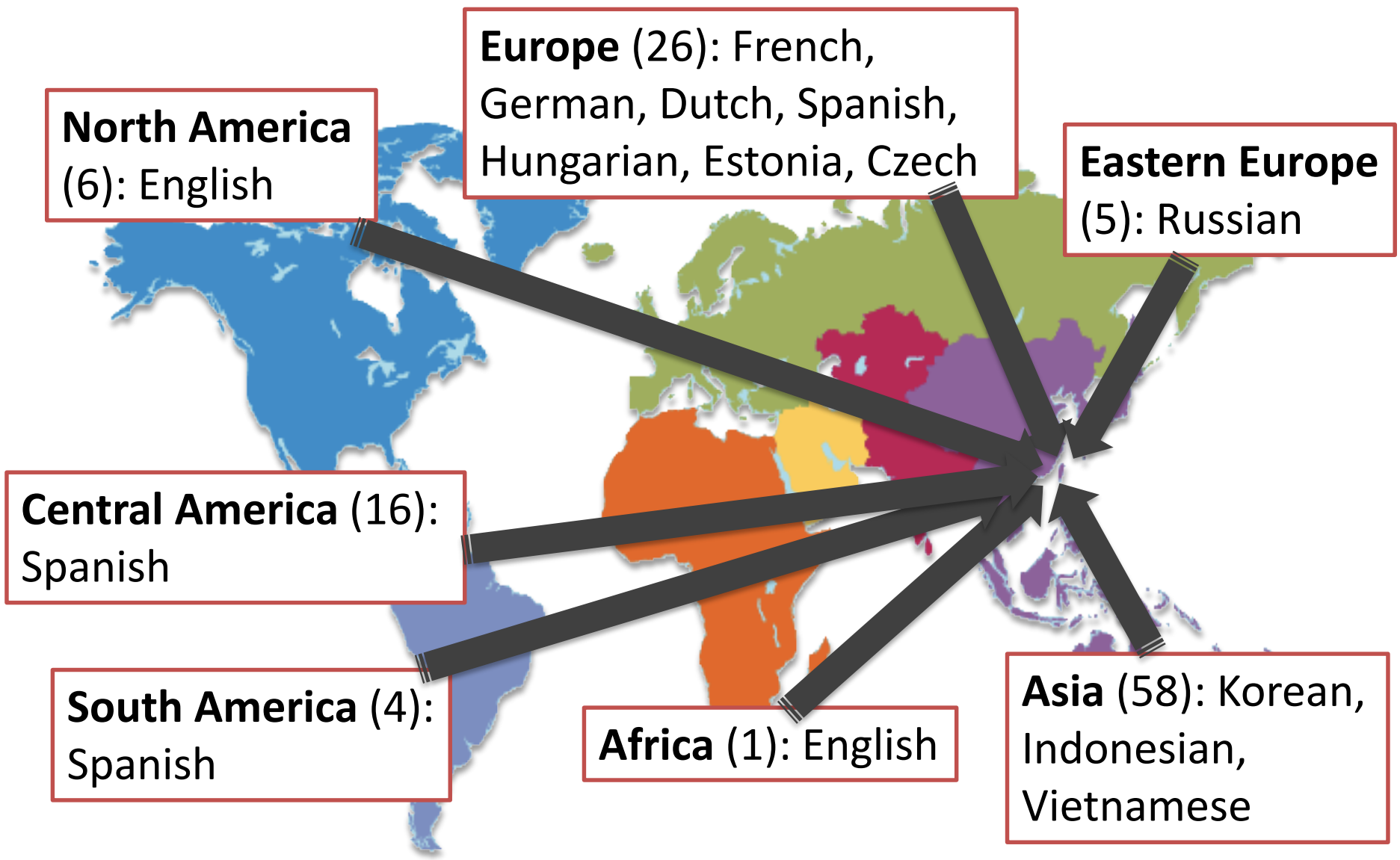


Uncorrected p=.001, spatial extent $p<FDR_{.05}$

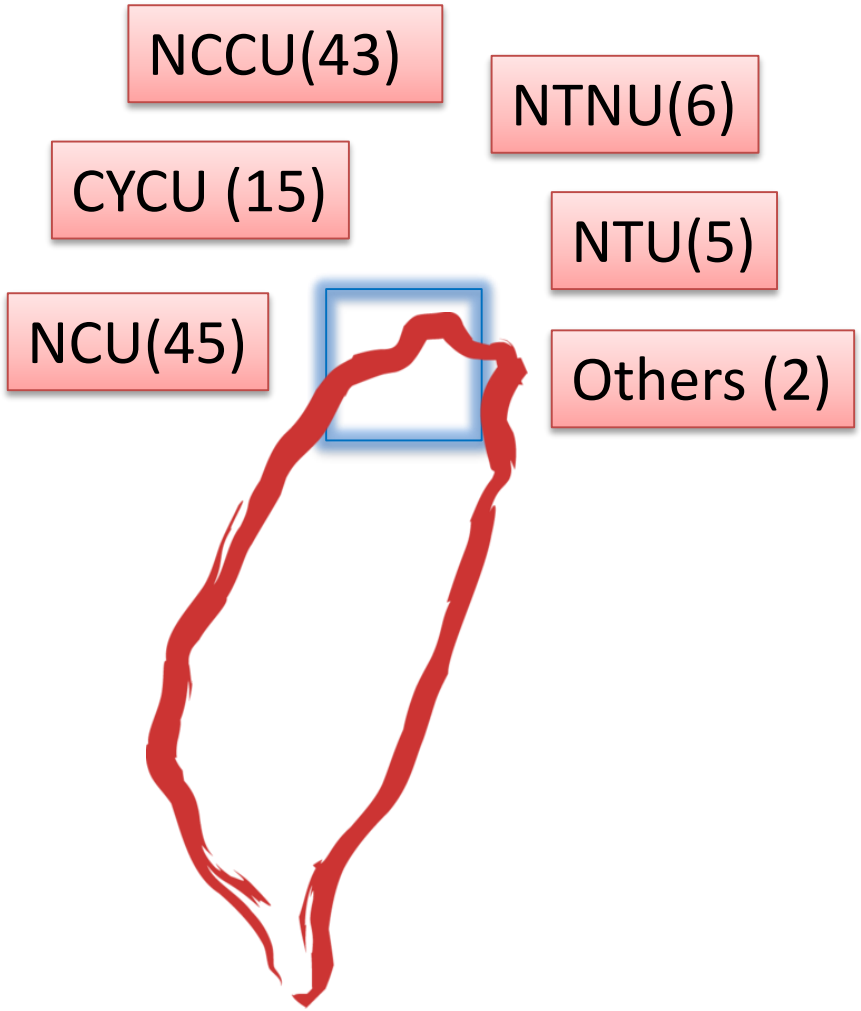
Revisit the STM Model

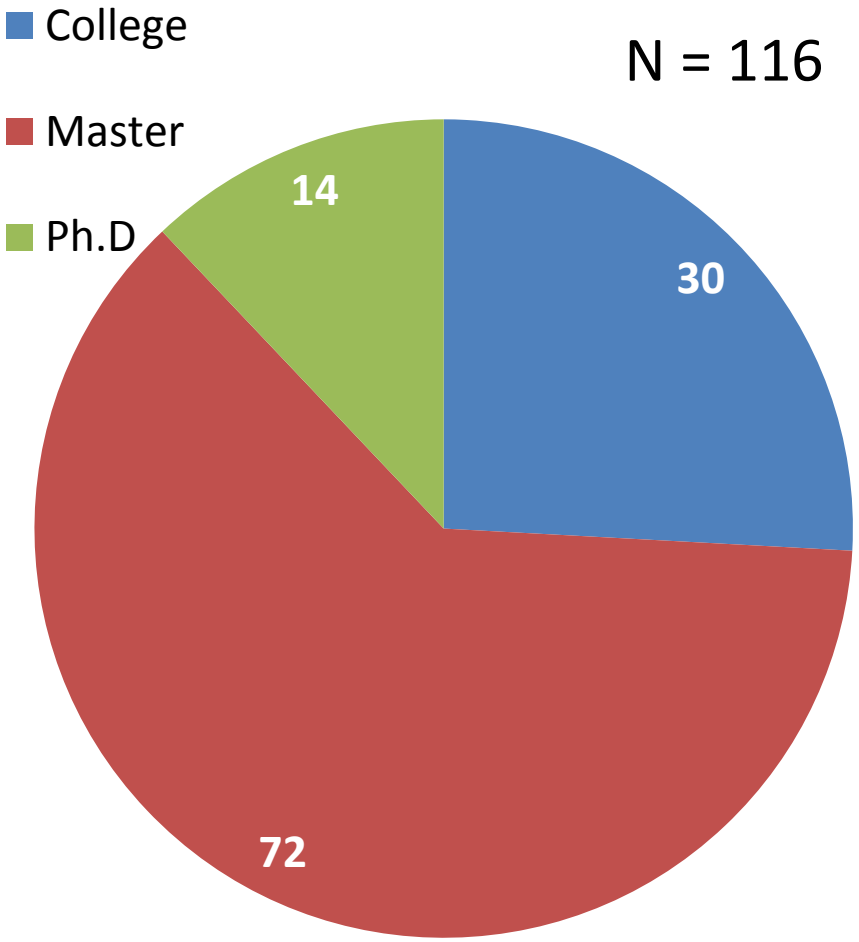


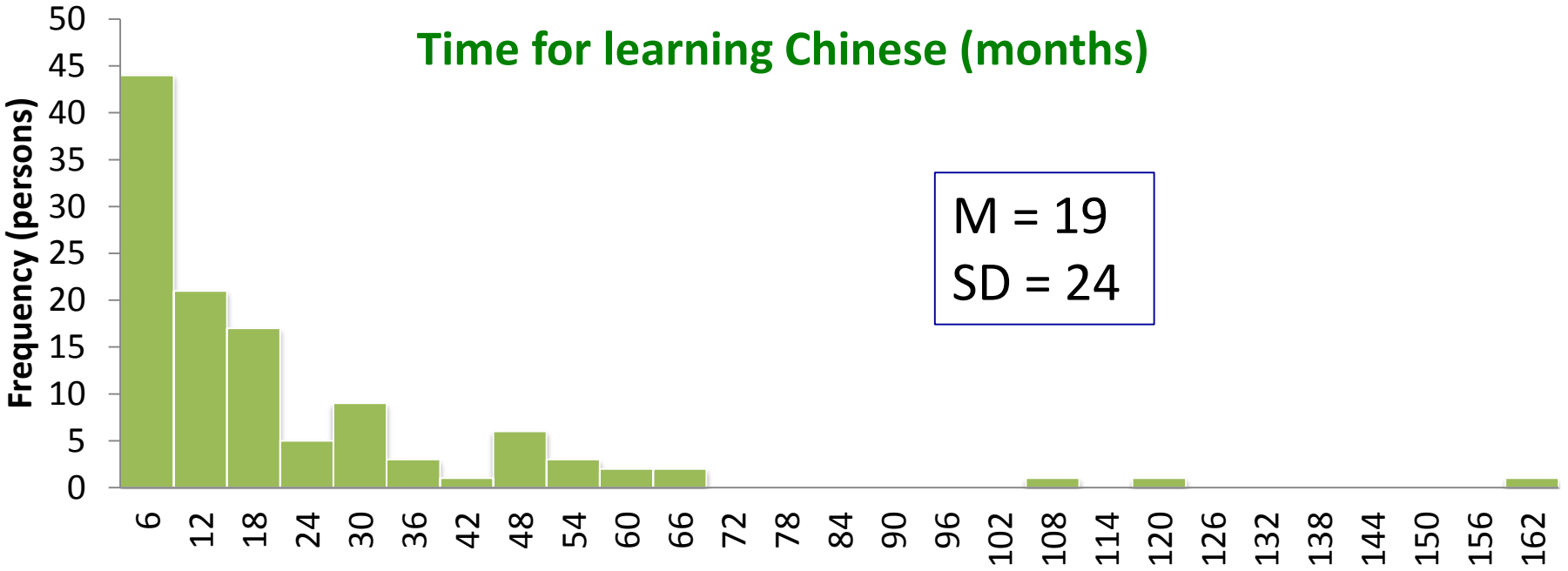
How about learning Chinese as L2?

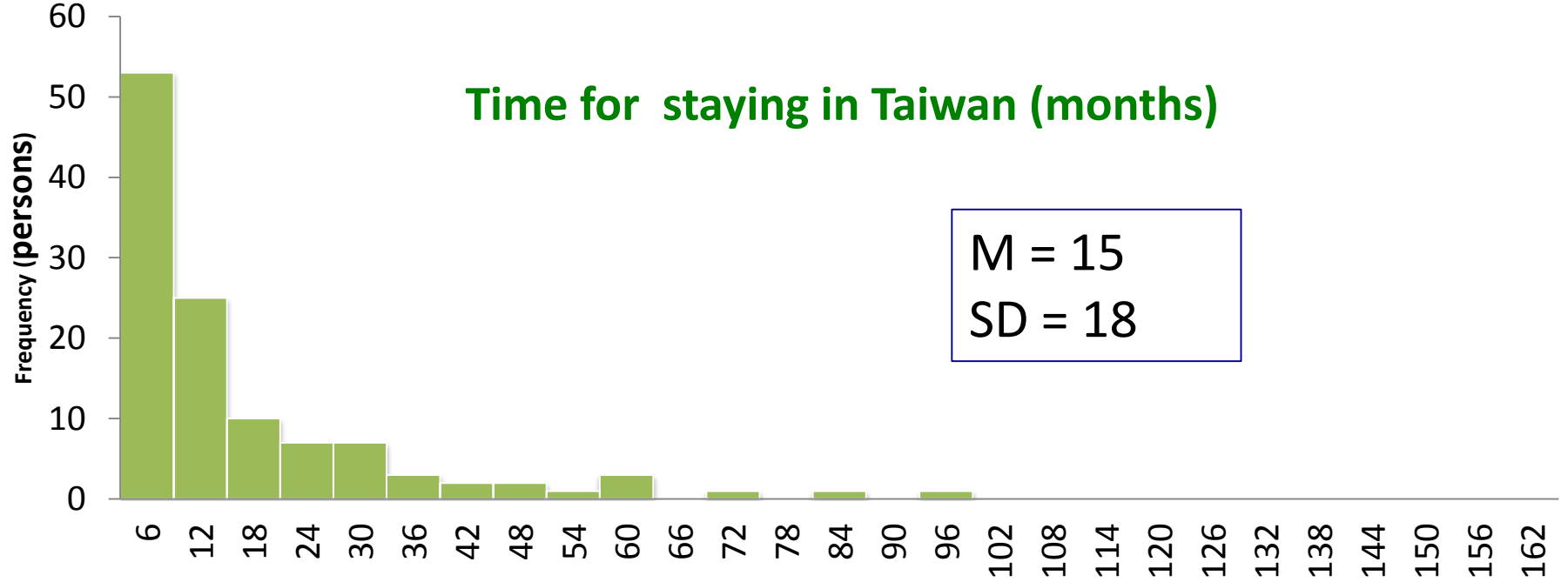


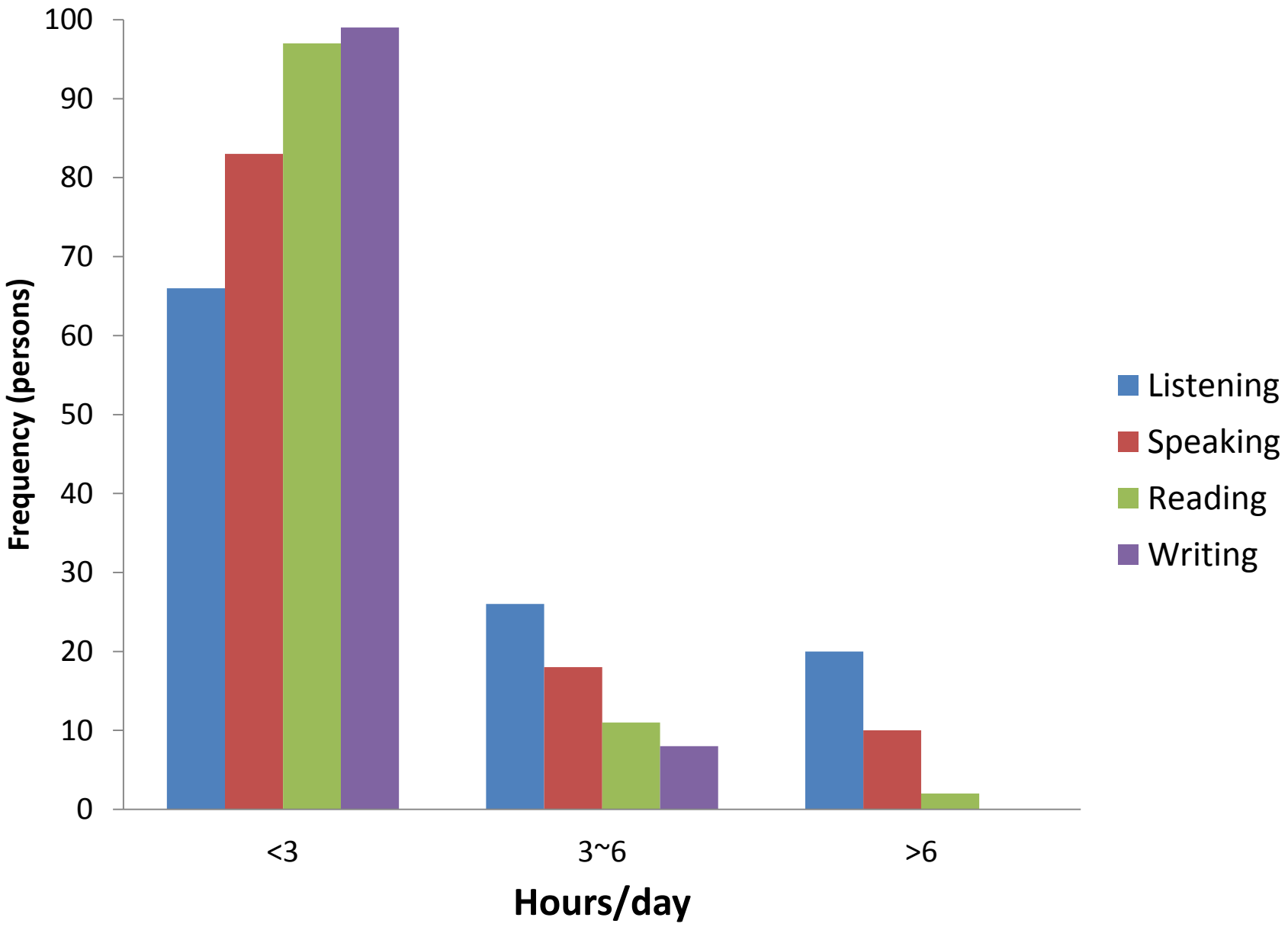
Age: 20~37y (M = 26)






Time for learning Chinese (months)
Frequency (persons)
M = 19
SD = 24


Time for staying in Taiwan (months)
Frequency (persons)
M = 15
SD = 18

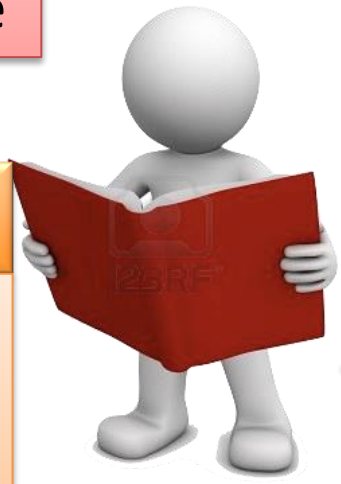

Time spent on learning Chinese
100
90
80
70
60
50
40
30
20
10
0
Frequency (persons)
<3
3~6
>6
Hours/day
Listening
Speaking
Reading
Writing

Demographic Info

Age
Education level
Linguistic background
Time for learning Chinese

General Cognitive Abilities

Raven's APM/block design
Digit span
Corsi block
Visual pattern (VPT)



Chinese Literacy

Character size
Character decoding
Lexical decision
Rapid automatized naming

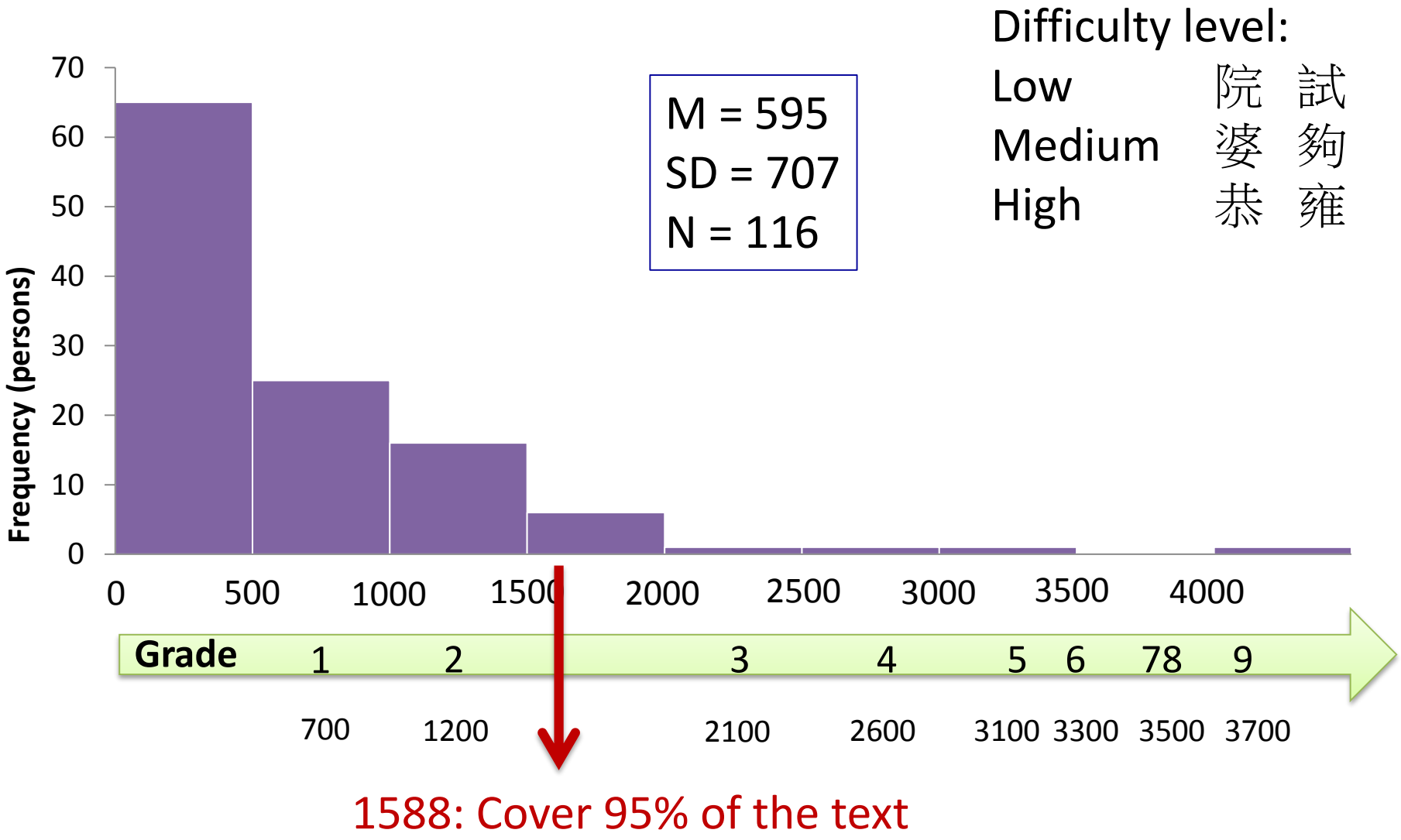
Perceptual Abilities

Two-tone discrimination
Visual perceptual skills (TVPS)

Statistical Learning

Visual SL
Auditory SL

Chinese literacy: Character size



N = 116	Character size	Decoding (with context)	Decoding (no context)	LDT_ ACC	RAN_ num	RAN_ col	RAN_ pic
CH Learning Time	.63	.55	.59	.59	-.33	-.43	-.43
Raven's score	-.02	.00	-.05	-.11	-.07	-.27	-.03
Block design	-.06	-.01	-.07	-.05	-.06	-.28	-.06
Digit span	-.10	-.12	-.18	-.19	.11	.03	.18
VPT	.09	.23	.22	.26	-.24	-.09	.12
Corsi	.05	-.12	-.03	.00	.04	-.10	.08
VSL	.37	.21	.17	.18	-.14	-.15	-.17
ASL	.02	-.01	.01	.10	.10	-.04	-.04
DIS	.09	.16	.12	.11	.09	-.06	-.02
SPA	.04	.17	.16	.09	-.05	-.29	-.19
CLO	-.11	-.05	.02	-.02	.01	.08	.11

Statistical learning (SL)

- Auditory SL

Familiarization

Test

1

2

- Visual SL

Familiarization

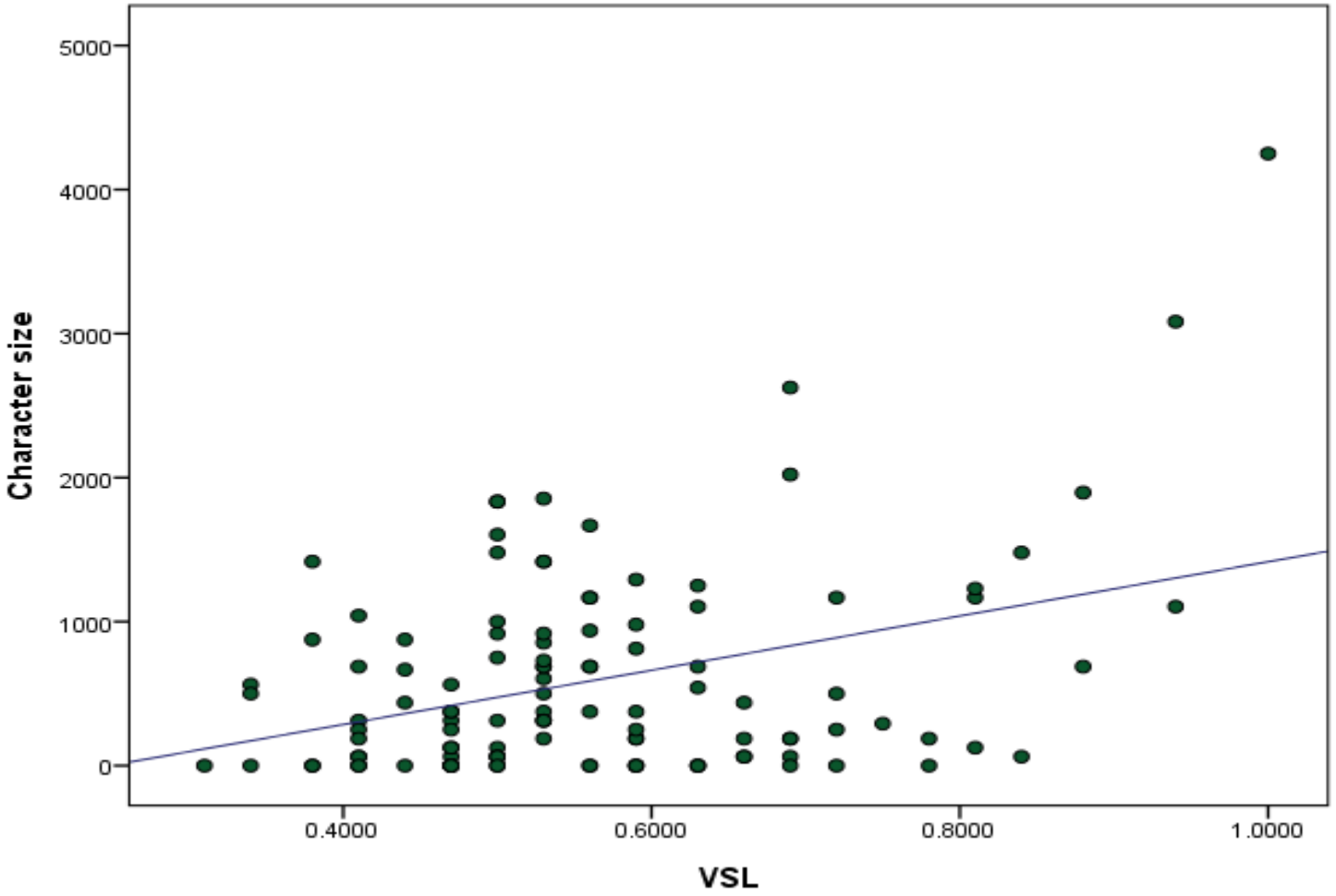
Test

1

2

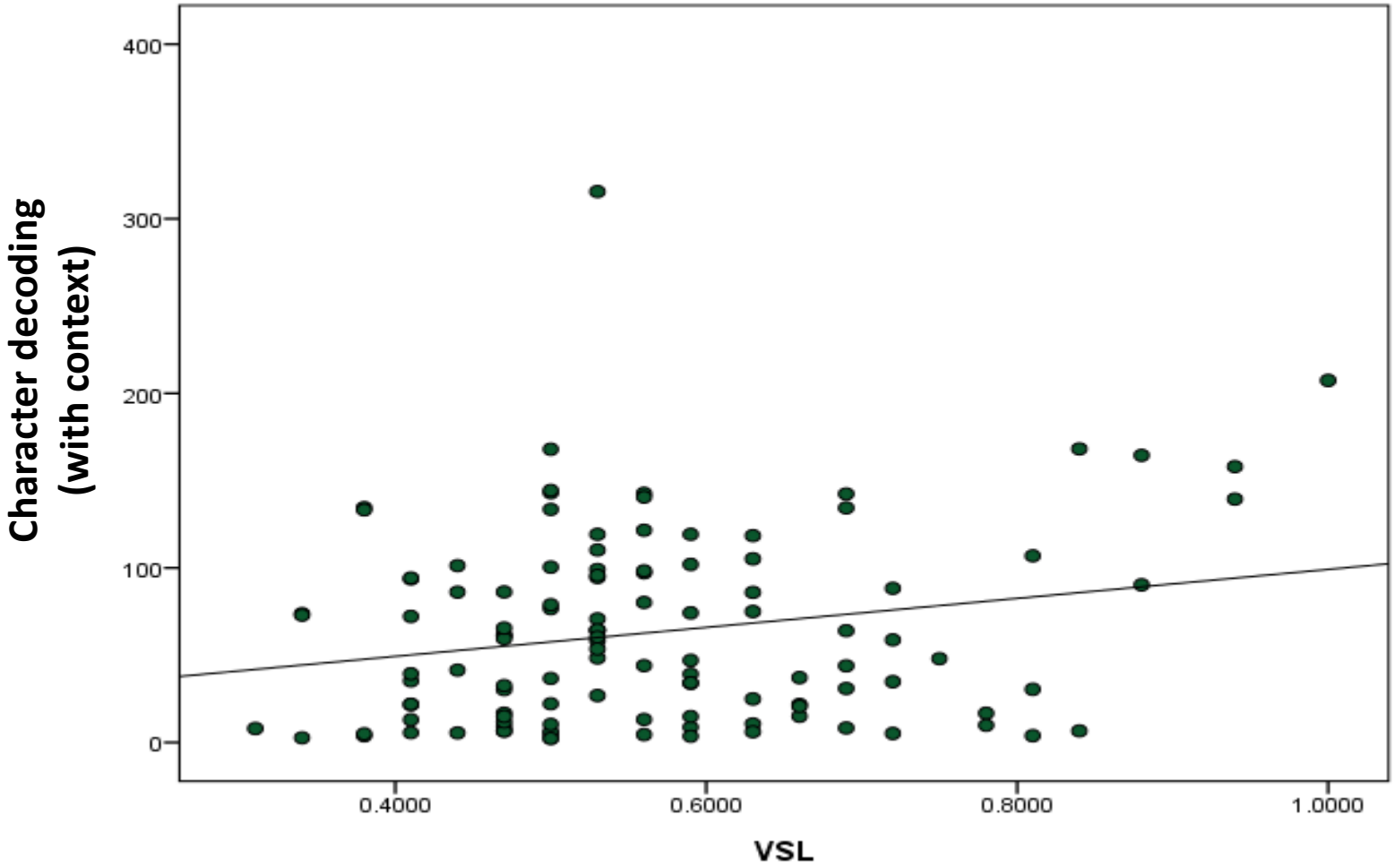
Statistical learning (SL) vs. Character size

r = .37
N = 116



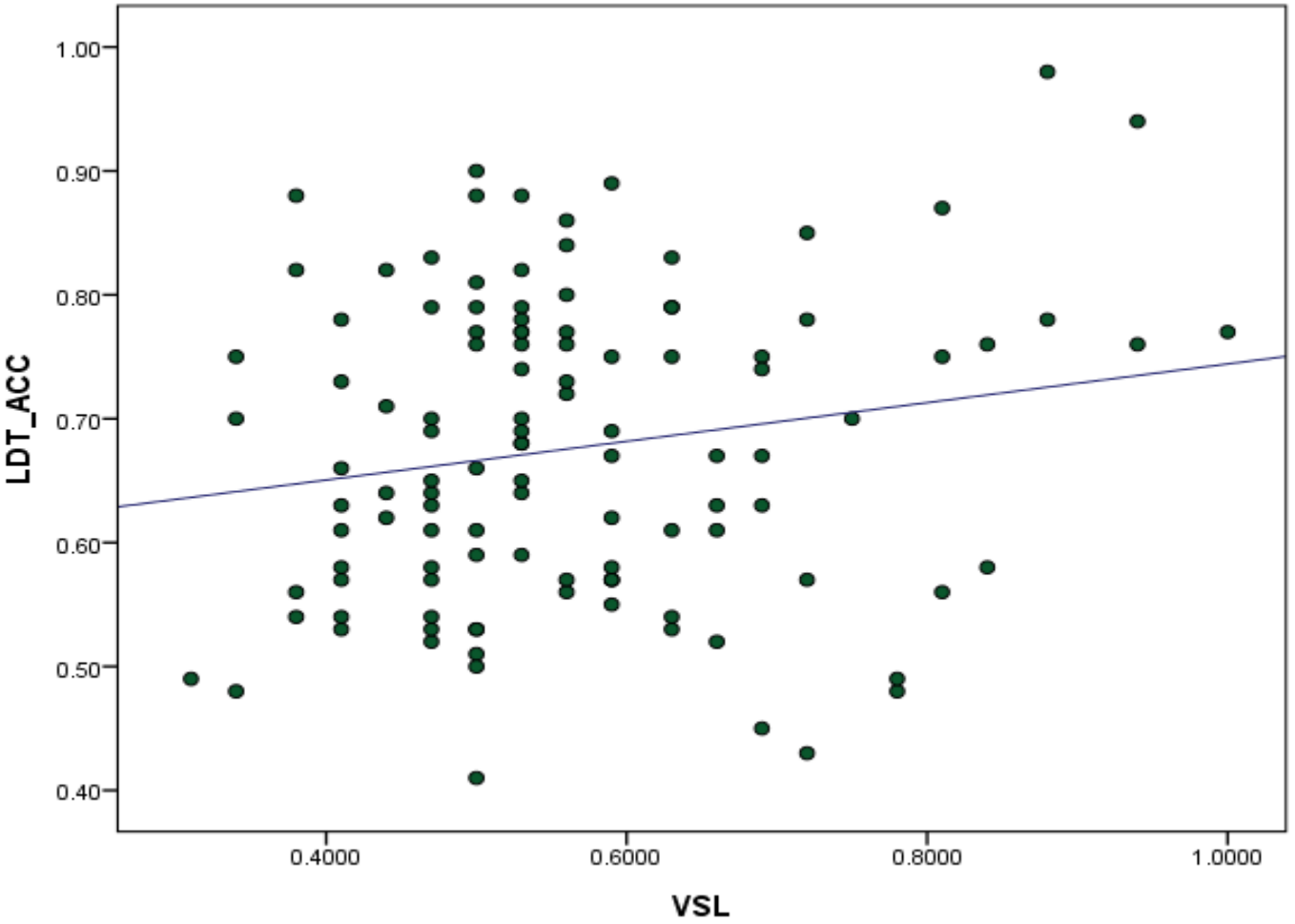
Statistical learning (SL)

r = .21
N = 116



Statistical learning (SL) vs. LDT_ACC

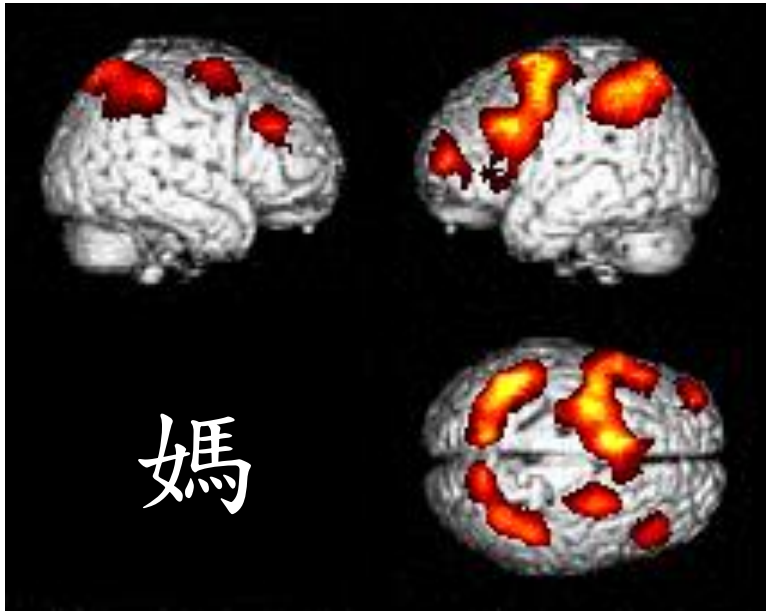
r = .18
N = 115



Regression analysis

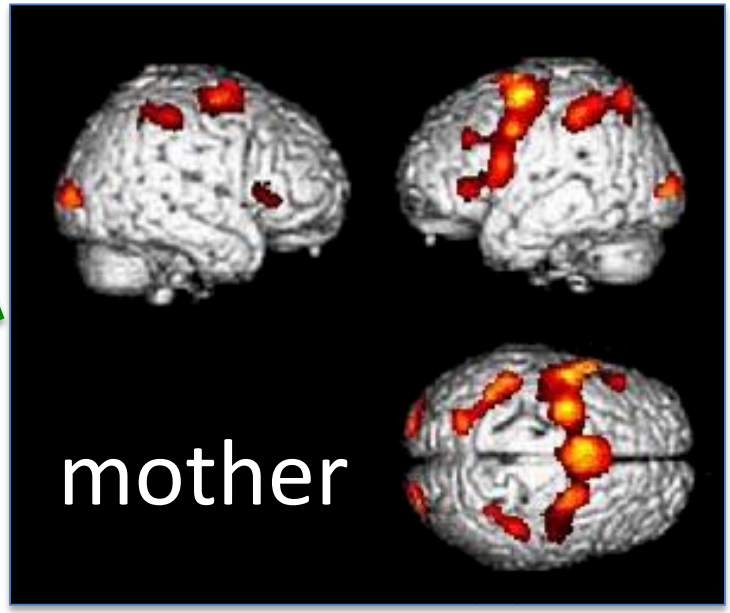
N = 59	Character size	Decoding (with context)	Decoding (no context)	LDT_ ACC	RAN_ num (N=57)	RAN_ col (N=28)	RAN_ pic (N=23)
CH Learning Time	.59	.44	.53	.46	-.30	-.35	-.27
Raven's score	-.13	.03	-.08	-.09	-.06	-.17	-.12
Digit span	.07	-.03	-.07	-.10	.11	.18	.37
VPT	.06	.30	.21	.27	-.26	-.16	.08
Corsi	.03	-.21	-.09	-.08	.12	.10	.18
VSL	.26	.20	.11	.15	-.11	-.14	-.15

Chinese speakers retain Chinese (sensitivity to word form is left lateralized)



alphabetic readers acquire Chinese?

English speakers retain English (sensitivity to word form is right lateralized)



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