

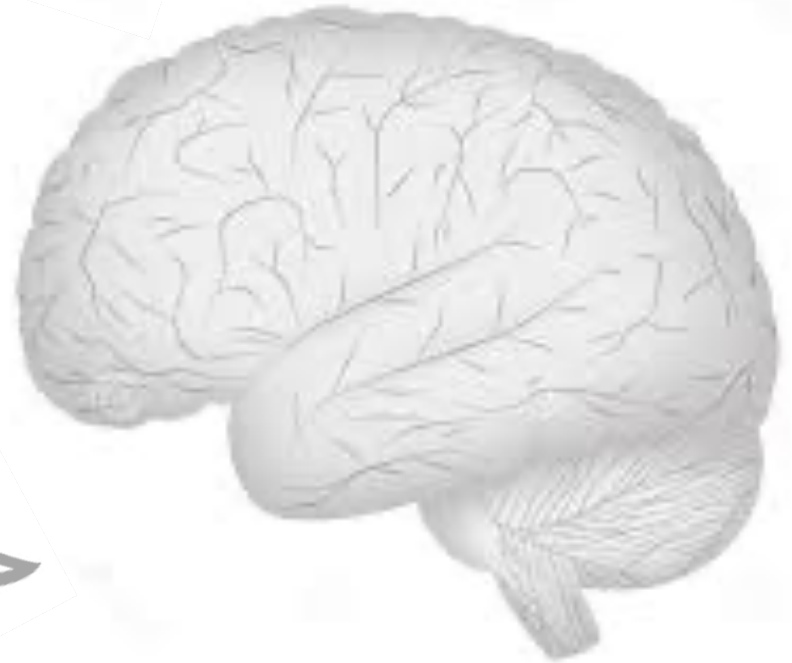
# The Bilingual Brain

Hola!

Terve!

مرحبا

Hello!



- 1) Do different languages occupy different parts of your brain?
- 2) When you're using one language, what's going on with the other one? Is it napping? Or ready?
- 3) How does the brain switch between languages?

# 1) Do different languages occupy different parts of your brain?

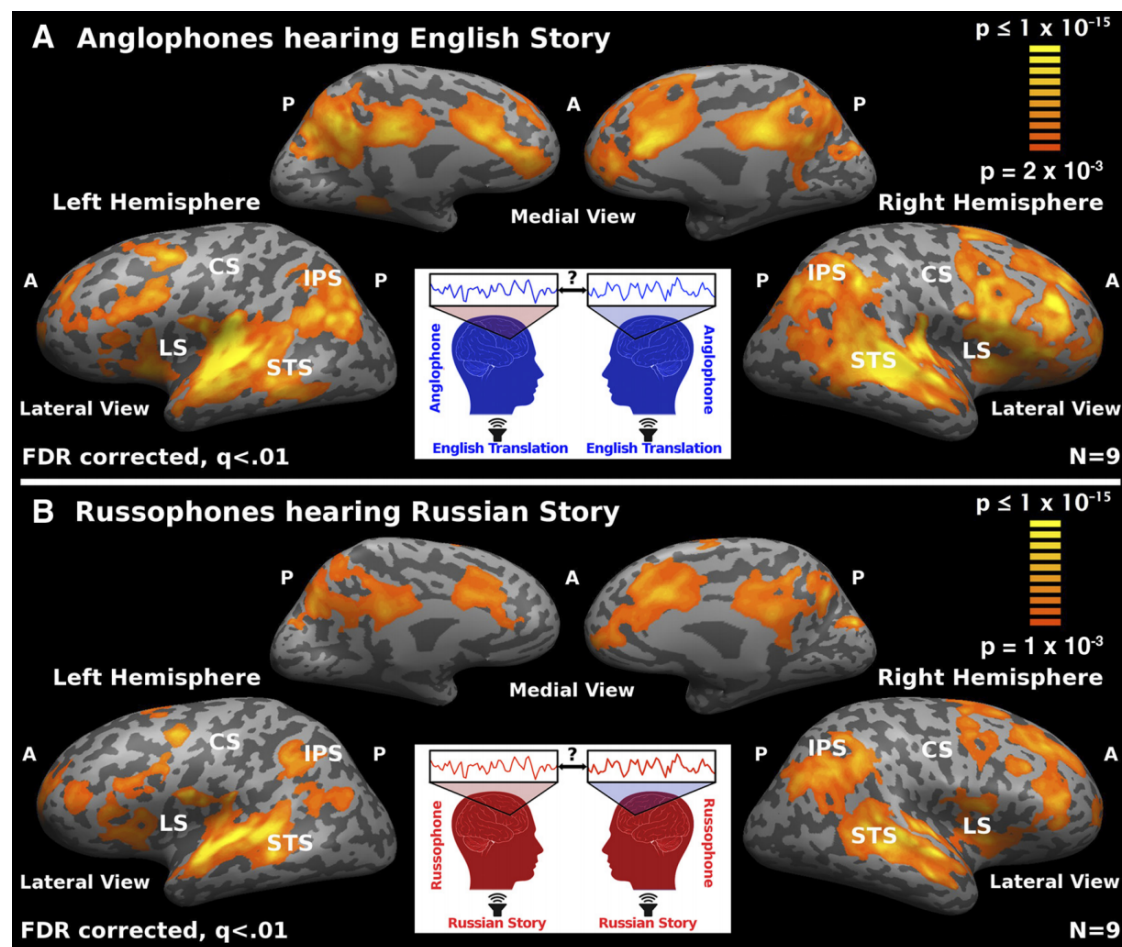
- By and large, the neural basis of language is much more similar across languages.
- One example, Russian vs. English →
- But what does it look like if you stuff both languages into the same brain?

## Not Lost in Translation: Neural Responses Shared Across Languages

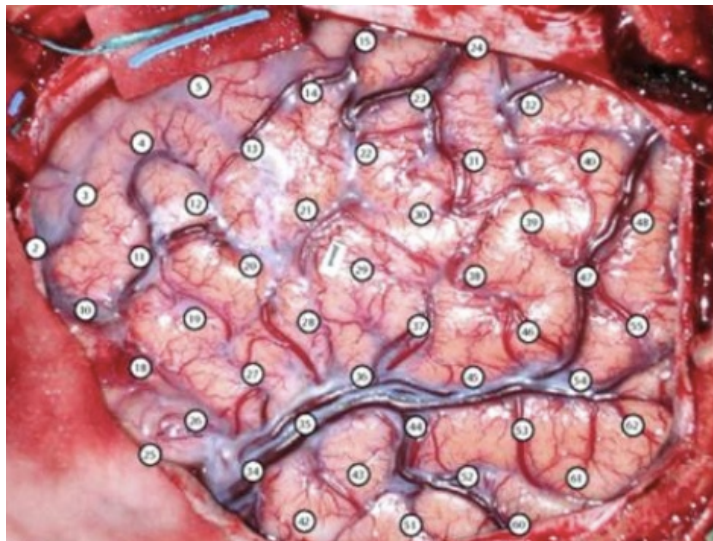
The Journal of Neuroscience, October 31, 2012 • 32(44):15277–15283 • 15277

Christopher J. Honey,<sup>1,2\*</sup> Christopher R. Thompson,<sup>1,\*</sup> Yulia Lerner,<sup>1,2</sup> and Uri Hasson<sup>1,2</sup>

<sup>1</sup>Department of Psychology and <sup>2</sup>Princeton Neuroscience Institute, Princeton University, Princeton, New Jersey 08540



- But what does it look like if you stuff both languages into the same brain?
- At a macroscopic level, different languages in a bilingual brain don't generally spatially separate (Costa, 2020).
- When we examine the details, differences can be observed.



## The Bilingual Brain

George A. Ojemann, MD, Harry A. Whitaker, PhD

Arch Neurol—Vol 35, July 1978

**CASE 1.**—At the time of this craniotomy, this right-handed patient was 37 years old; he had had the onset of psychomotor seizures at age 4. He was reared in Holland, and spoke only Dutch as a youth. While in his native country, a left temporal EEG focus was discovered, and a partial left temporal lobectomy was performed when he was 23. Seizures recurred at age 28, with similar EEG localization. At age 25 he emigrated to the United States; he claims that at that time he spoke only one word of English. However, he has subsequently acquired a working command of spoken English, although his comprehension of written English remained somewhat limited and he preferred to read in Dutch.



 **DUTCH**  
**ENGLISH**

Picture naming task








“bird”

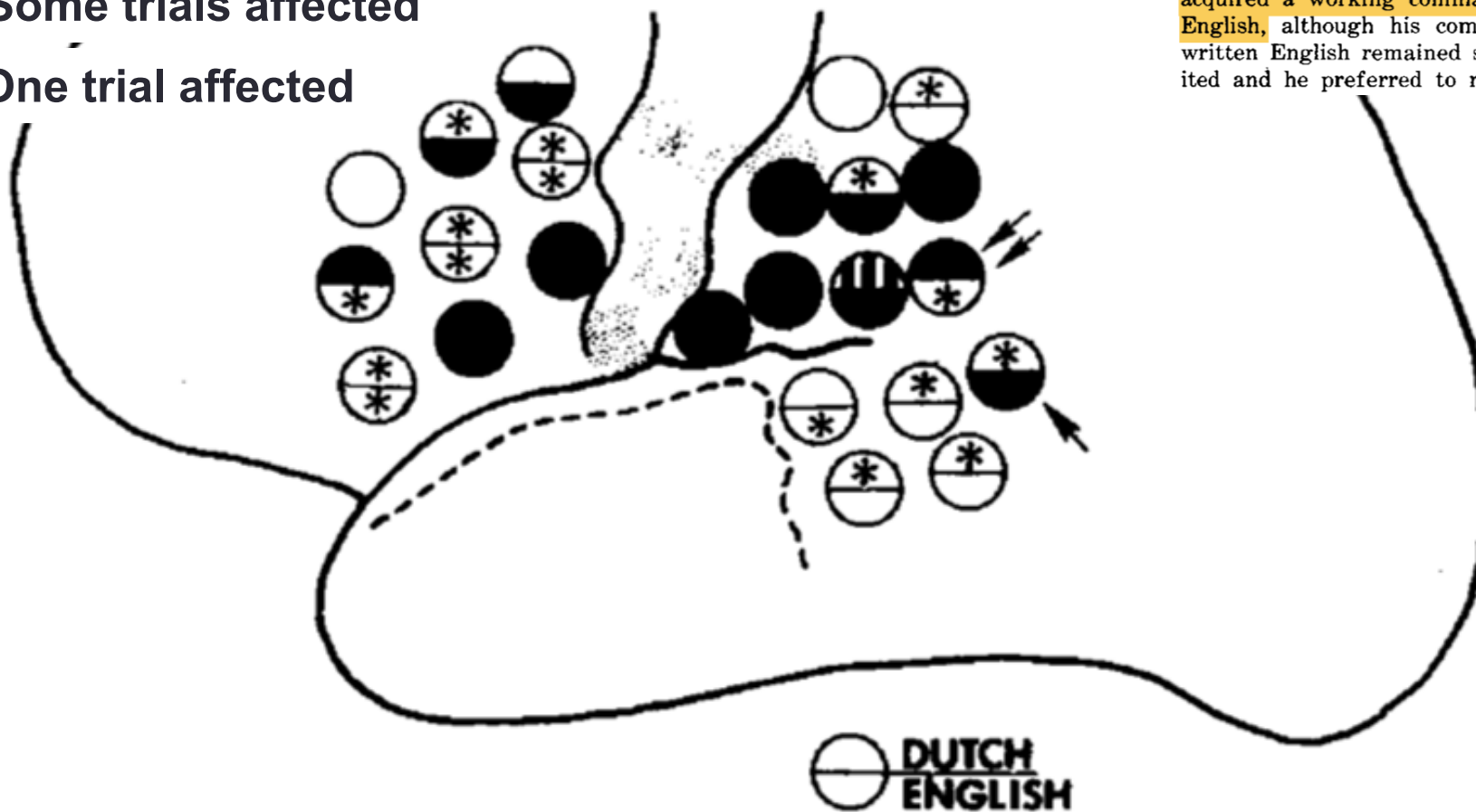
“vogel”

## The Bilingual Brain

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**CASE 1.**—At the time of this craniotomy, this right-handed patient was 37 years old; he had had the onset of psychomotor seizures at age 4. He was reared in Holland, and spoke only Dutch as a youth. While in his native country, a left temporal EEG focus was discovered, and a partial left temporal lobectomy was performed when he was 23. Seizures recurred at age 28, with similar EEG localization. At age 25 he emigrated to the United States; he claims that at that time he spoke only one word of English. However, he has subsequently acquired a working command of spoken English, although his comprehension of written English remained somewhat limited and he preferred to read in Dutch.

-  both affected
-  English only affected (all trials)
-  Dutch only affected (all trials)
-  Some trials affected
-  One trial affected



 **DUTCH**  
**ENGLISH**



1) Do different languages occupy different parts of your brain?

➤ **Not in broad terms, but at the micro-level we see differences.**

2) When you're using one language, what's going on with the other one? Is it napping? Or ready?

3) How does the brain switch between languages?

2) When you're using one language, what's going on with the other one?

**Related**

Wood – Carpenter

**Unrelated**

Ham – Train

2) When you're using one language, what's going on with the other one?

**Related**

Wood – Carpenter

**Unrelated**

Ham – Train

Doctor – Nurse

Rabbit – Pencil

## 2) When you're using one language, what's going on with the other one?

### Related

### Unrelated

Form related in Chinese	Wood – Carpenter	Ham – Train
	木头 – 木匠 mu tou – mu jiang	火腿 – 火车 huo tui – huo che

Doctor – Nurse

Rabbit – Pencil



## 2) When you're using one language, what's going on with the other one?

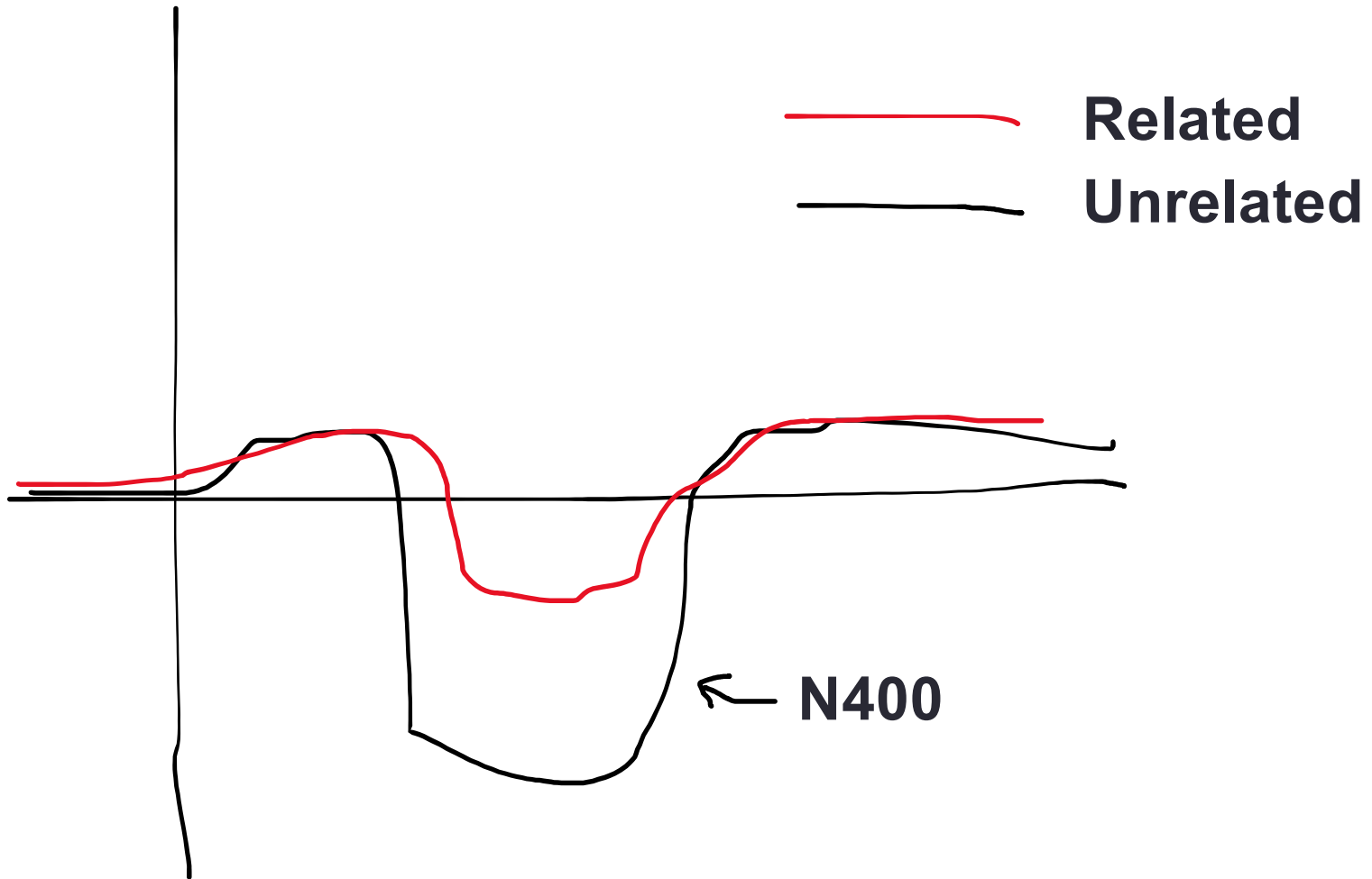
### Related

### Unrelated

Form related in Chinese	Wood – Carpenter	Ham – Train
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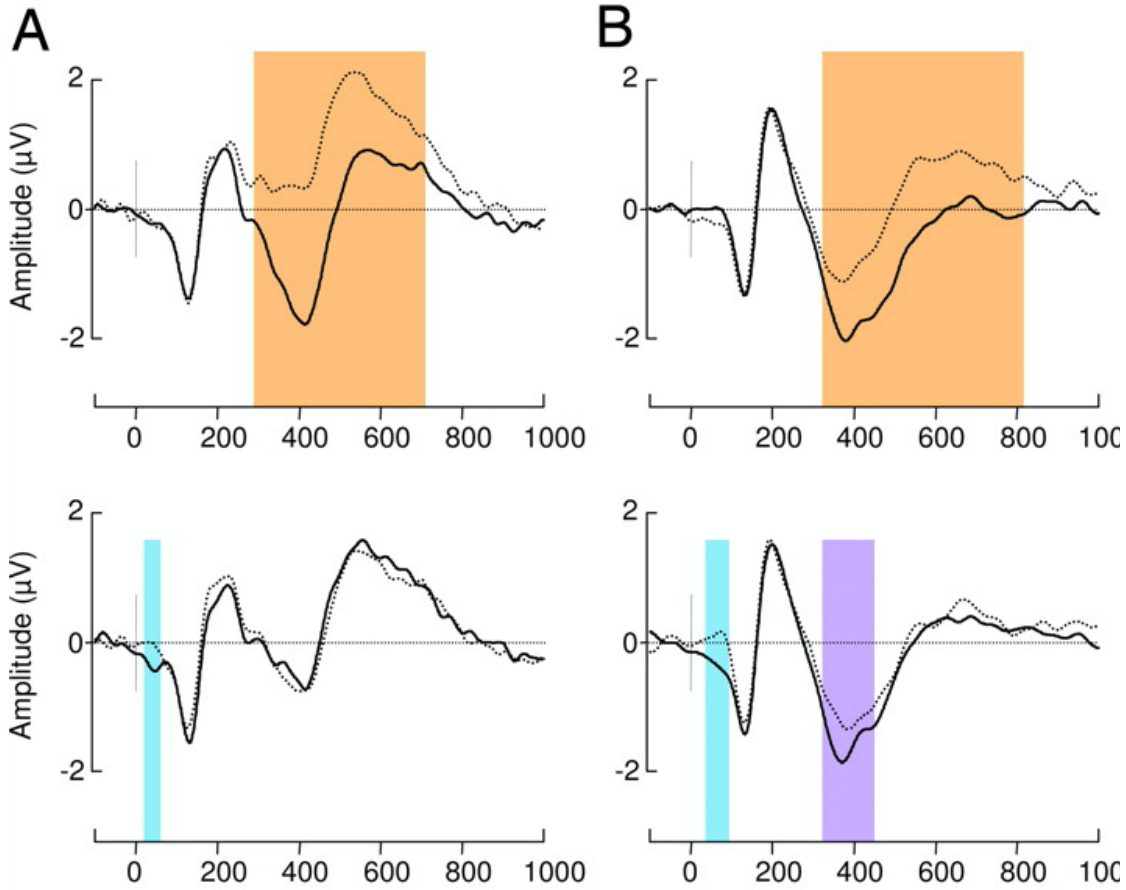
Unrelated in Chinese	Doctor – Nurse	Rabbit – Pencil
	医生 – 病人 yi sheng – bing ren	兔子 – 钢笔 tu zi – gang bi

# Dependent measure: N400



### English monolinguals

### Chinese-English bilinguals



Main effect of semantic relatedness

- ..... Meaning Related (S+)
- Meaning Unrelated (S-)

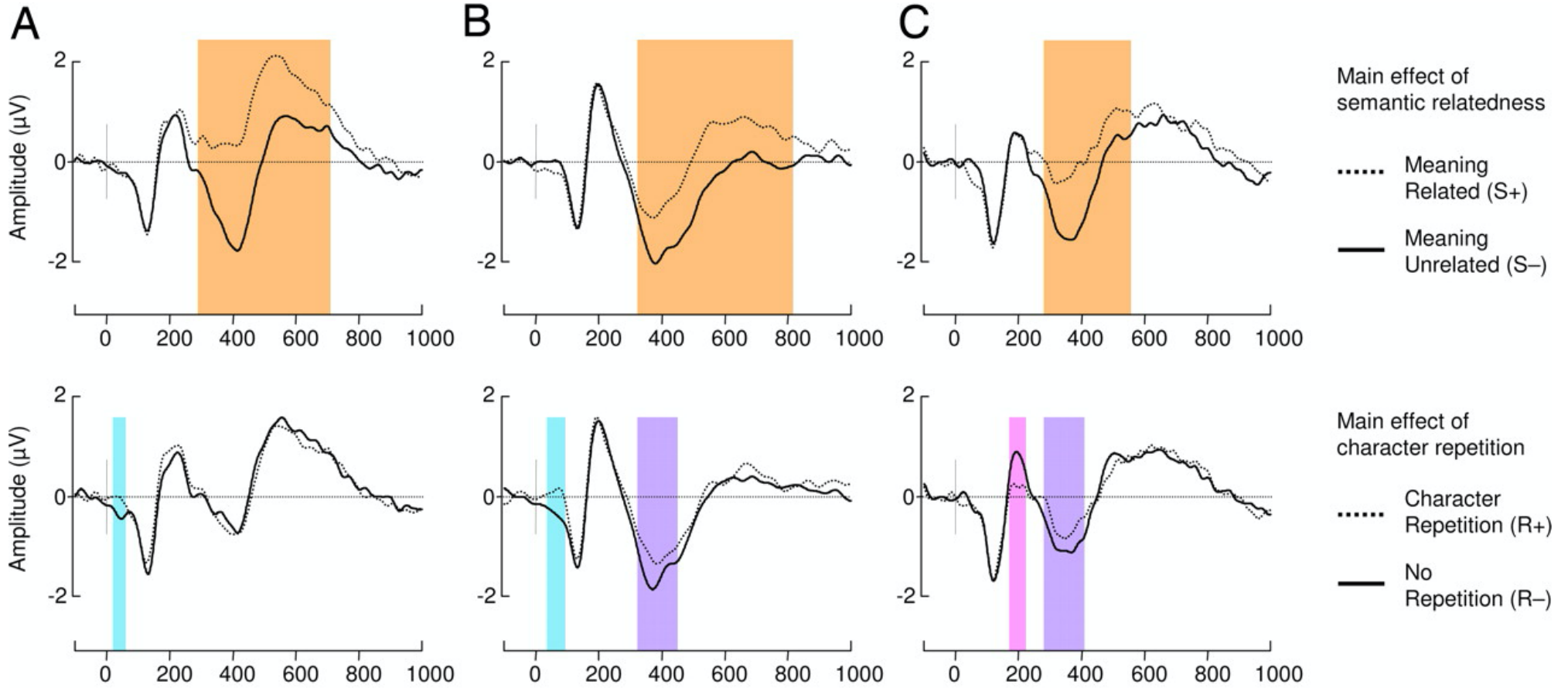
Main effect of character repetition

- ..... Character Repetition (R+)
- No Repetition (R-)

### English monolinguals

### Chinese-English bilinguals

### Chinese monolinguals (did the task in Chinese)



1) Do different languages occupy different parts of your brain?

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2) When you're using one language, what's going on with the other one?

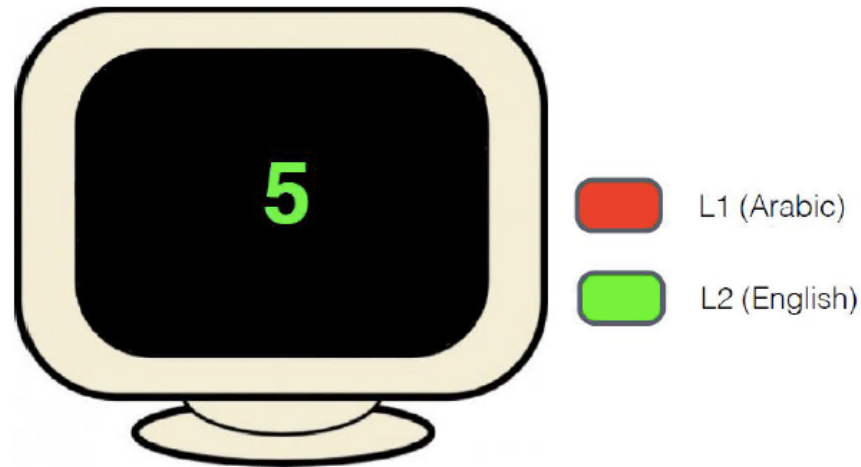
➤ Even when a language is not being used, it is still activate and can affect the processing of the language that is in use.

3) How does the brain switch between languages?



### 3) How does the brain switch between languages?

- Popular paradigm and result:



- Switching is difficult and heavily recruits prefrontal executive control systems
- In a bilingual brain, executive control gets extra “exercise” leading to better control and inhibitory mechanisms in general. “Bilingual advantage”

Is language switching under more ecologically valid conditions actually costly?

To what extent does more natural language switching engage the executive control systems?

# When do bilinguals switch languages?

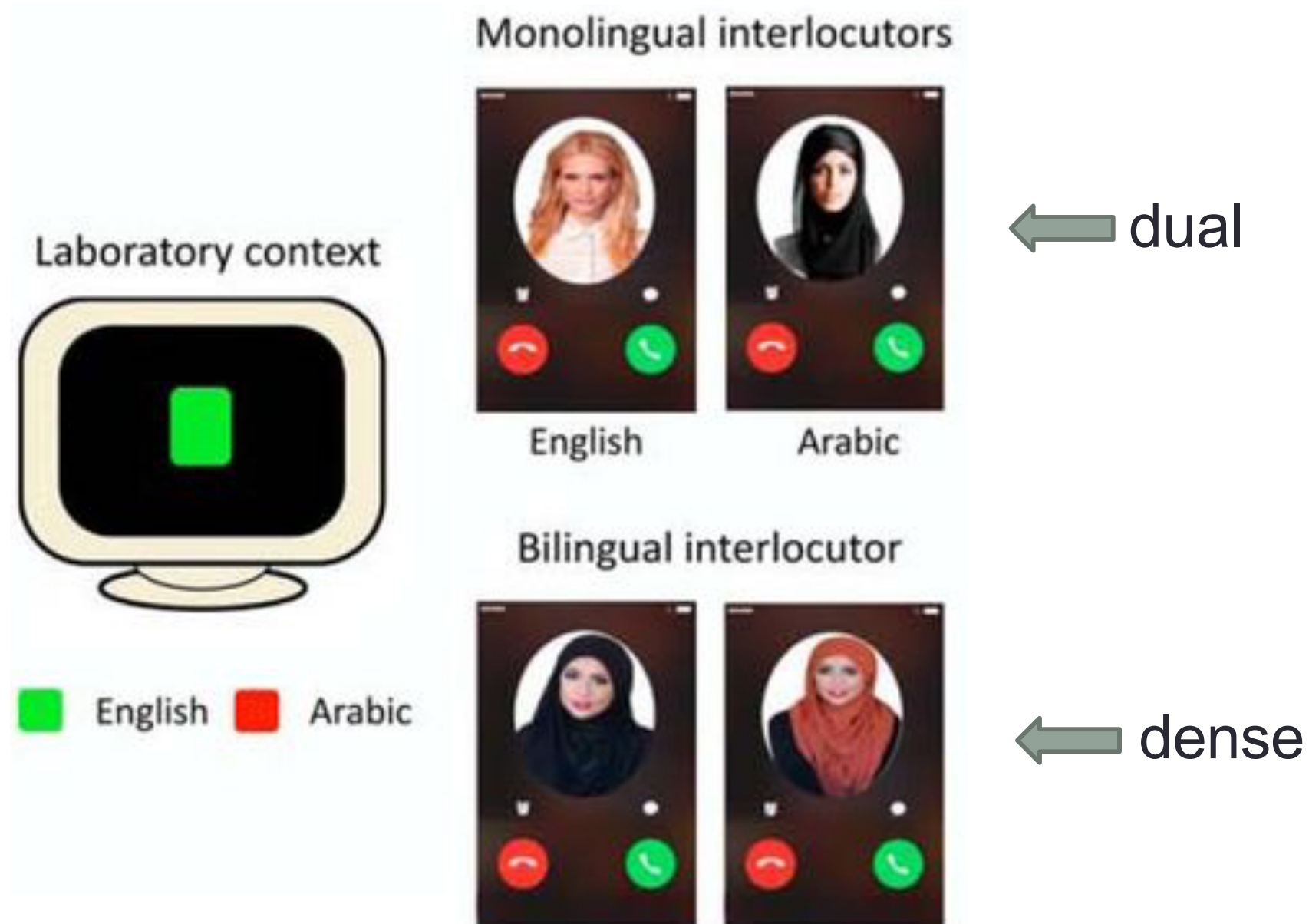
- When they want to:
  - When conversing with a similarly bilingual person, you can switch languages whenever you want and still be understood.
  - “Dense code-switching context”
- When they have to:
  - When switching from conversing with person A to person B and they both command just one of your languages.
  - “Dual language context”



**Esti Blanco  
Elorrieta**



# Modelling constrained (dual) and free (dense) language switching in the lab



# Picture naming



(Blanco-Elorrieta & Pylkkänen, 2017, *Journal of Neuroscience*)



# Picture naming



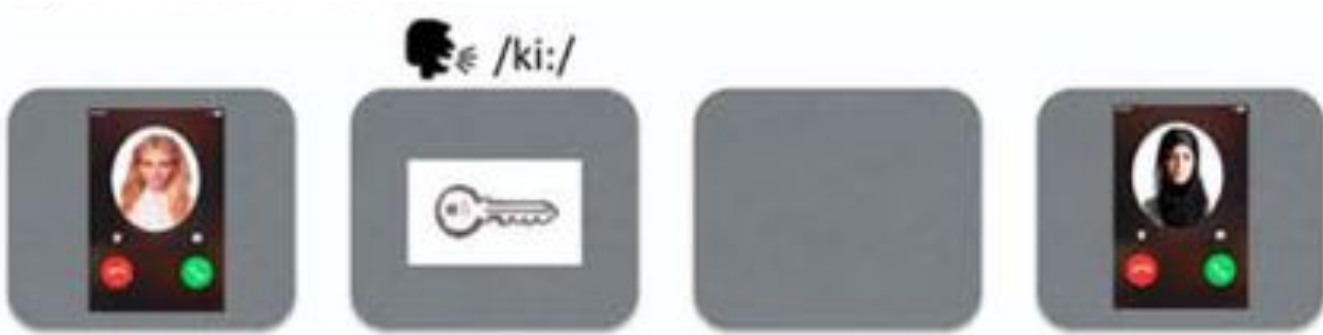
(Blanco-Elorrieta & Pylkkänen, 2017, *Journal of Neuroscience*)

# Picture naming



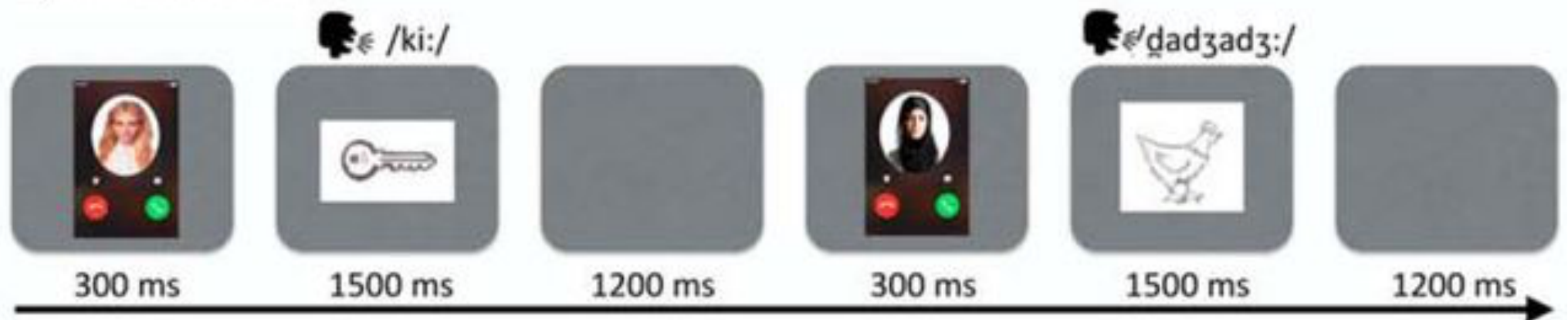
(Blanco-Elorrieta & Pylkkänen, 2017, *Journal of Neuroscience*)

# Picture naming



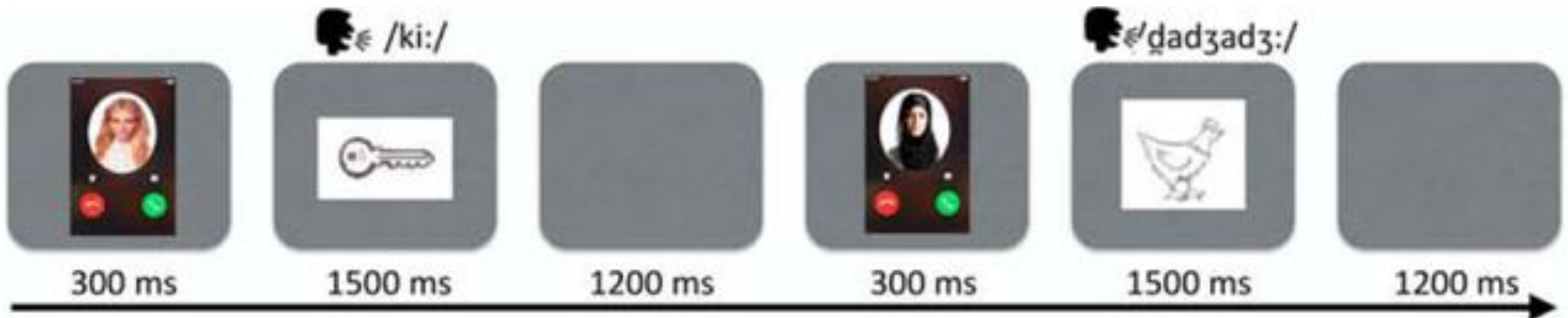
(Blanco-Elorrieta & Pylkkänen, 2017, *Journal of Neuroscience*)

# Picture naming



(Blanco-Elorrieta & Pylkkänen, 2017, *Journal of Neuroscience*)

# Picture naming

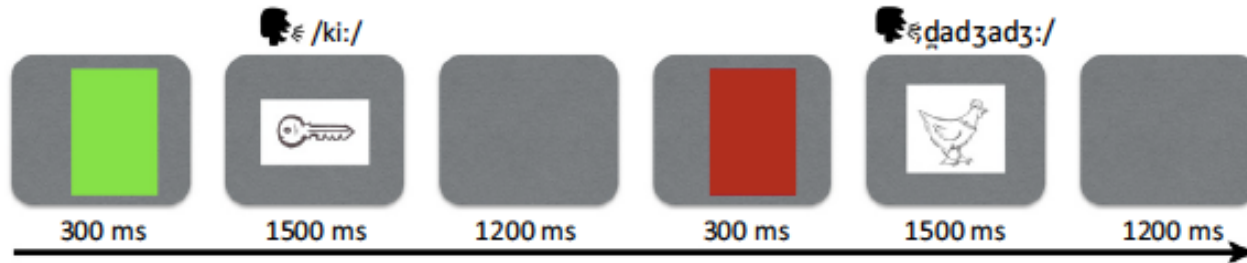


(Blanco-Elorrieta & Pylkkänen, 2017, *Journal of Neuroscience*)

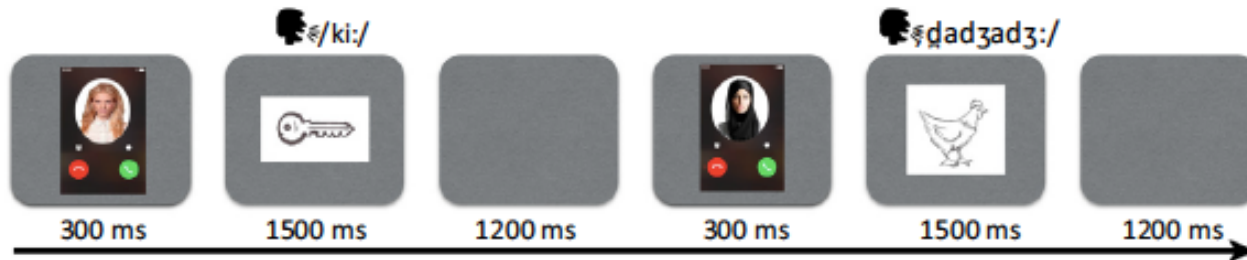


**(A)** Context designs

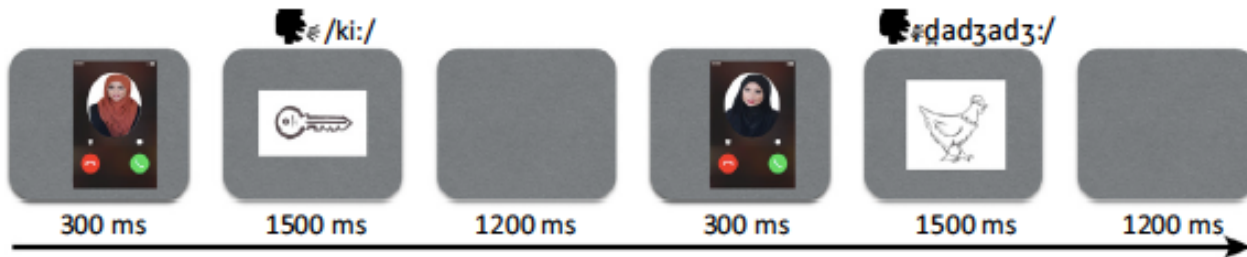
(i) Dual-language context (artificial cues)



(ii) Dual-language context (natural cues)



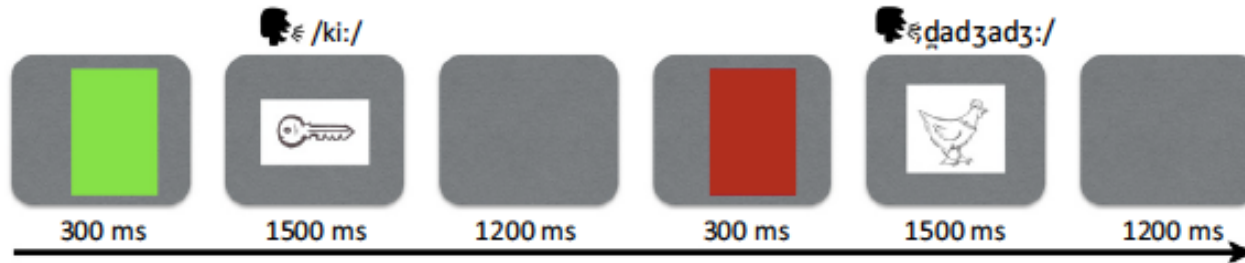
(iii) Dense code-switching context (natural cues)



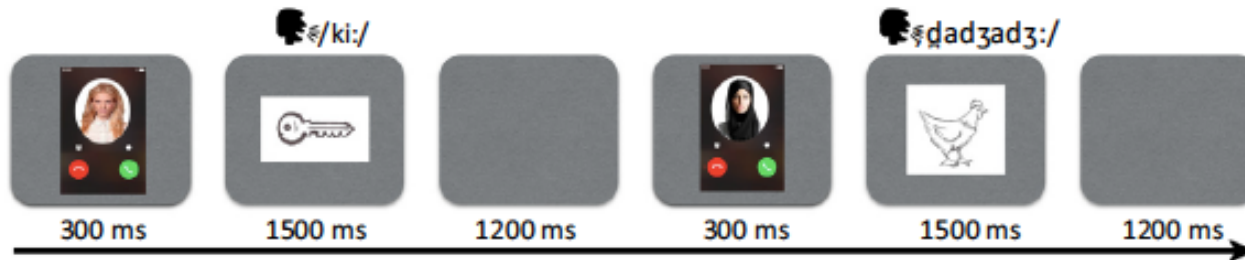
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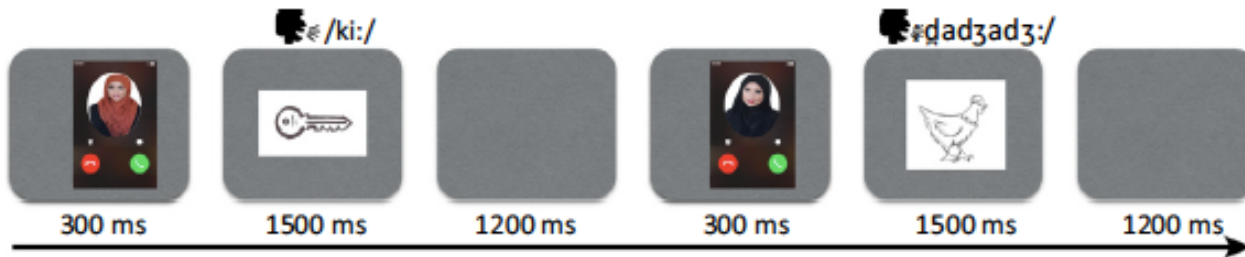
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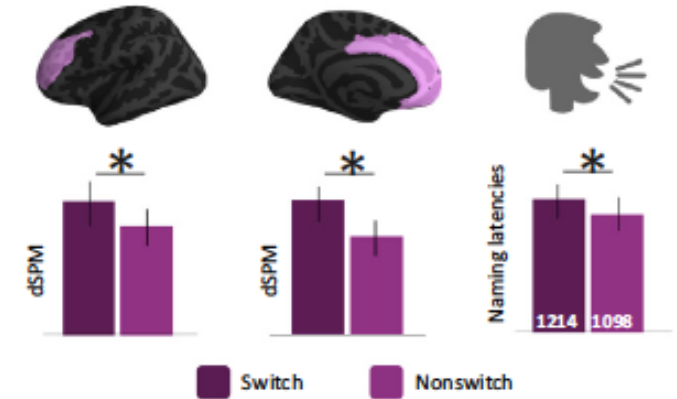
**(ii) Dual-language context (natural cues)**



**(iii) Dense code-switching context (natural cues)**

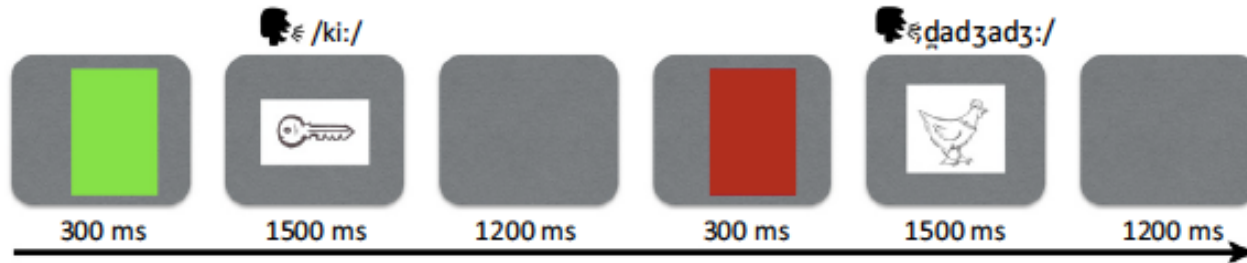


**(B) Context effects on brain activity and naming latencies**

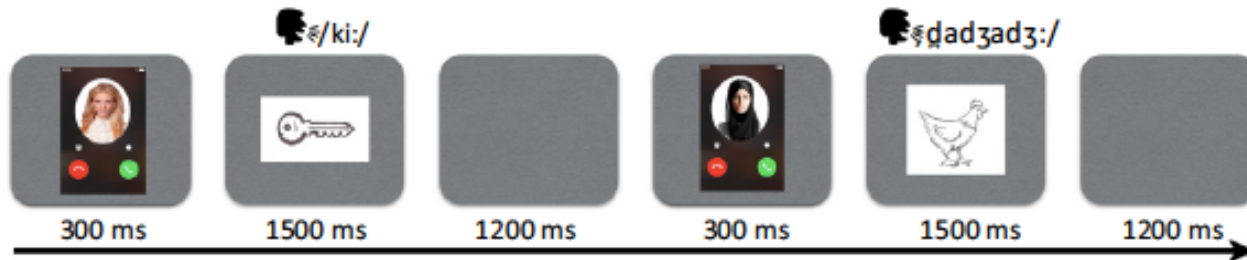


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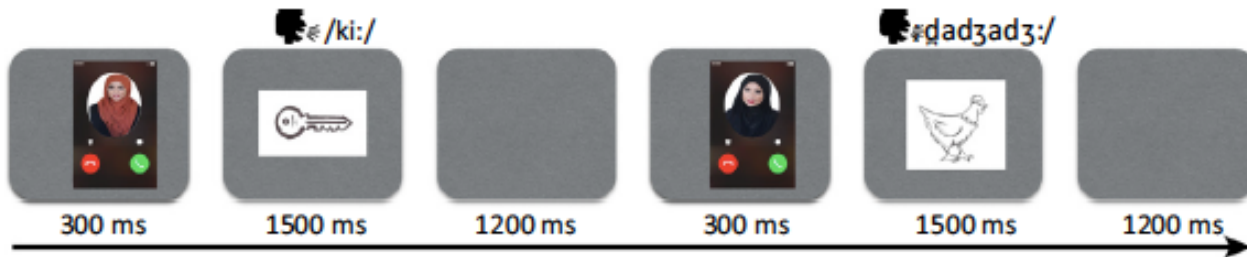
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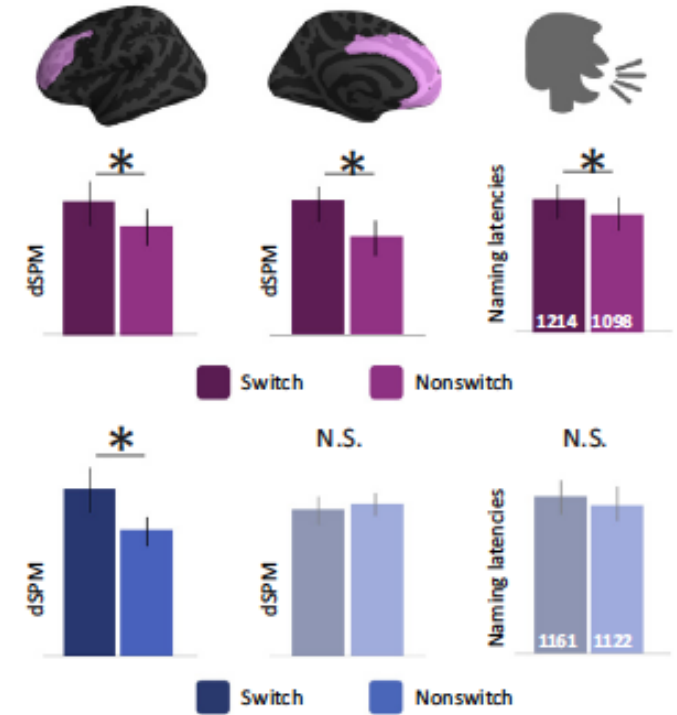
**(ii) Dual-language context (natural cues)**



**(iii) Dense code-switching context (natural cues)**

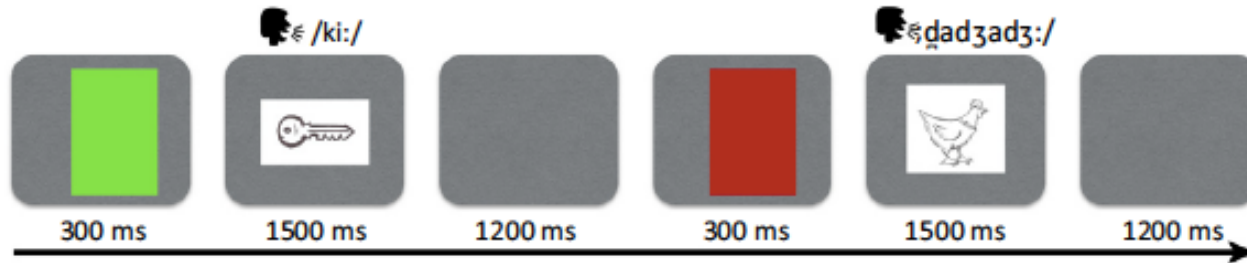


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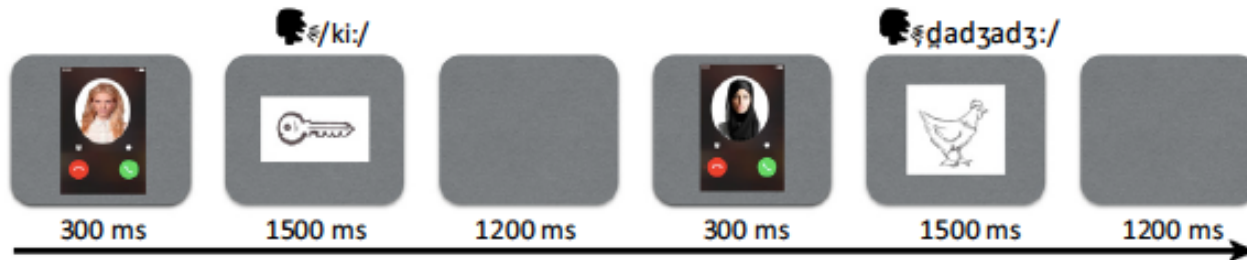


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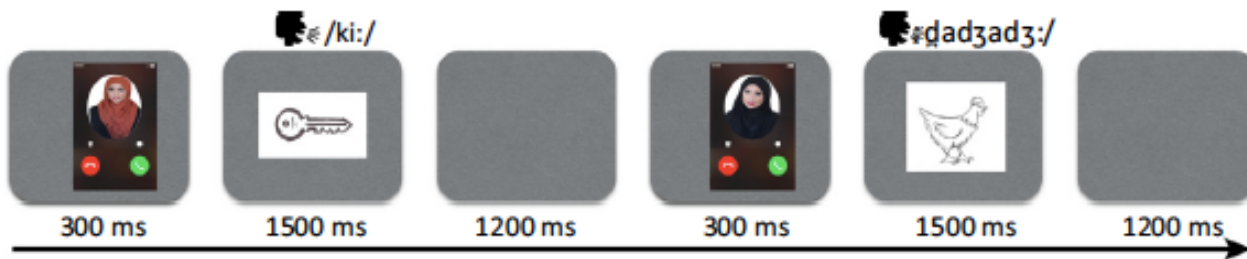
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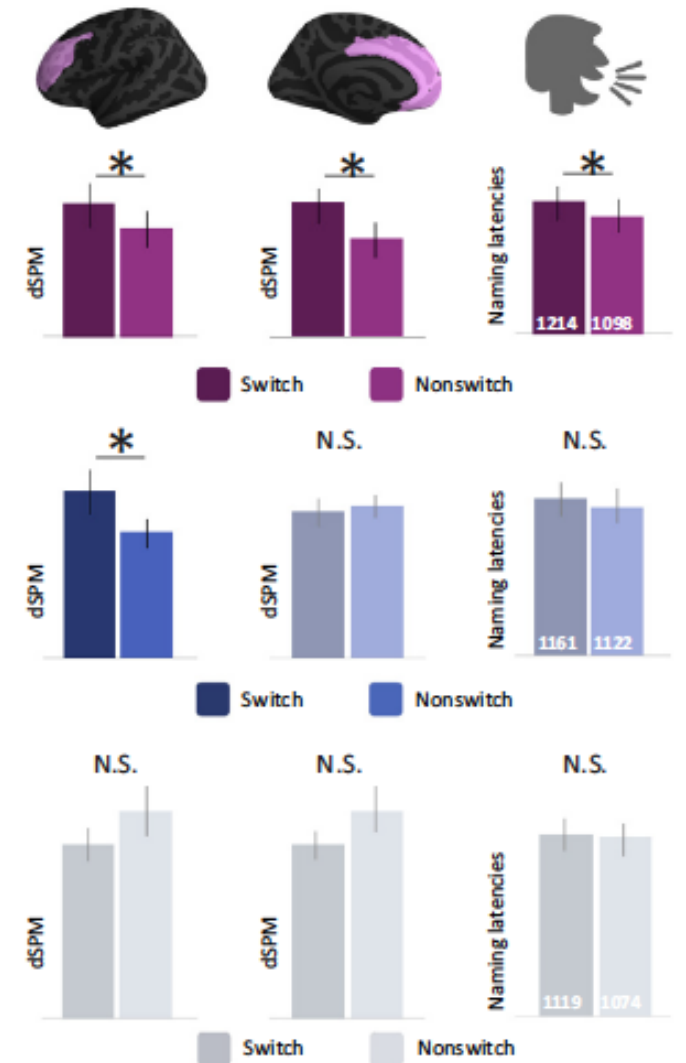
**(ii) Dual-language context (natural cues)**



**(iii) Dense code-switching context (natural cues)**



**(B) Context effects on brain activity and naming latencies**



(Blanco-Elorrieta & Pylkkänen, 2017, *Journal of Neuroscience*)

## (A) Context designs

### (i) Dual-language context (artificial cues)

- Replication of behavioral switching cost and prefrontal engagement for artificial cues

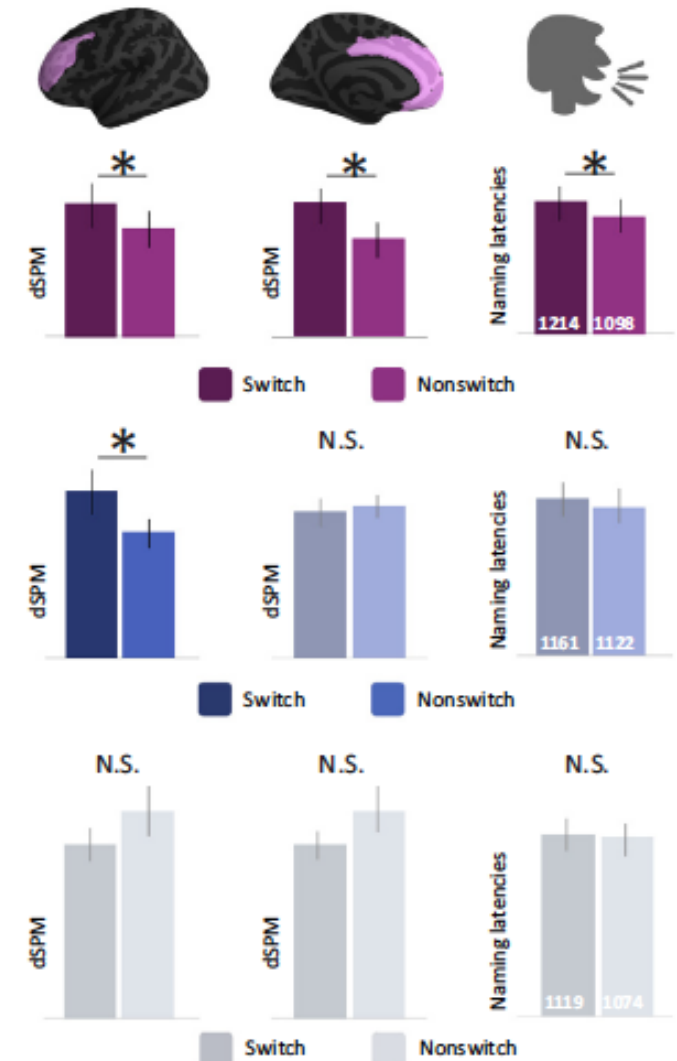
### (ii) Dual-language context (natural cues)

- No behavioral cost and less prefrontal engagement in a more natural dual language context

### (iii) Dense code-switching context (natural cues)

- No behavioral cost and no prefrontal increase for switches in a natural dense context.

## (B) Context effects on brain activity and naming latencies



1) Do different languages occupy different parts of your brain?

- Not in broad terms, but at the micro-level we see differences.

2) When you're using one language, what's going on with the other one?

- Even when a language is not being used, it is still activate and can affect the processing of the language that is in use.

3) How does the brain switch between languages?

- In a highly context dependent way.
- The more natural the switching situation, the less “brain effort” is recruited, although switching mandated by the context is always somewhat costly.

ALBERT  
COSTA



# The Bilingual Brain

And What It Tells Us  
About the Science  
of Language