On the cross talk between bilingual language control and executive control

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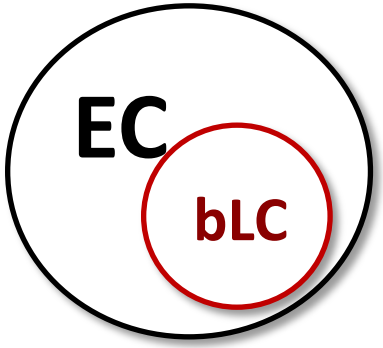
Barcelona, Spain

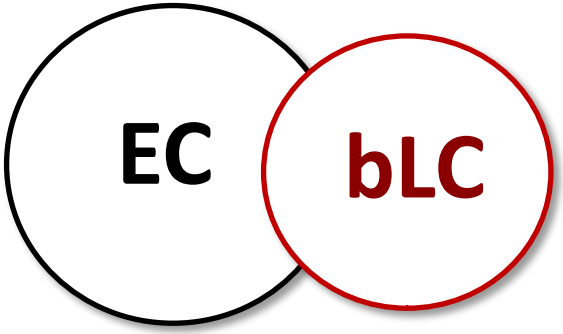
CUNY, May 19th

The question

Which are the common mechanisms between domain-general EC and bilingual language control?



Fully overlapped



Partially overlapped

The approach

Explore associations and dissociations in linguistic and non-linguistic tasks that "supposedly" share a common mechanism.

- Single case studies of patients
- Healthy adults
- Patients with cognitive impairments
- Functional overlap at the brain level
- Differences between bilinguals and monolinguals in switching

Costa & Sebastian-Gallés (2014), Nature Reviews Neuroscience

The answer

The link between bilingual language control and domain executive control is an elusive one, especially if you look at behavioral measures.

It is difficult to find associations across tasks, and sometimes language control and executive control clearly dissociate, especially in impaired individuals…..

Still, the neuroimaging data suggests some sort of overlap, and some differences between monolinguals and bilinguals in the networks involved in executive control.

The approach

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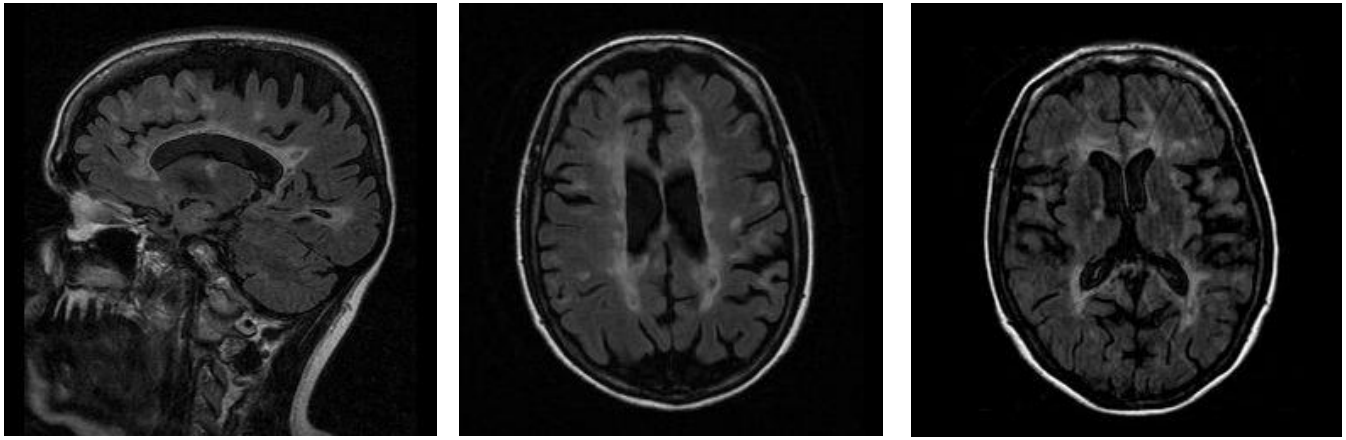
Costa & Sebastian-Gallés (2014), Nature Reviews Neuroscience

Single-case study of pathological language control

Calabria M., Marne P., Romero-Pinel , Juncadella M. and Costa A. (2014), Cognitive Neuropsychology

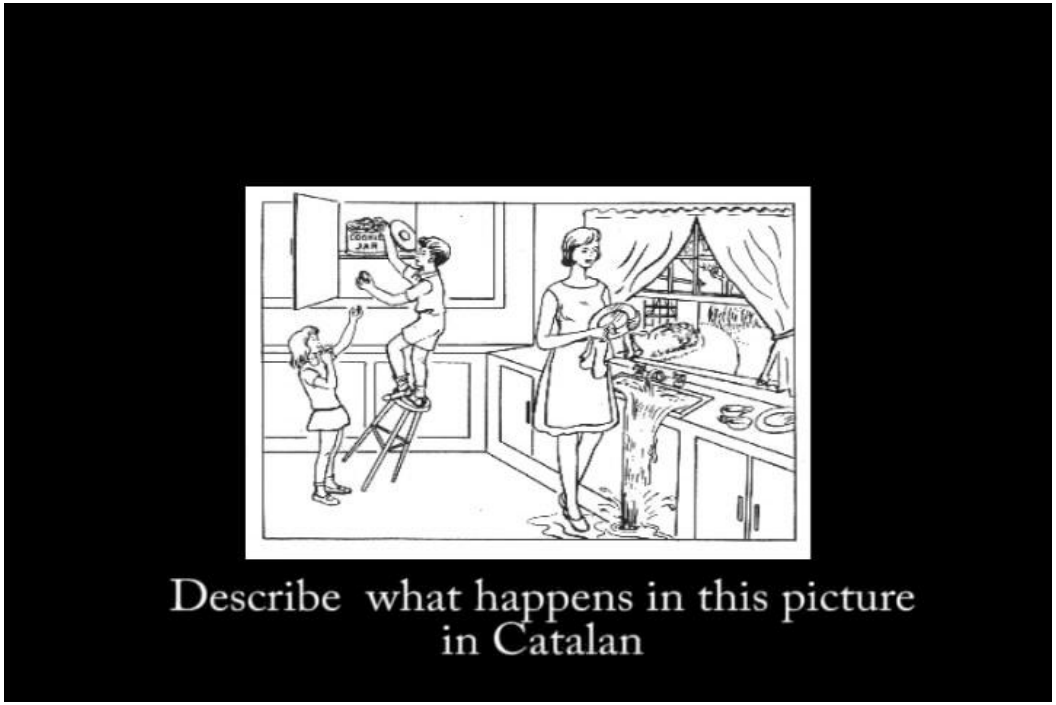
RRT, Catalan-Spanish bilingual, 44 years old, female



2011 MRI

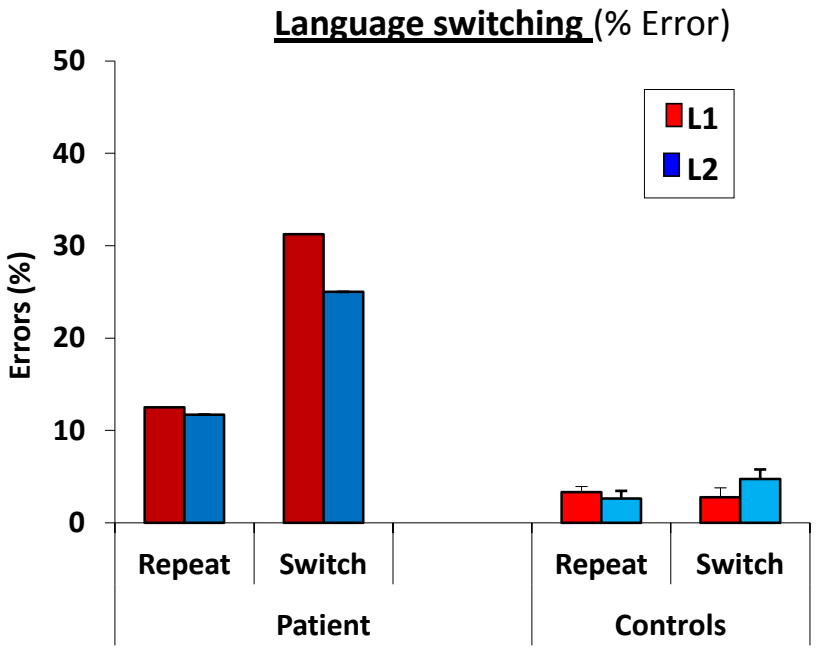
Multiple lesions of the white matters both at the supratentorial level and at the infratentorial level (corpus callosum, right side of the mesencephalon, the medial part of the cerebellar peduncle, cerebellum, superior part of the left temporal lobe).
The **left caudate** showed lesions both in its posterior part and in its tail, whereas the **right caudate** showed lesions only in its tail.

RRT: **Spontaneous pathological language switching**



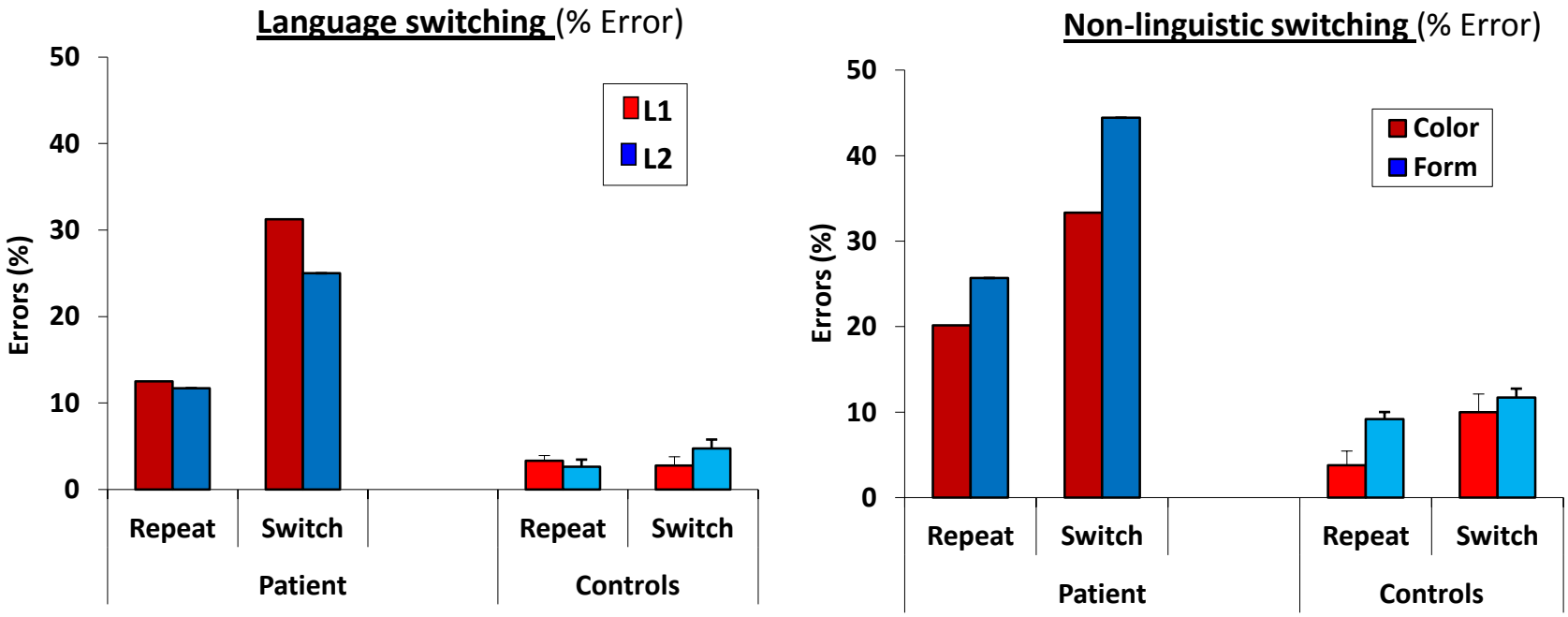
Language to speak	Catalan	Spanish	Spontaneous switches
Catalan (510 words)	*39.6%*	***60.4%***	*24*
Spanish (528 words)	***7.8%***	*92.2%*	*7*

RRT: **Linguistic and non-linguistic task switching**



Deficit in Language switching

RRT: **Linguistic and non-linguistic task switching**



The patient ***was impaired both*** in linguistic and non-linguistic switching as compared to controls

However… dissociations tend to be more informative

Aglioti A., Beltramello A., Girardi F., and Fabbro F. (1996), Brain

E.M. , Venetan-Italian speaker, subcortical aphasia

Spontaneous speech: in L1 there was a high percentage of words (51.7%) in the non-requested language (L2); by contrast, the percentage of words in L1 during L2 sessions was rather low (4.4%).'

'It is noteworthy that E.M.'s performance in the Wisconsin card sorting test, a non-verbal task which taps the ability to change from one criterion of choice to another, was within normal range. ***This result suggests that E.M.'s fixation behavior is mostly linguistic in nature.'***

Presence of associations but also of instructive dissociations, which suggest relative independence of the BLC system. In other words, BLC can be disrupted independently of executive control processes.

The approach

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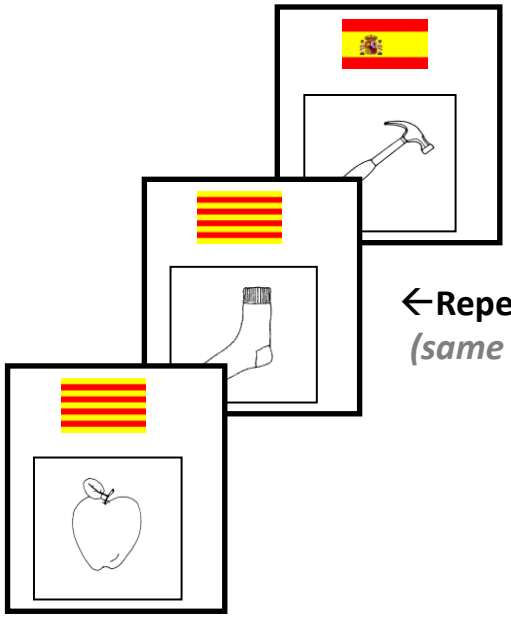
Costa & Sebastian-Gallés (2014), Nature Reviews Neuroscience

Correlations of the individual performances in linguistic and non-linguistic tasks

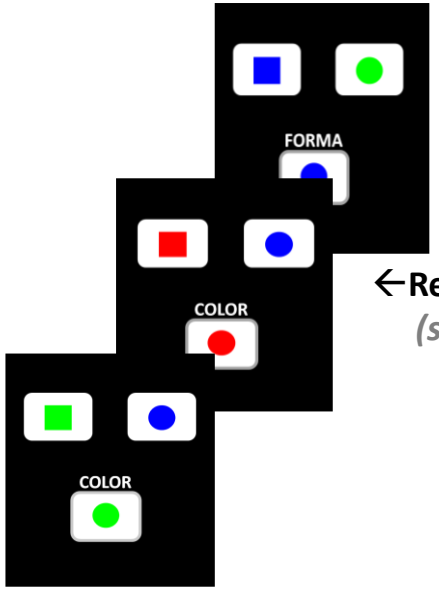
LANGUAGE SWITCHING



←Switch trial
(different language)

←Repeat trial
(same language)

NON-LINGUISTIC SWITCHING TASK



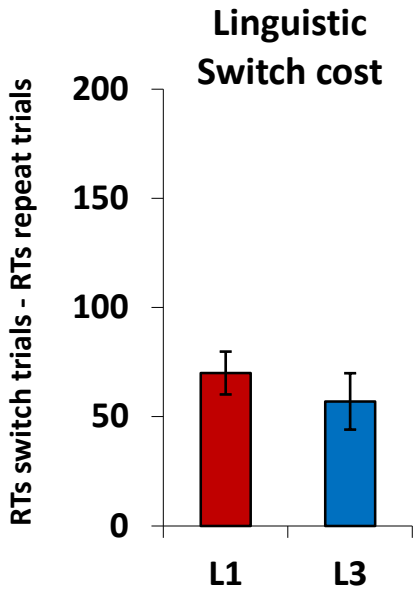
←Switch trial
(different sorting criterion)

←Repeat trial
(same sorting criterion)

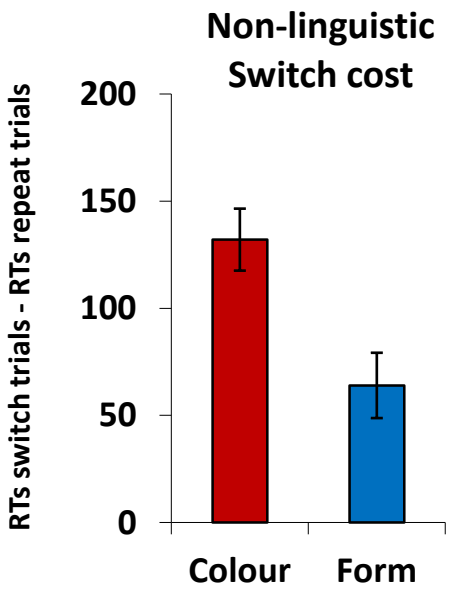
Branzi F.M., Calabria M., Boscarino M.L., and Costa, A. (Under Review)

Correlations of the individual performances in linguistic and non-linguistic tasks

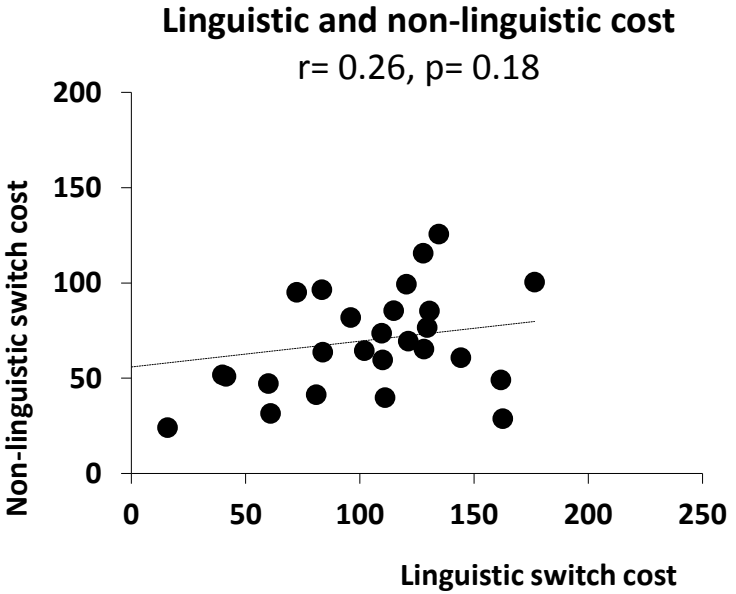
Calabria M., Hernández M., Branzi FM., and Costa A. (2012), Frontiers in Psychology



Symmetrical switch costs



asymmetrical switch costs



No correlation between the magnitudes of the linguistic and non-linguistic switch costs

→ **bLC and EC not completely overlapped**

Correlations of the individual performances in linguistic and non-linguistic tasks

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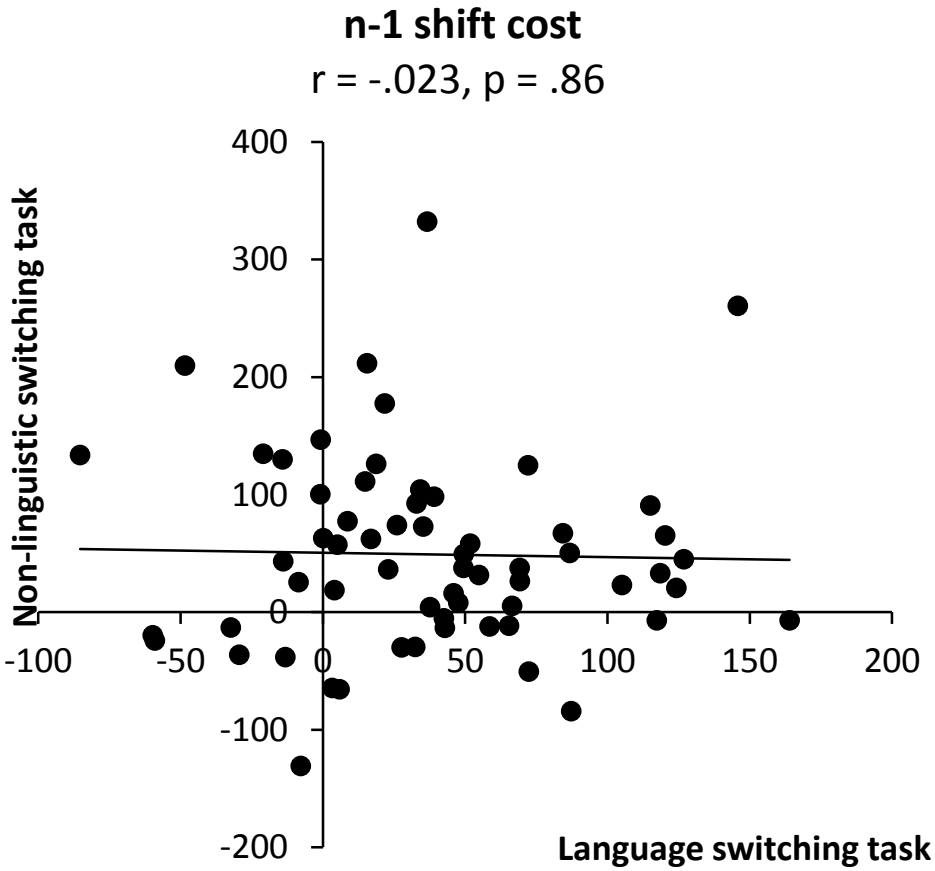

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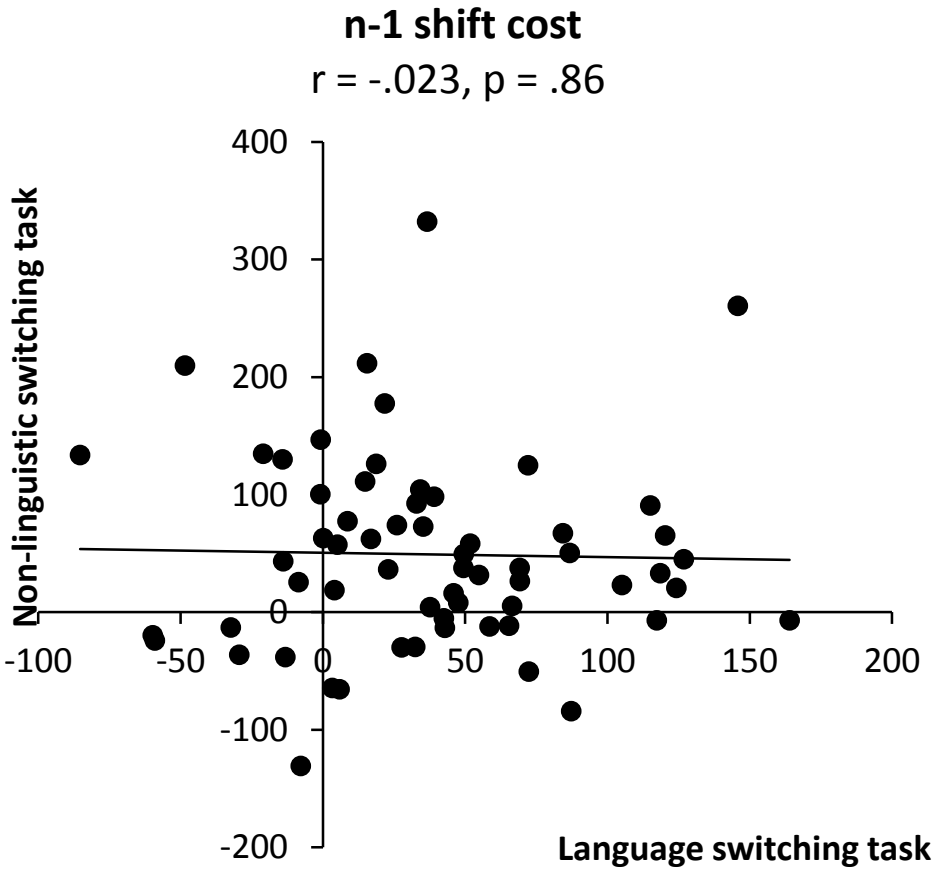
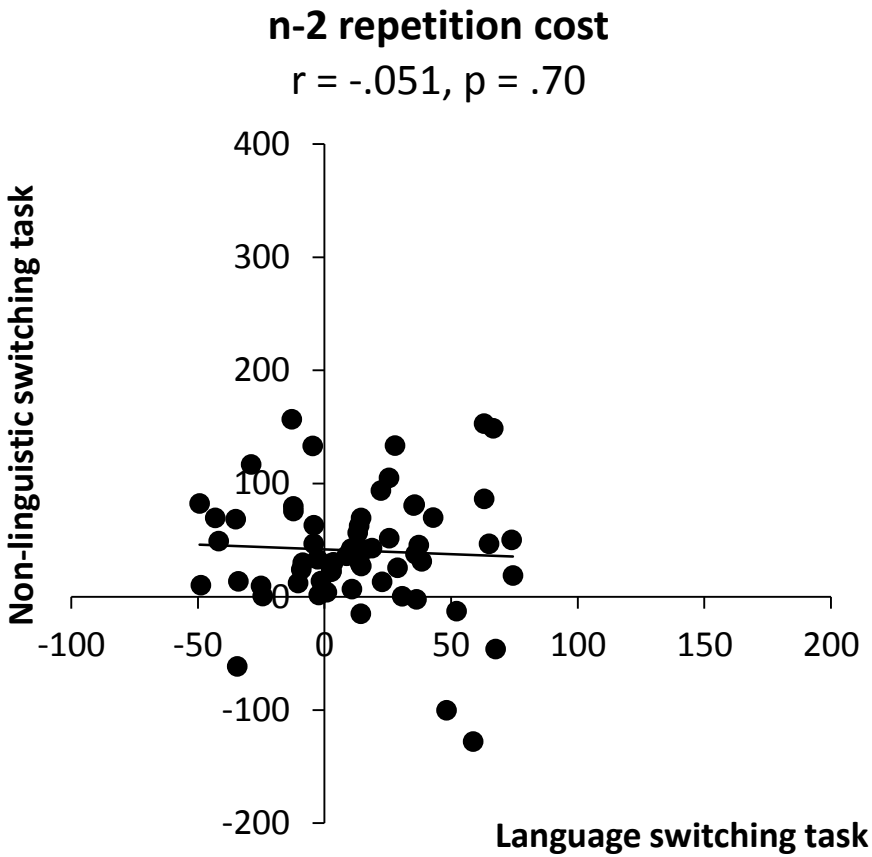
Linguistic and non-linguistic tasks: n-1 and n-2 repetition costs

Branzi F.M., Calabria M., Boscarino M.L., and Costa, A. (Under Review)





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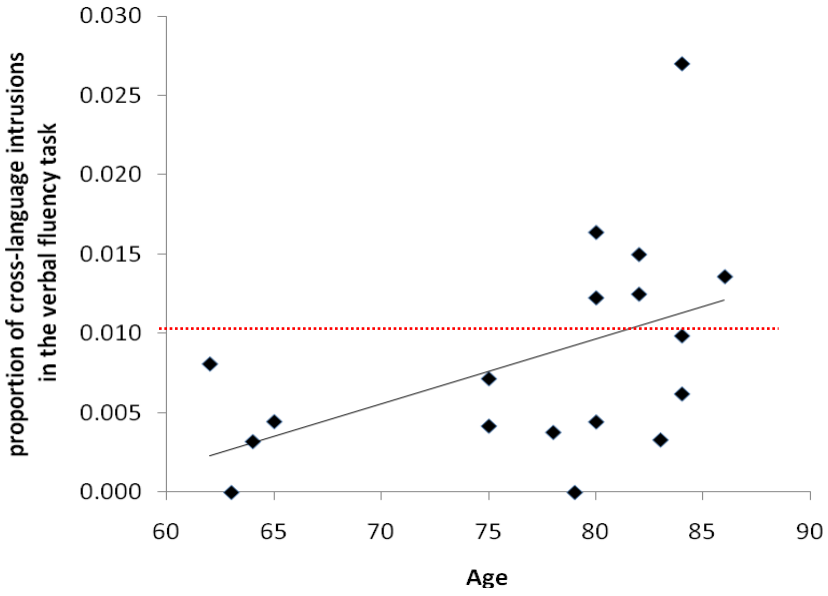
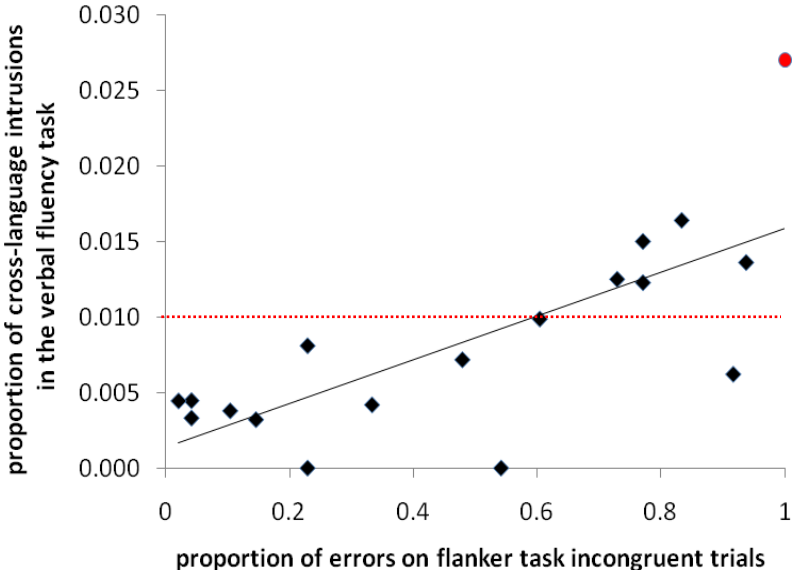
Linguistic and non-linguistic tasks across lifespan

Cross-language intrusions increase with age



Cross-language intrusions increase with error-rate on flanker task



Positive correlations between flankers task and cross-language intrusions.

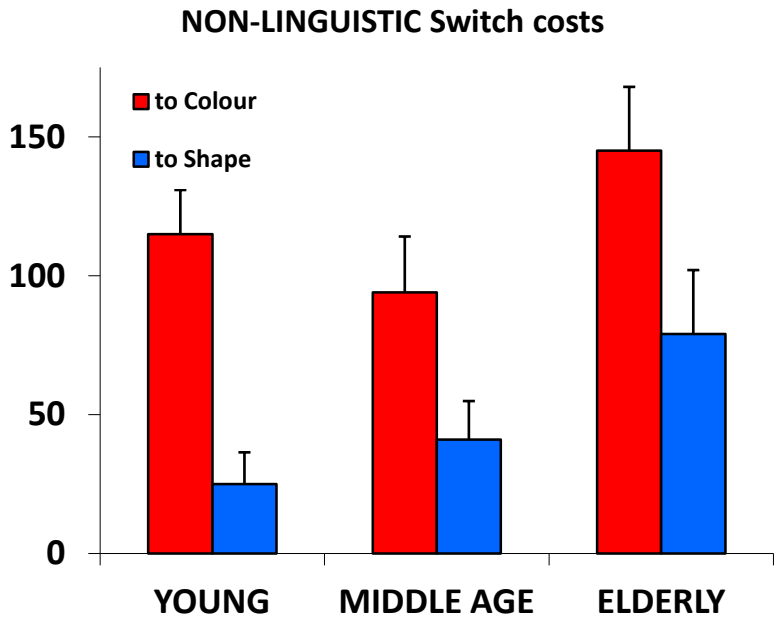
However, "…cross-language intrusions were the least common error type."

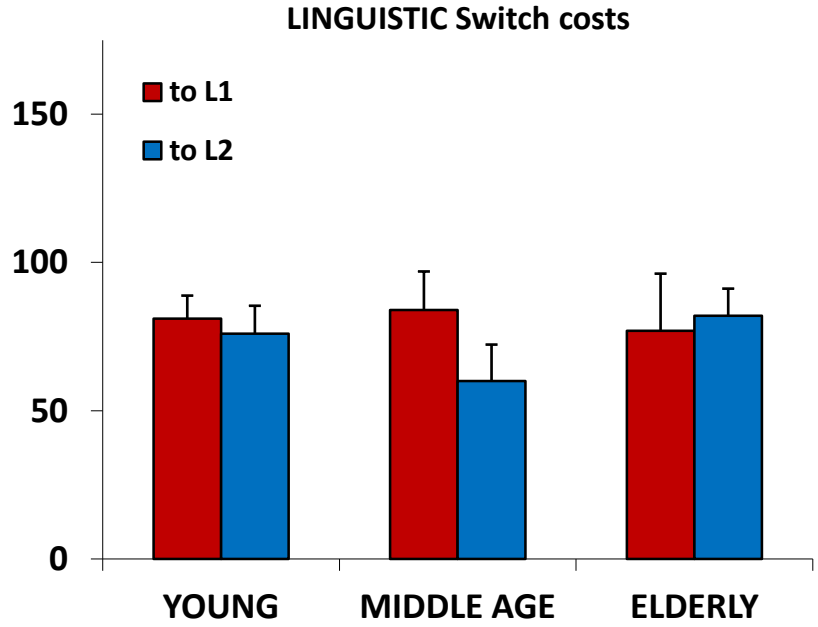
Gollan T.H., Sandoval T., Salmon D.P. (2011), Psychological Science

Linguistic and non-linguistic tasks across lifespan

Calabria M., Branzi FM., Hernández M., and Costa A. (2015), Bilingualism: Language and Cognition

Age-related decline of EC functions also affects bLC?





→ EC mechanisms are sensitive to aging

→ BLC mechanisms are <u>not</u> sensitive to aging

Linguistic and non-linguistic tasks across lifespan

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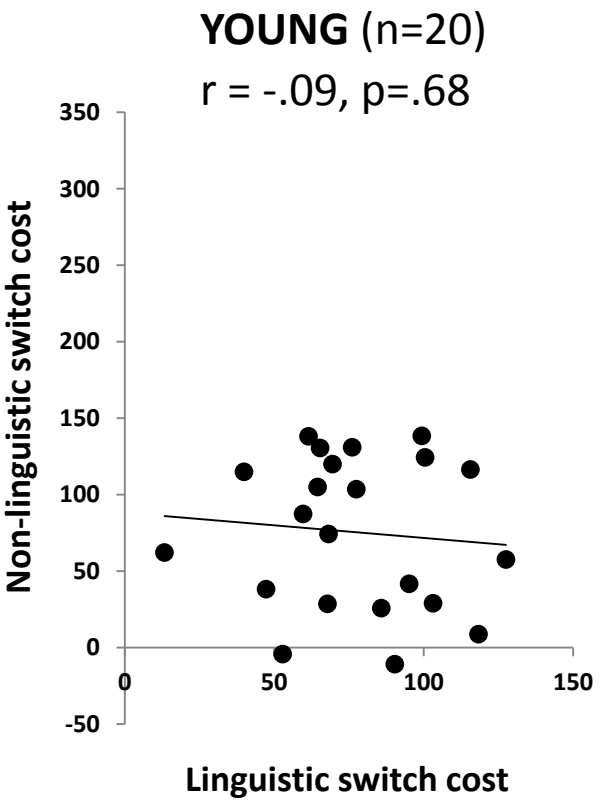

No correlation between the magnitudes of the linguistic and non-linguistic switch costs

→The underlying mechanisms of bLC and EC are ***not completely overlapped***

Linguistic and non-linguistic tasks across lifespan

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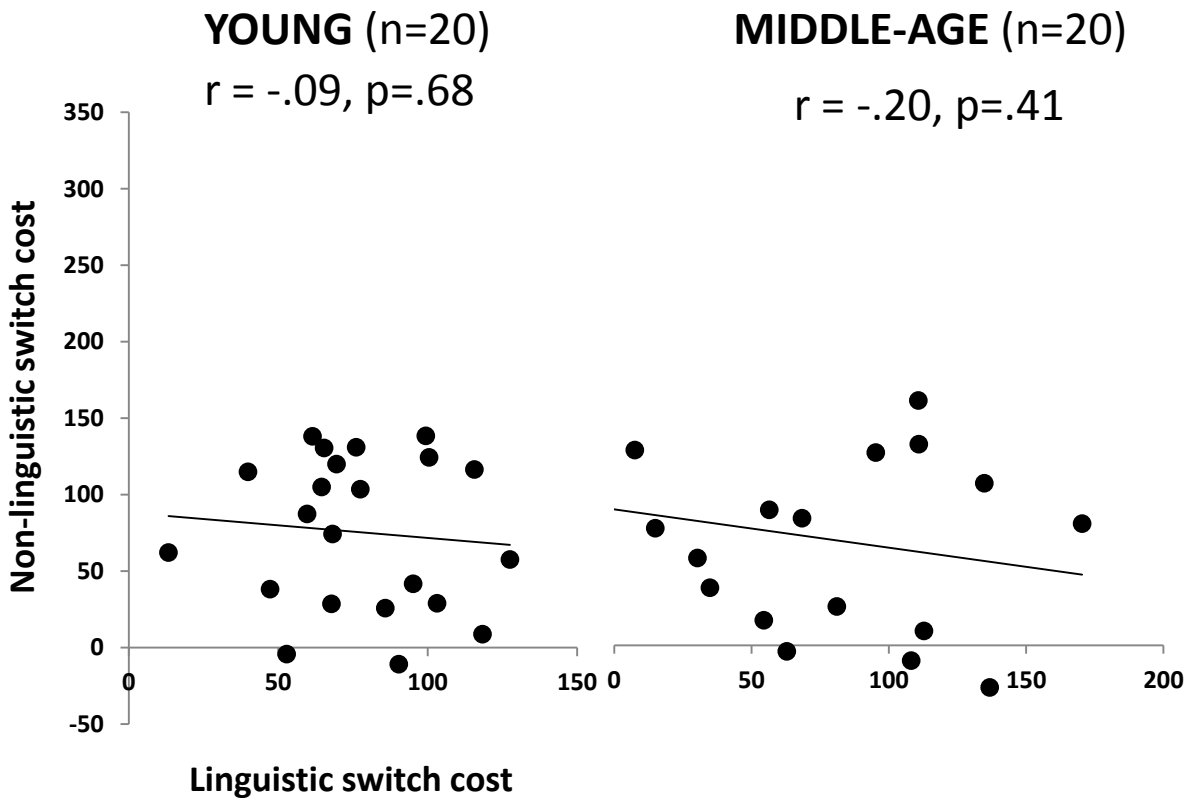

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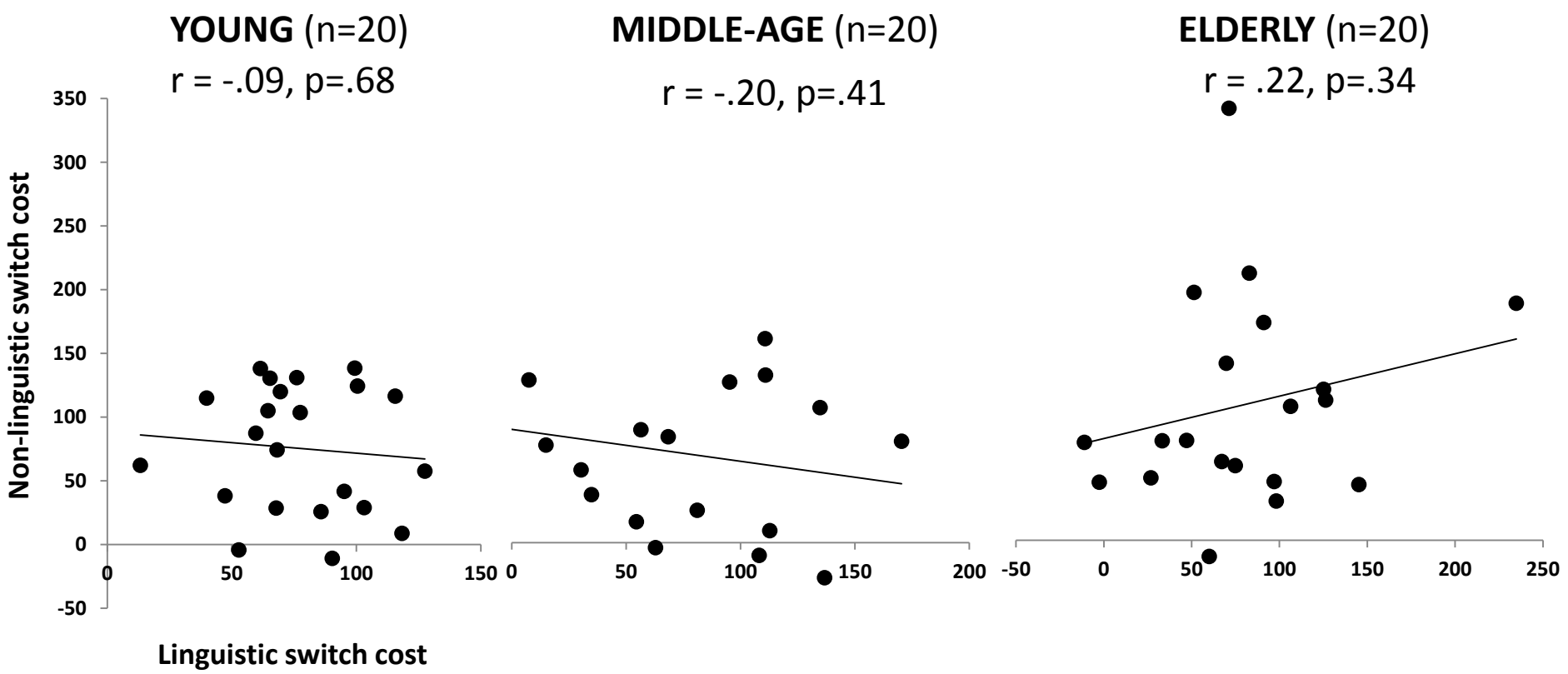

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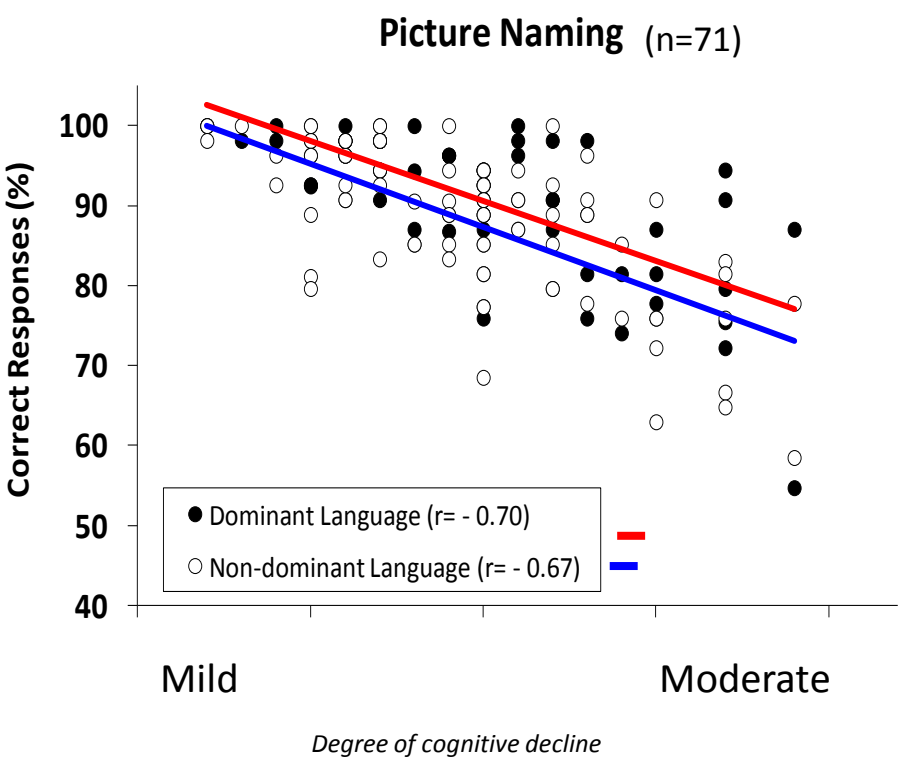
Costa & Sebastian-Gallés (2014), Nature Reviews Neuroscience

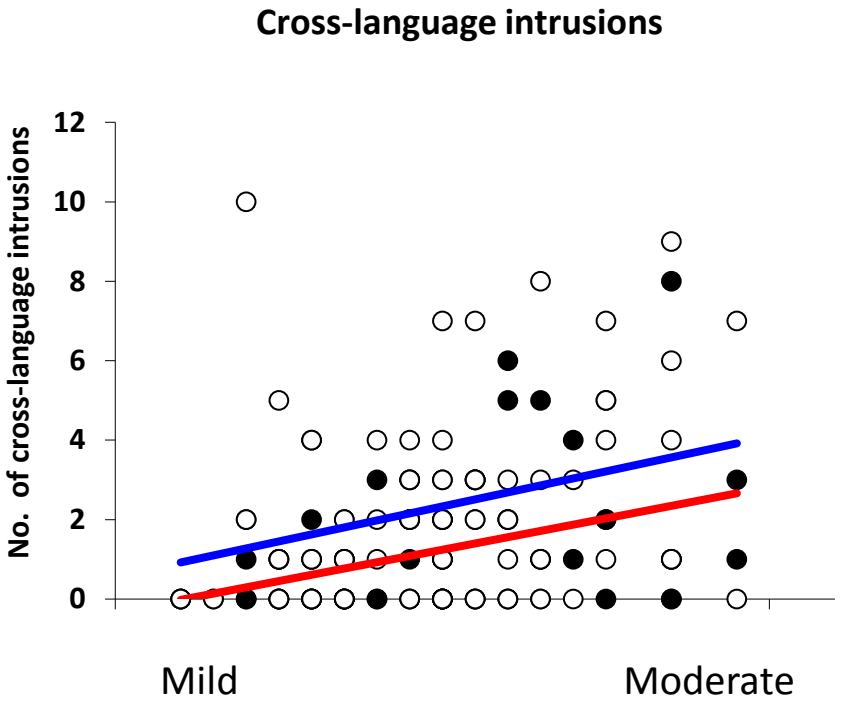
Cross-language intrusions in patients with cognitive decline?

Costa et al. (2012), Neuropsychologia

Language deterioriation



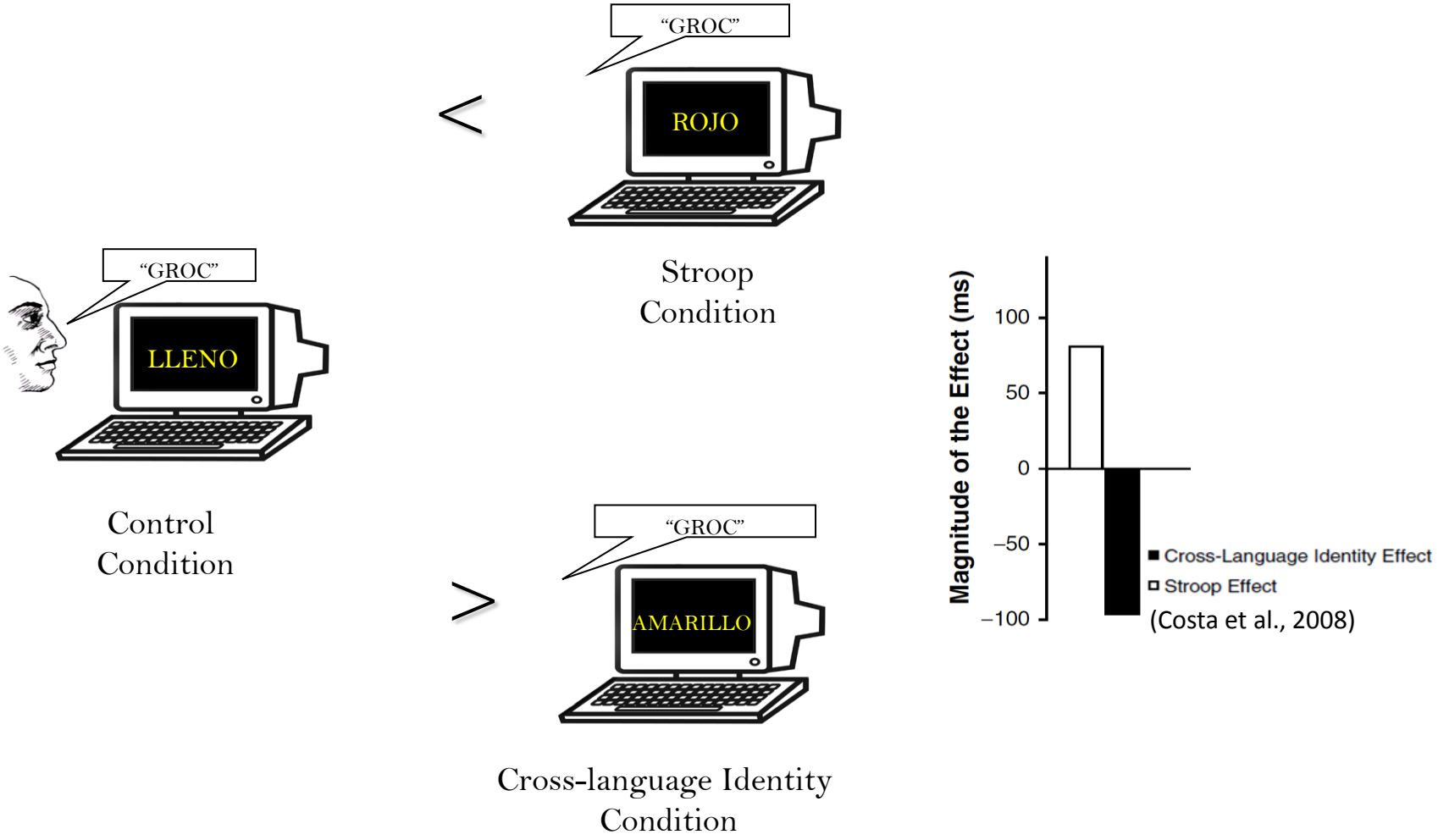
Language control



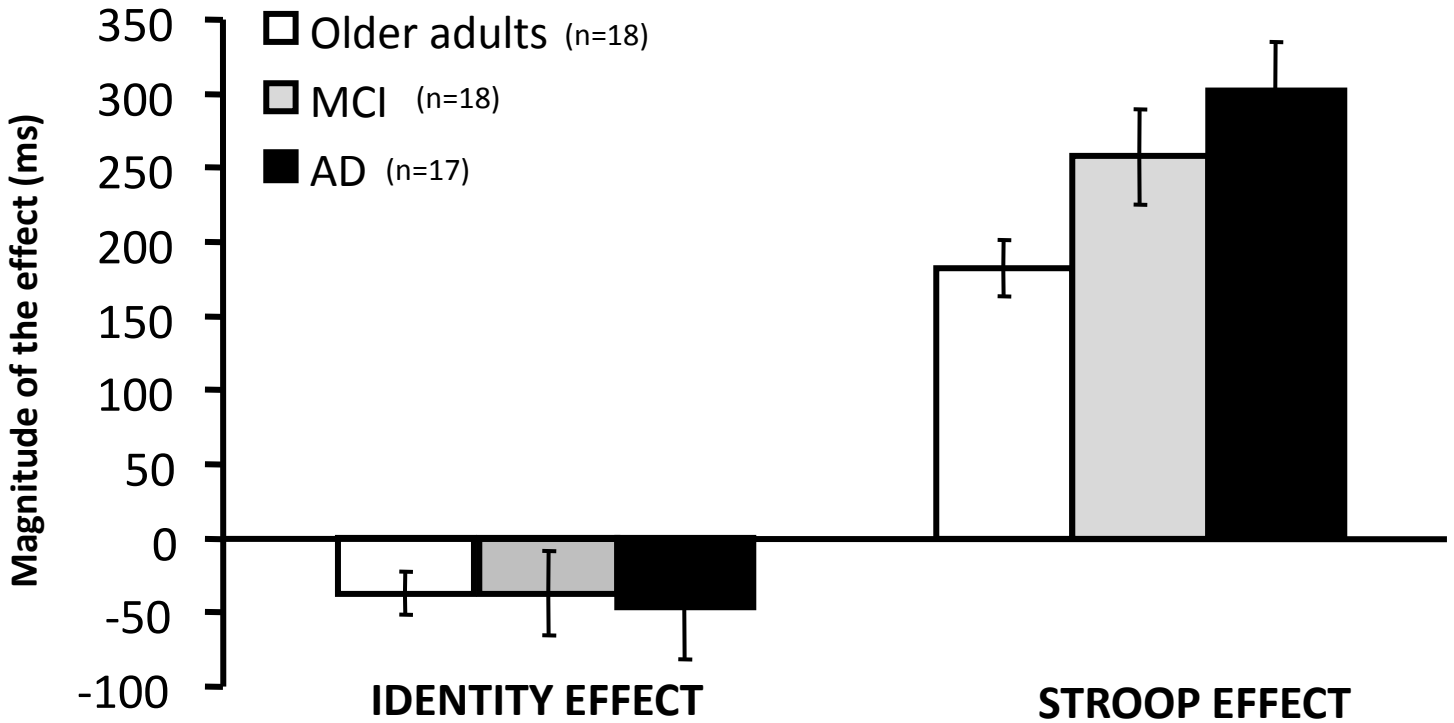
Deterioration similar for the two languages.

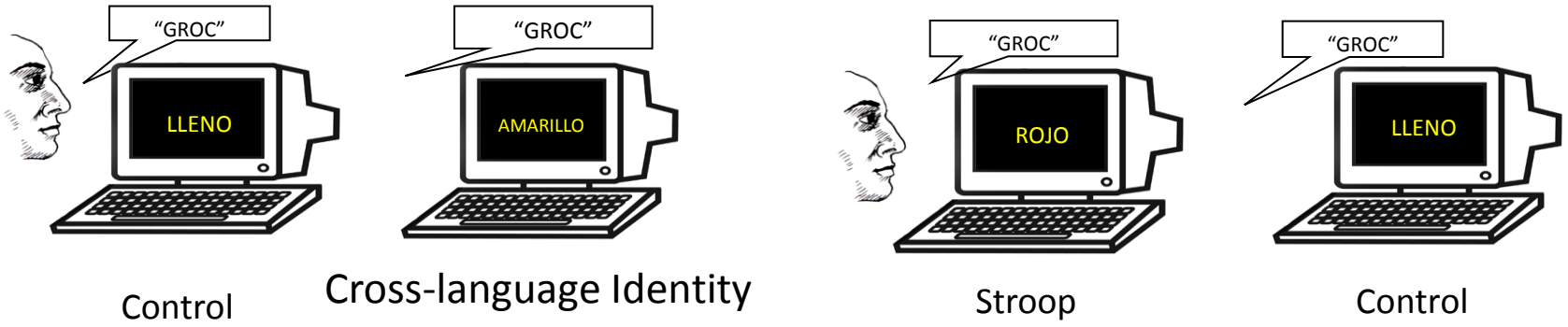
→ ***Very few language intrussions***

Cross-language Stroop task in patients with cognitive decline



Cross-language Stroop task in patients with cognitive decline

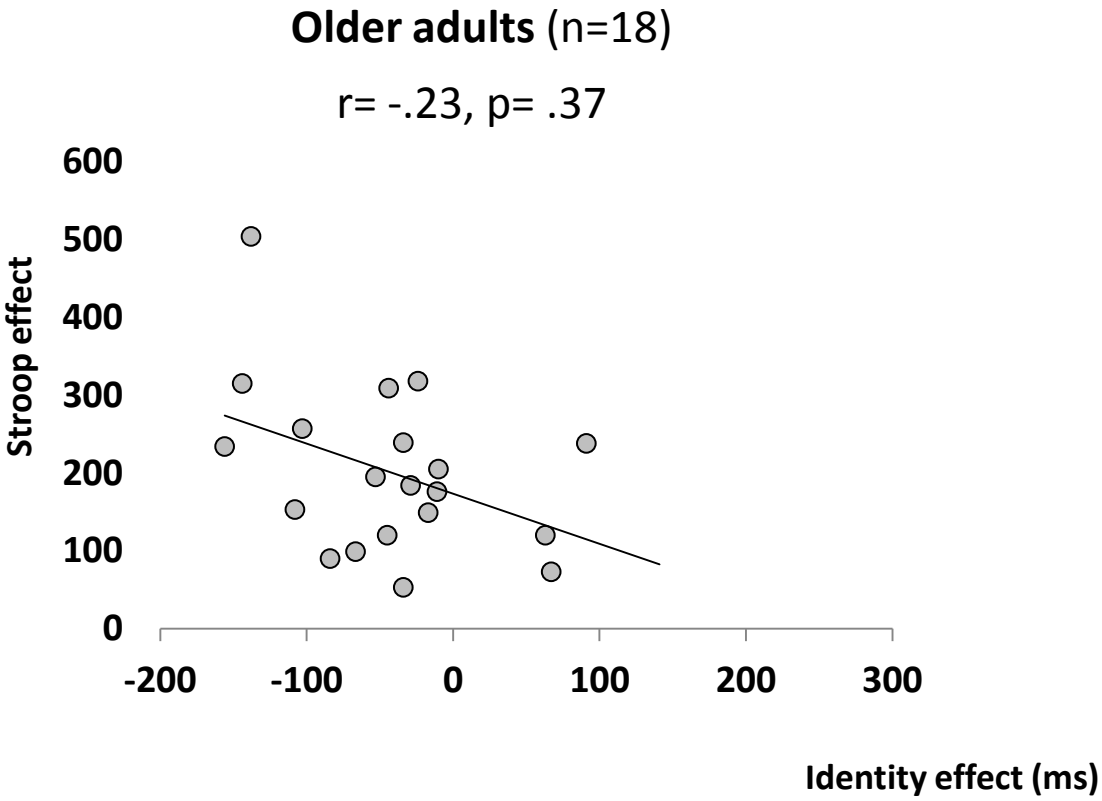




Cognitive Decline affects the Stroop effect but not the *Identity effect.*

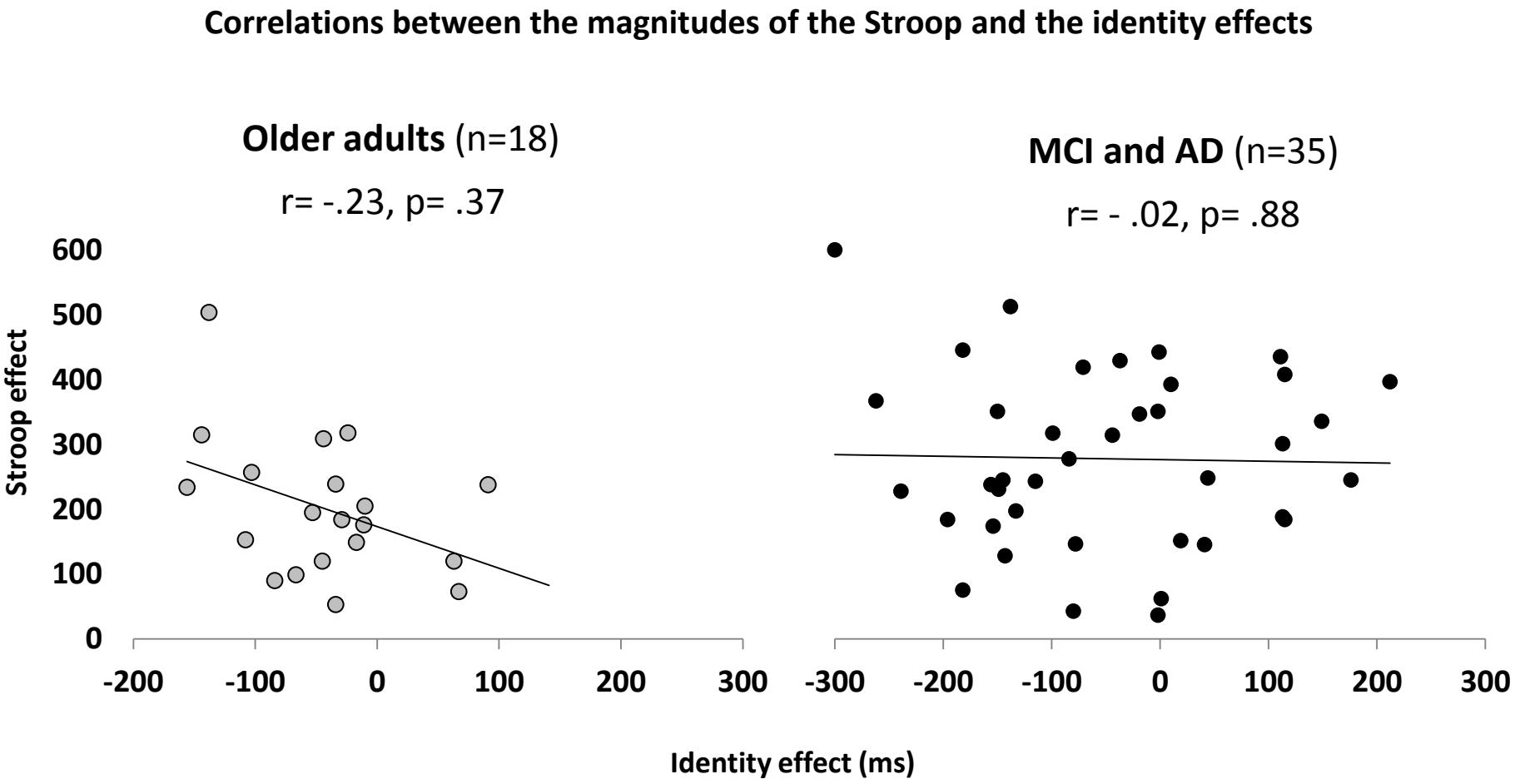
Cross-language Stroop task in patients with cognitive decline

Correlations between the magnitudes of the Stroop and the identity effects



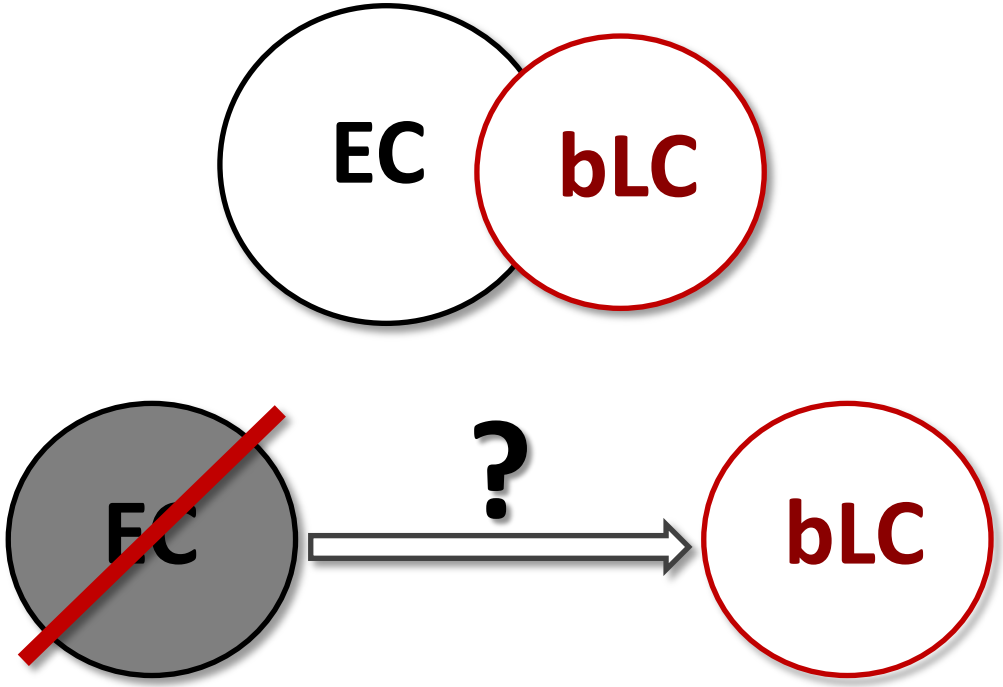
Modest correlation suggesting different control mechanisms

Cross-language Stroop task in patients with cognitive decline

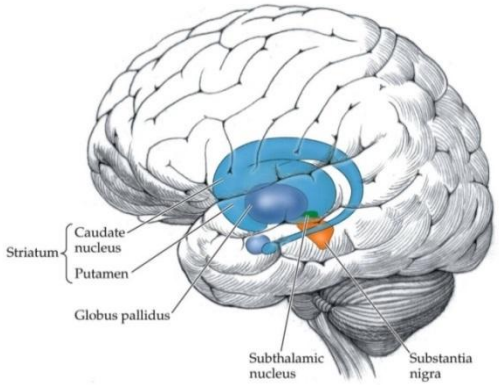


Modest correlation suggesting different control mechanisms

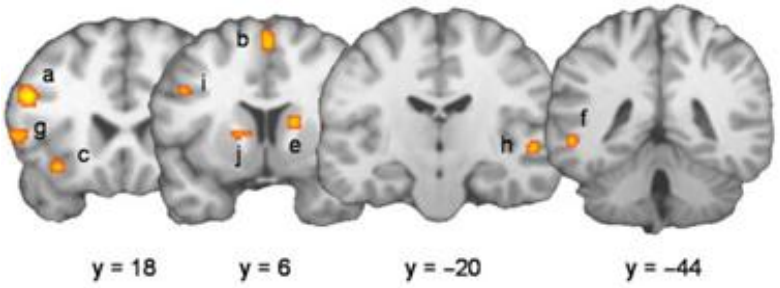
Patients with EC deficits



Parkinson's disease patients



a. **EC deficits**
b. **Lesions:** Basal ganglia and Fronto-striatal connections



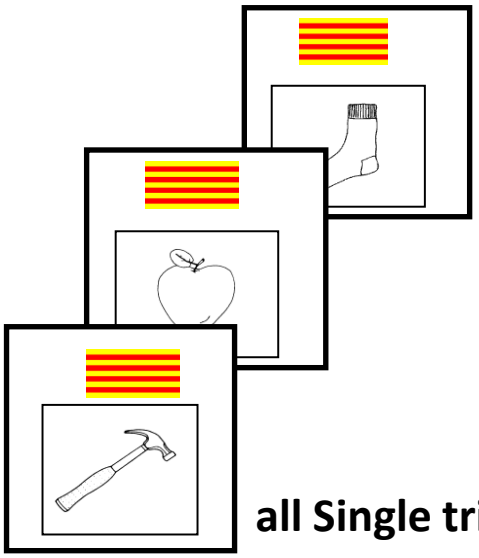
Language switching (Luk et al., 2012)

- Temporal areas
- Frontal areas
- **Subcortical areas**: left and right caudates

Patients with EC deficits

SINGLE BLOCKS

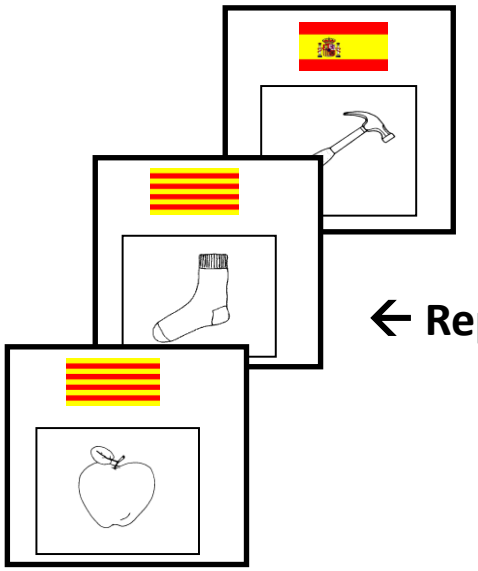
only one naming language



all Single trials

MIXED BLOCK

two naming languages



← Switch trial

← Repeat trial

Two different types of control

(Braver, Reynolds & Donaldson, 2003)

1. Mixing cost: RTs (Repeat trials) - RTs(Single trials) — **Global/Sustained control**

2. Switch cost: RTs (Switch trials) - RTs(Repeat trials) — **Local/Transient control**

Cattaneo, G., Calabria M., Marne P., Gironell A., Abutalebi J., & Costa A. (2015) Neuropsychologia.

Switch and mixing costs in Parkinson's disease patients (n=28)

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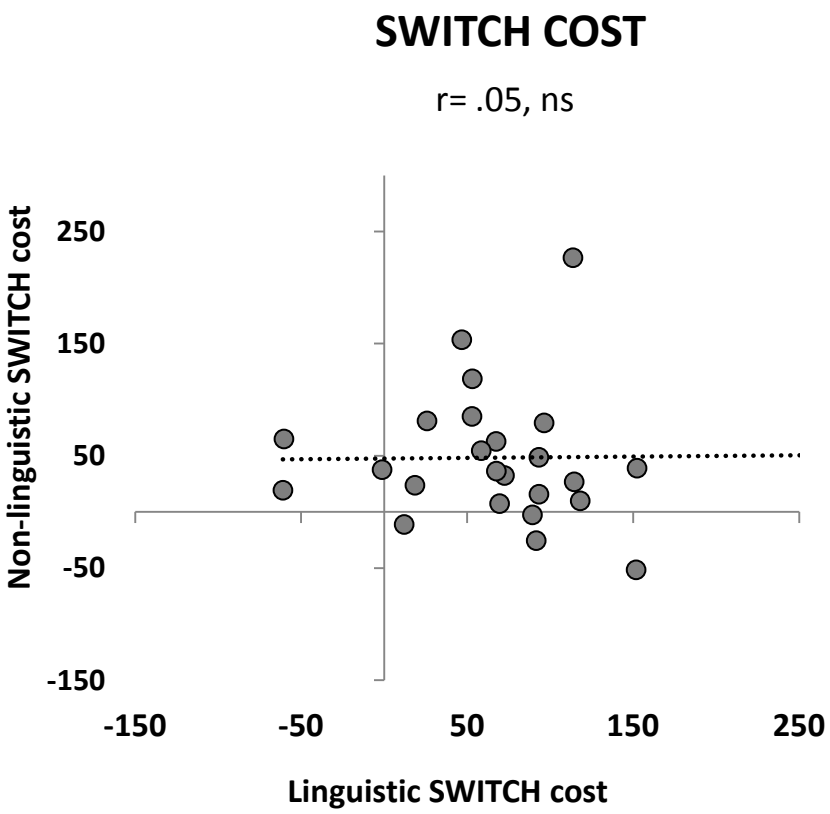

No correlation between bLC and the EC system for transient control

Switch and mixing costs in Parkinson's disease patients (n=28)

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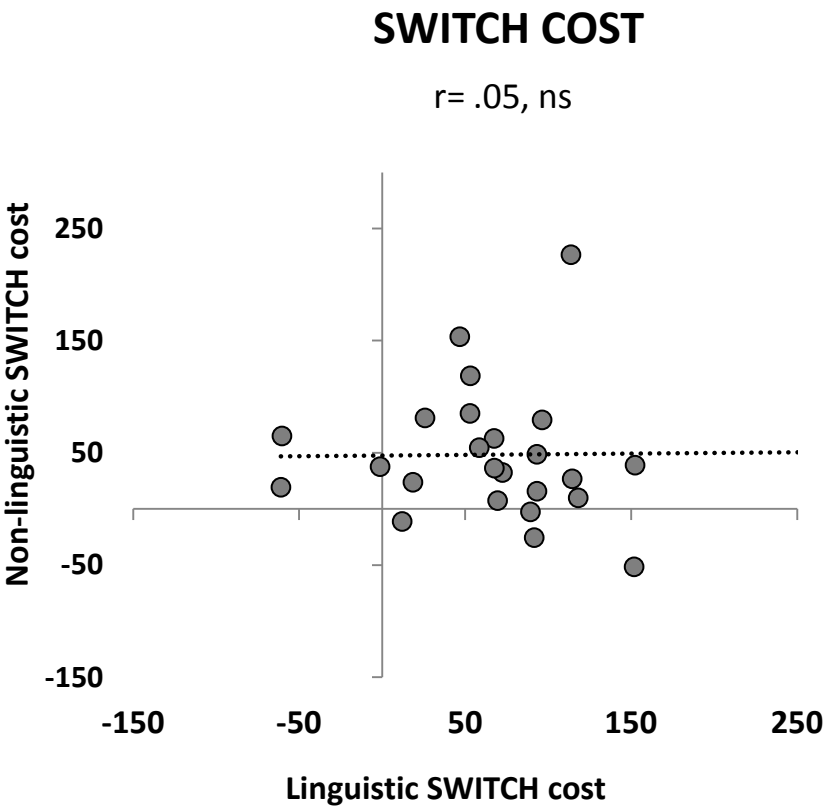

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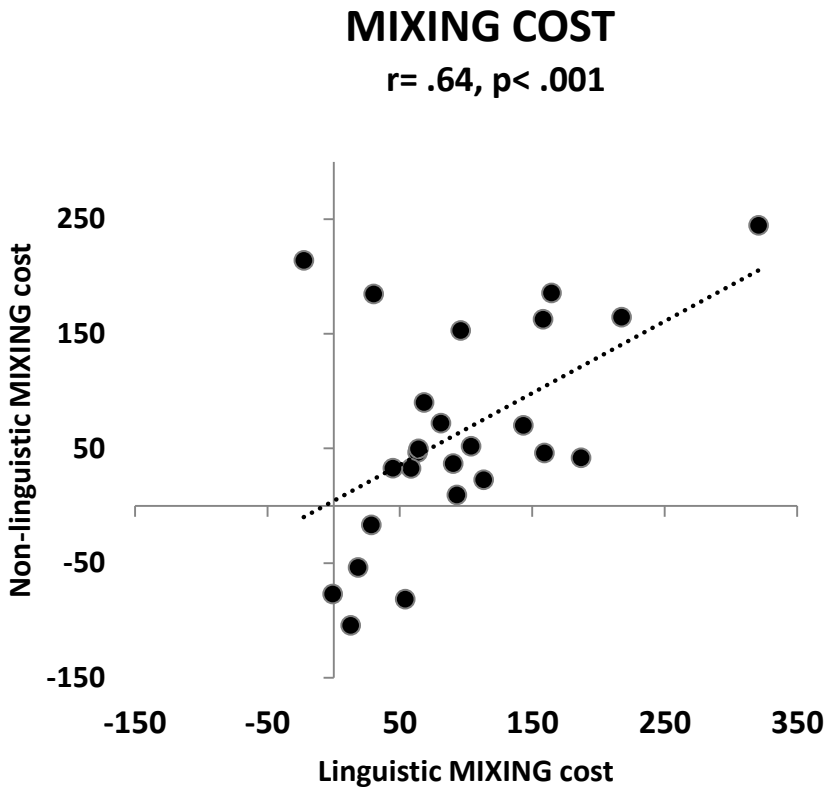


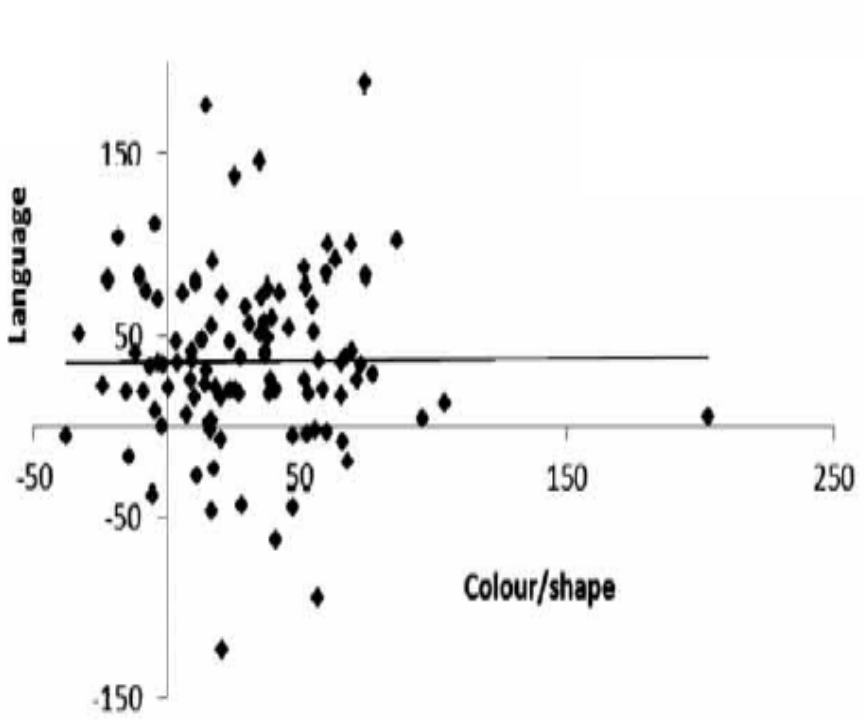
Correlation between bLC and the EC system for sustained control

The overlap between the bLC and the EC system is for the abilities of the sustained control (mixing cost) but not for those of the transient control

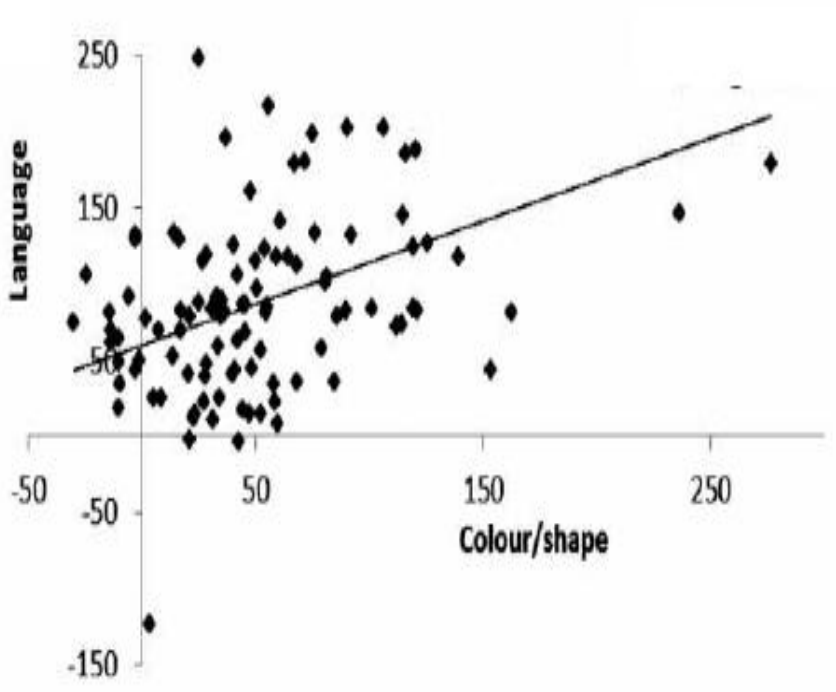
Similar findings in young bilinguals…

Prior A., and Gollan T. (2013), Journal of Cognitive Psychology

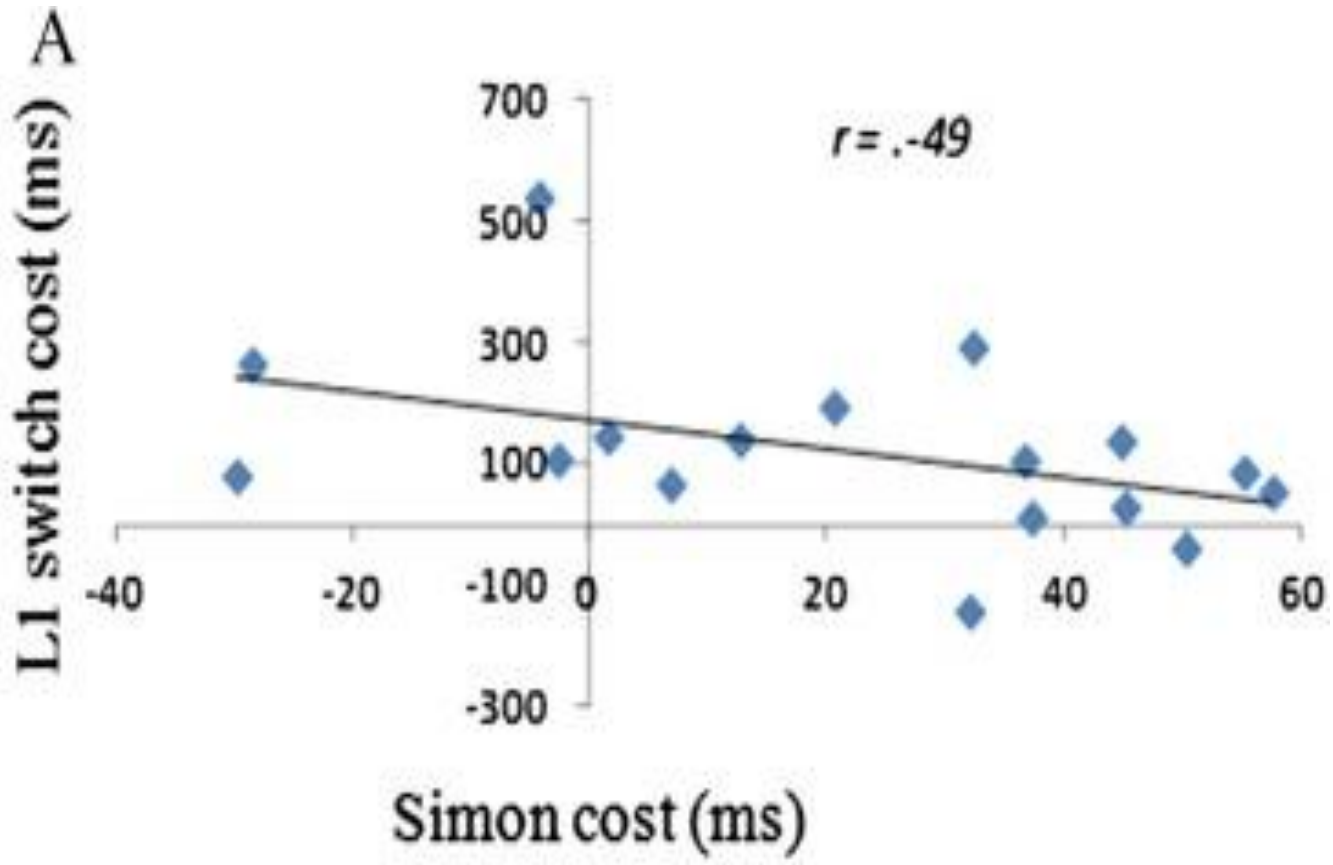
SWITCH COSTS



MIXING COSTS



Other findings: Simon cost and Switching cost to L1



The greater the inhibition in the Simon task (small simon cost), the greater the inhibition on the L1 (consequently larger switch cost)

De Bruin et al. (2014). *NeuroImage*

Behavioral studies: Complex scenario

bLC and EC mechanisms **partially overlap**

→ no correlation between linguistic and non-linguistic SWITCH costs

→ correlation between linguistic and non-linguistic tasks for mixing costs and when comparing language switching with conflict tasks

The approach

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- Functional overlap at the brain level
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Costa & Sebastian-Gallés (2014), Nature Reviews Neuroscience

Study 5: Brain imaging

Question: Is the language network involved differently when controlling linguistic and non linguistic representations?

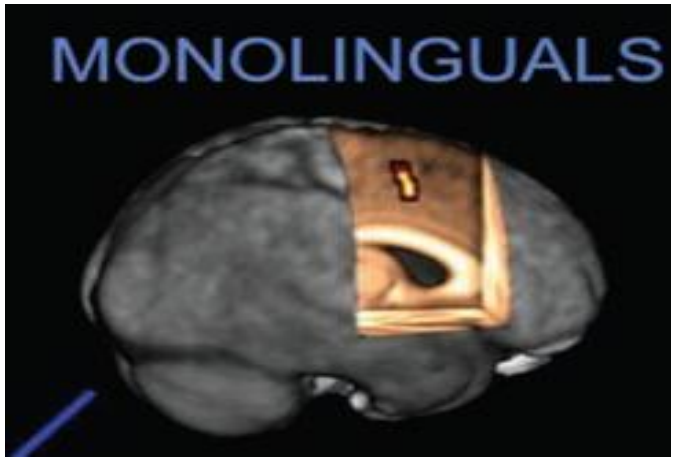
Abutalebi & Green (2007), *JNL.*

Abutalebi & Green (2013), *Journal of Cognitive Psychology.*

Overlap between language control and executive control networks

Abutalebi, Della Rosa, Green, Hernandez, Scifo, Keim, Cappa and Costa (2012), Cerebral Cortex

Noun/verb switching for monolinguals



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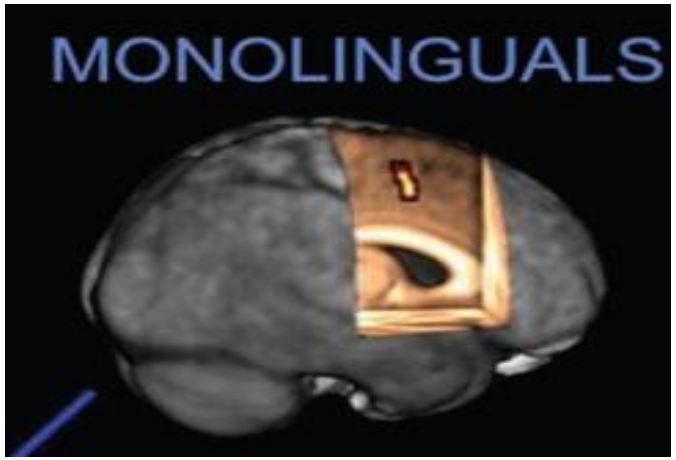
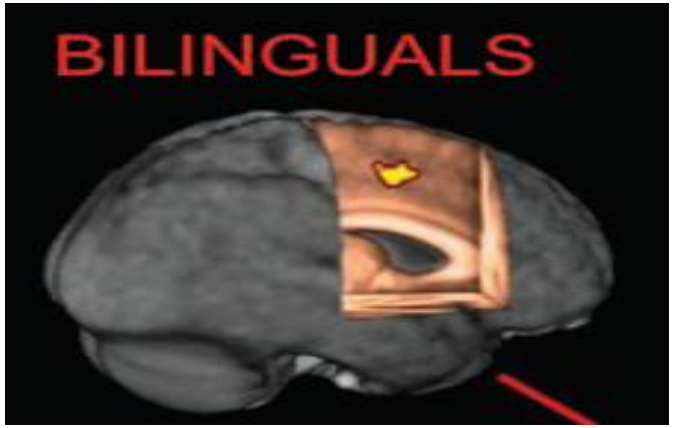


Language switching for bilinguals

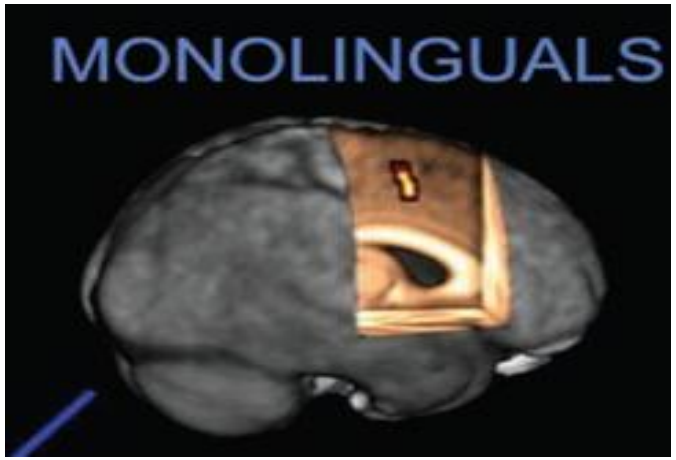


The ACC is commonly engaged by language switching and conflict monitoring in an EC task.

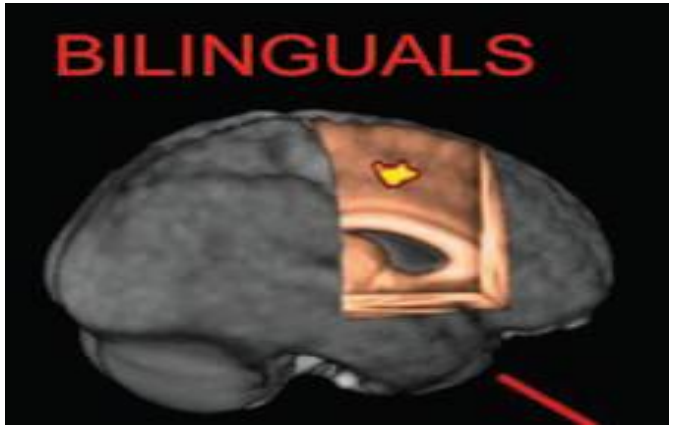
Overlap between language control and executive control networks

Abutalebi, Della Rosa, Green, Hernandez, Scifo, Keim, Cappa and Costa (2012), Cerebral Cortex

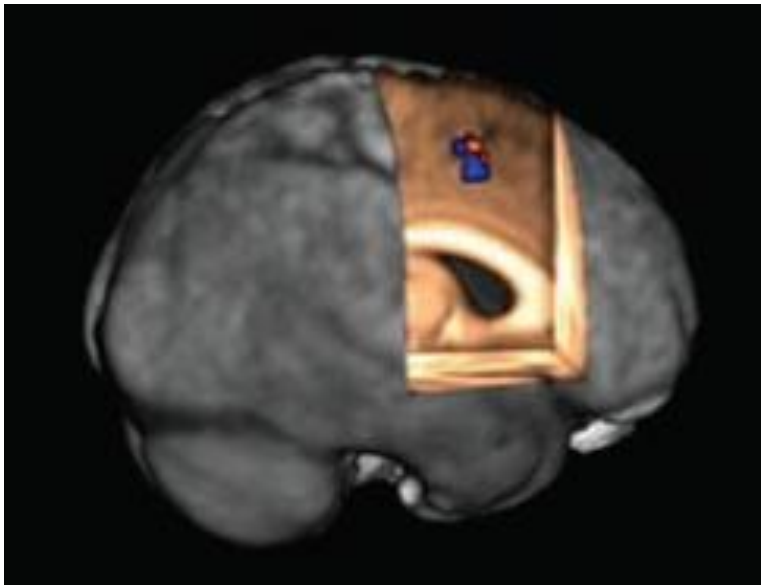
Noun/verb switching for monolinguals



Language switching for bilinguals



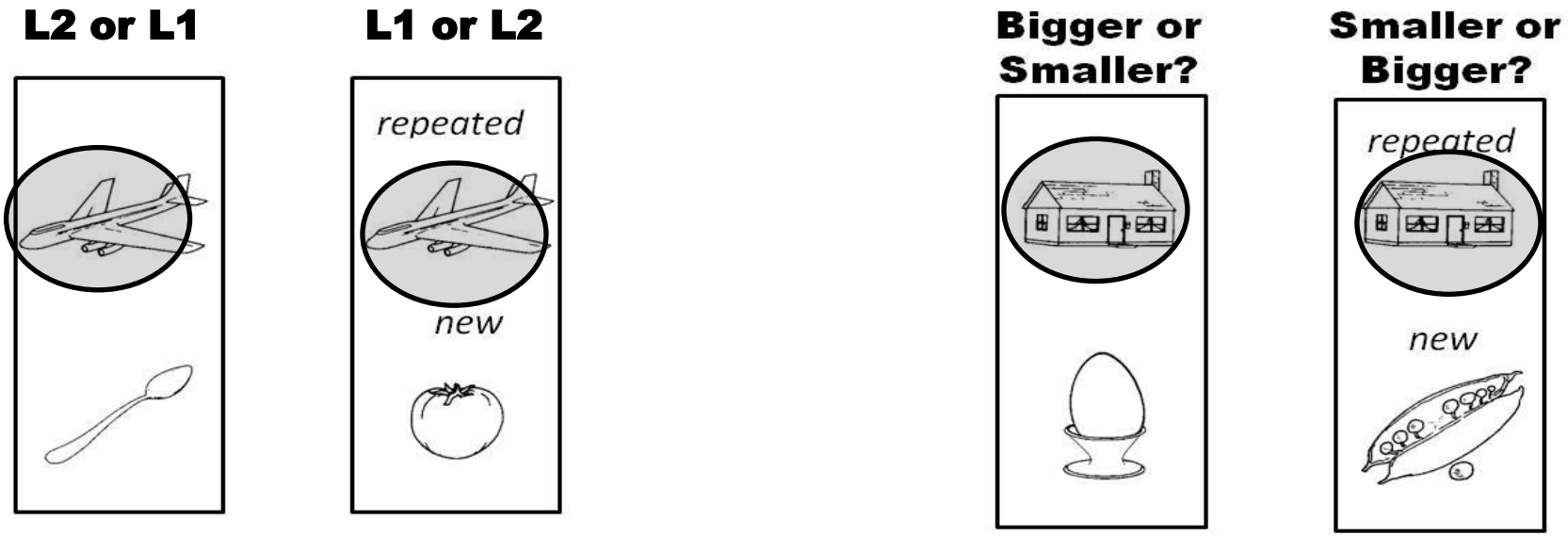
Areas common for linguistic switching and flanker task, (red = bil, blue = mon)



The ACC is commonly engaged by language switching and conflict monitoring in an EC task.

Study 5: Brain imaging

Linguistic and non linguistic blocked switching tasks with the same pictures.



Priming disruption to reveal the brain areas involved in the control of linguistic and non linguistic representations.

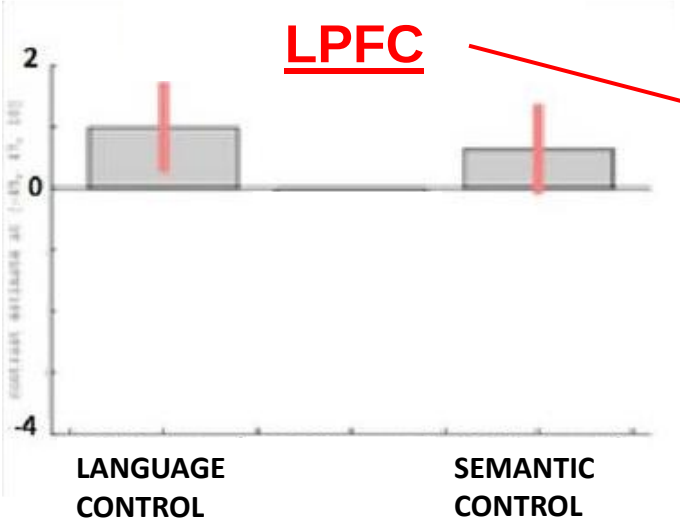
Branzi, Della Rosa, Canini, Costa, & Abutalebi (2015). Cerebral Cortex

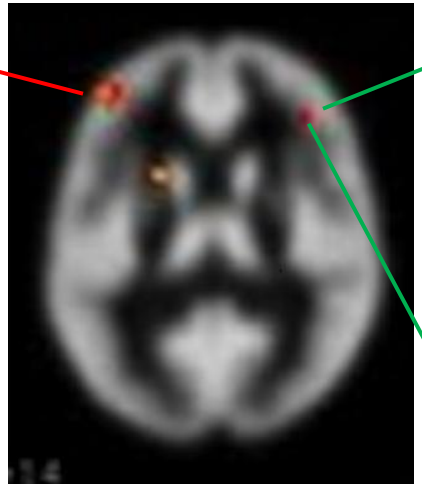
Study 5: Brain imaging

OVERLAP

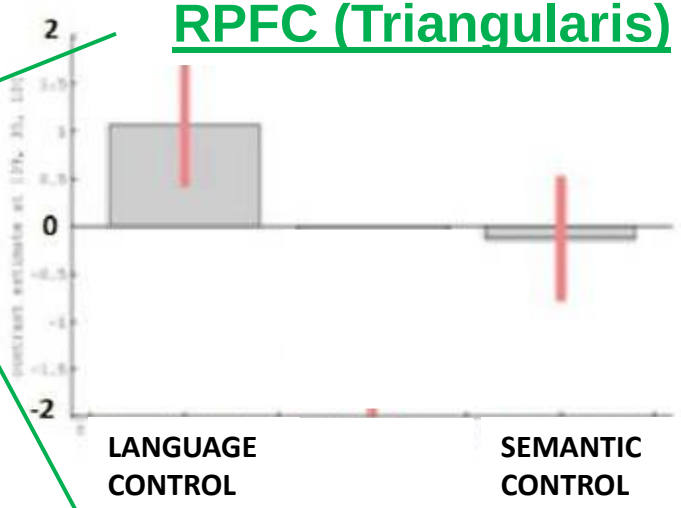
NO OVERLAP

LPFC

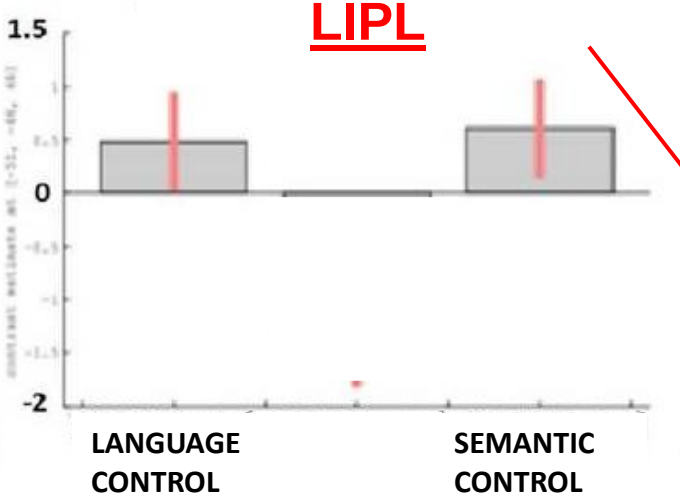


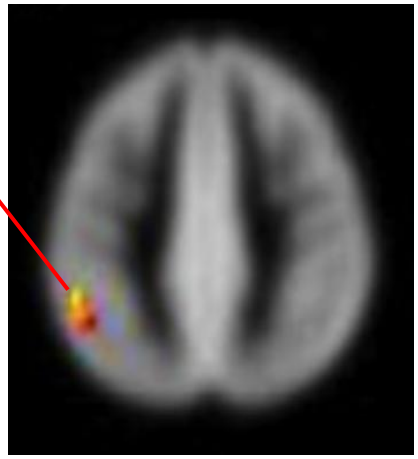


RPFC (Triangularis)

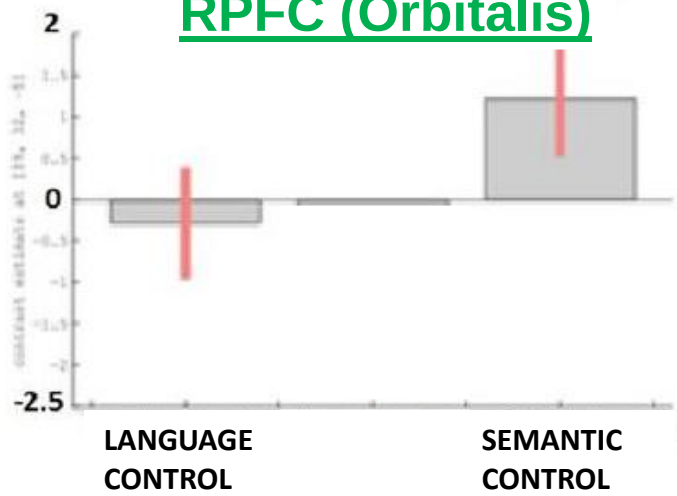


LIPL





RPFC (Orbitalis)



Branzi, Della Rosa, Canini, Costa, & Abutalebi (2015). *Cerebral Cortex*

Summary: Brain imaging

- The neural overlap between language control and domain-general EC is partial.

- The ACC is not consistently reported as involved in both language control and domain-general EC (Branzi et al., 2015; Abutalebi et al., 2008).

- The LPFC seem to be similarly involved in language control and domain-general EC.

The approach

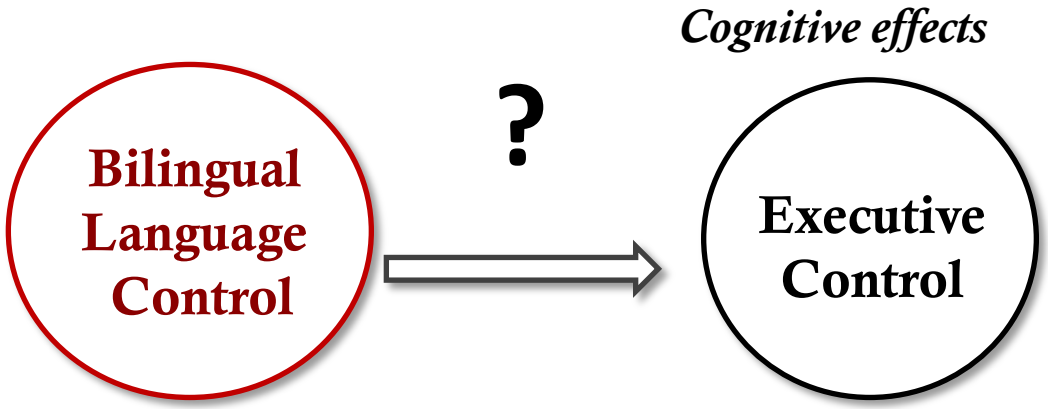
Explore associations and dissociations in linguistic and non-linguistic tasks that "supposedly" share a common mechanism.

- Single case studies of patients
- Healthy adults
- Patients with cognitive impairments
- Functional overlap at the brain level
- Differences between bilinguals and monolinguals in switching

Costa & Sebastian-Gallés (2014), Nature Reviews Neuroscience

There is a certain overlap between bLC and EC

Other source of evidence: the bilingualism effect on domain-general EC



Bilingual advantage: The case of task switching

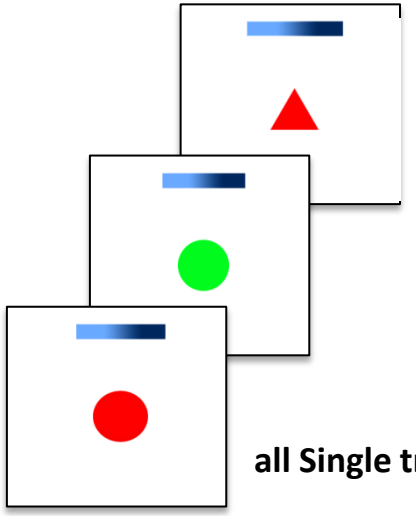
N-1 paradigm used in Prior and colleagues' studies

TASK: To indicate either the color (red or green) or shape (circle or triangle) of a target according to a cue

color cue shape cue

SINGLE BLOCKS

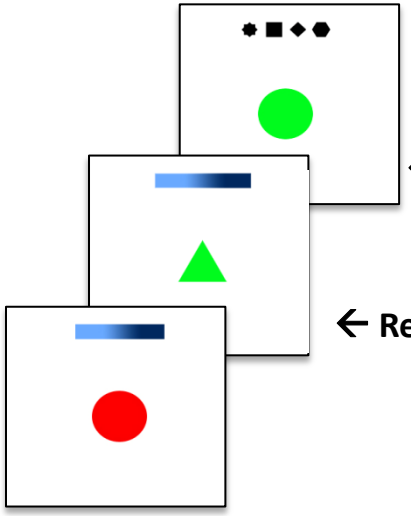
only one sorting criterion



all Single trials

MIXED BLOCK

two sorting criteria



← Switch trial

← Repeat trial

1. Mixing cost: RTs (Repeat trials) - RTs(Single trials)

Global/Sustained control

2. Switch cost (n-1): RTs (Switch trials) - RTs(Repeat trials)

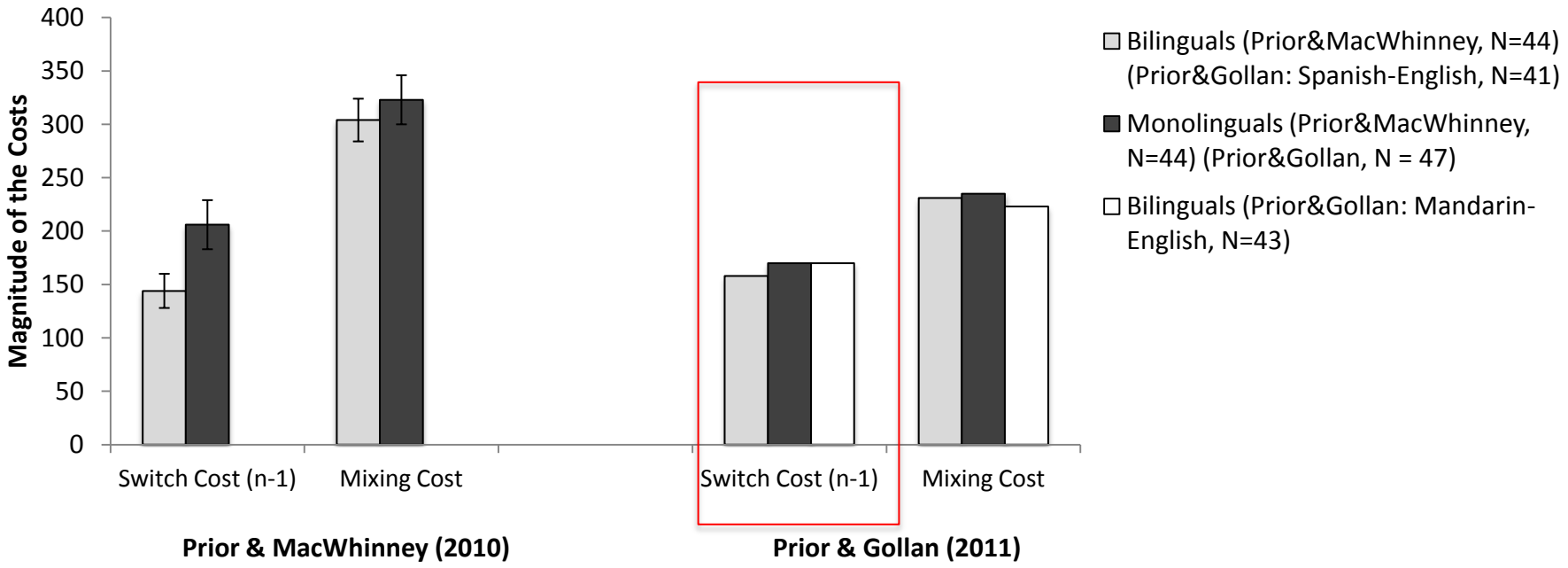
Local/Transient control

Prior & cols claimed reduced switch cost (n-1) for bilinguals, …

Prior A & MacWhinney B (2010), Bilingualism: Language and Cognition
Prior A & Gollan TH (2011), Journal of the International Neuropsychological Society

Mixing cost: RTs (Repeat trials) - RTs(Single trials)

Switch cost (n-1): RTs (Switch trials) - RTs(Repeat trials)



… but Prior & Gollan's (2011) results did not really replicate those of Prior & MacWhinney

- *either when considering good language-switchers (Spanish-English),*
- *or not so good language switchers (Mandarin-English)*

Prior & Gollan's cherry-picking strategy …

Prior A & Gollan TH (2011), Journal of the International Neuropsychological Society

1) ANCOVA analysis → control for differences in speed and SES
Dependent variable: relative switch costs (the switch cost divided by the mean RT of repeat trials)
And parent education level as a covariate

→Spanish-English Bilinguals showed a **reduced switch cost** vs. the other two groups

BUT … several participants were not included because they did not provide scores for parental education (a total of 10 participants excluded)

2) Second ANOVA analysis →subgroups of **20** Spanish-English Bilinguals vs. **20** monolinguals matched on parental education levels. The match was done selecting bilinguals with the highest and monolinguals with lowest levels of parental scores.

→Spanish-English Bilinguals showed a **reduced switch cost** vs.the other two groups

BUT … more than 50% of the participants were excluded from this analysis

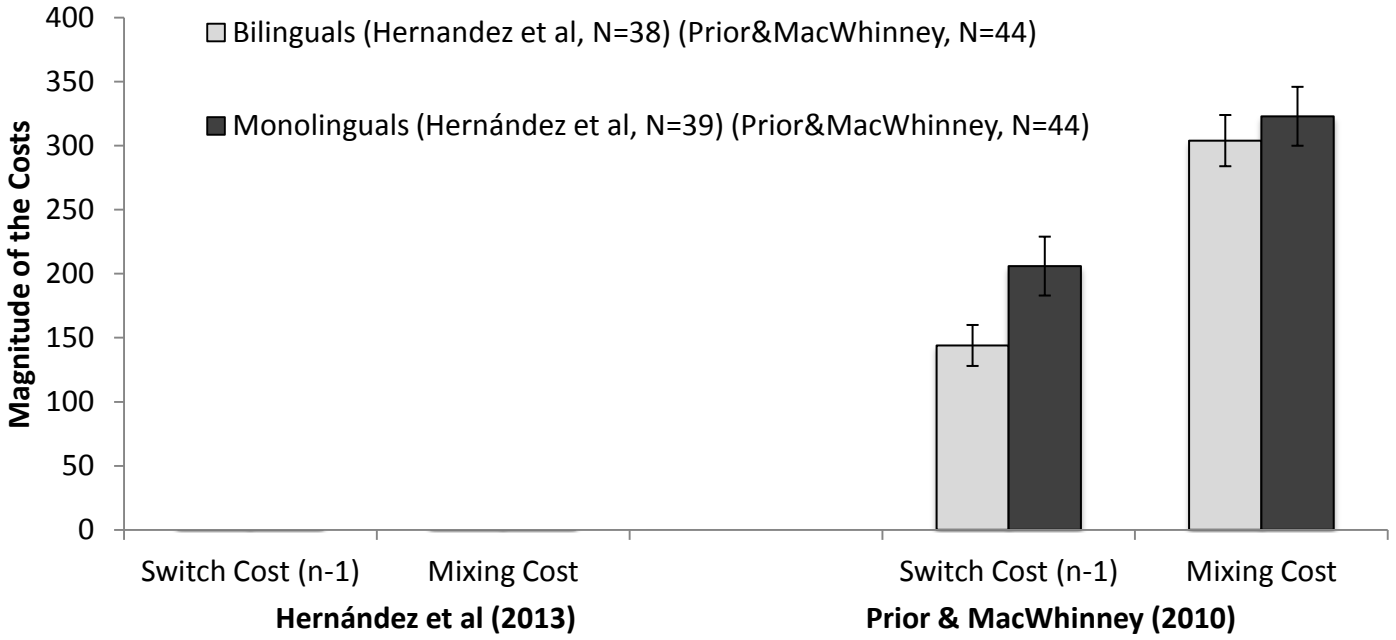
Whether bilingualism leads to an advantage on task-switching is unclear

Attempt of a direct replication of Prior and colleagues

Hernández M., Martin CD., Barceló F., and Costa A. (2013), Journal of Memory and Language

Mixing cost: RTs (Repeat trials) - RTs(Single trials)

Switch cost (n-1): RTs (Switch trials) - RTs(Repeat trials)



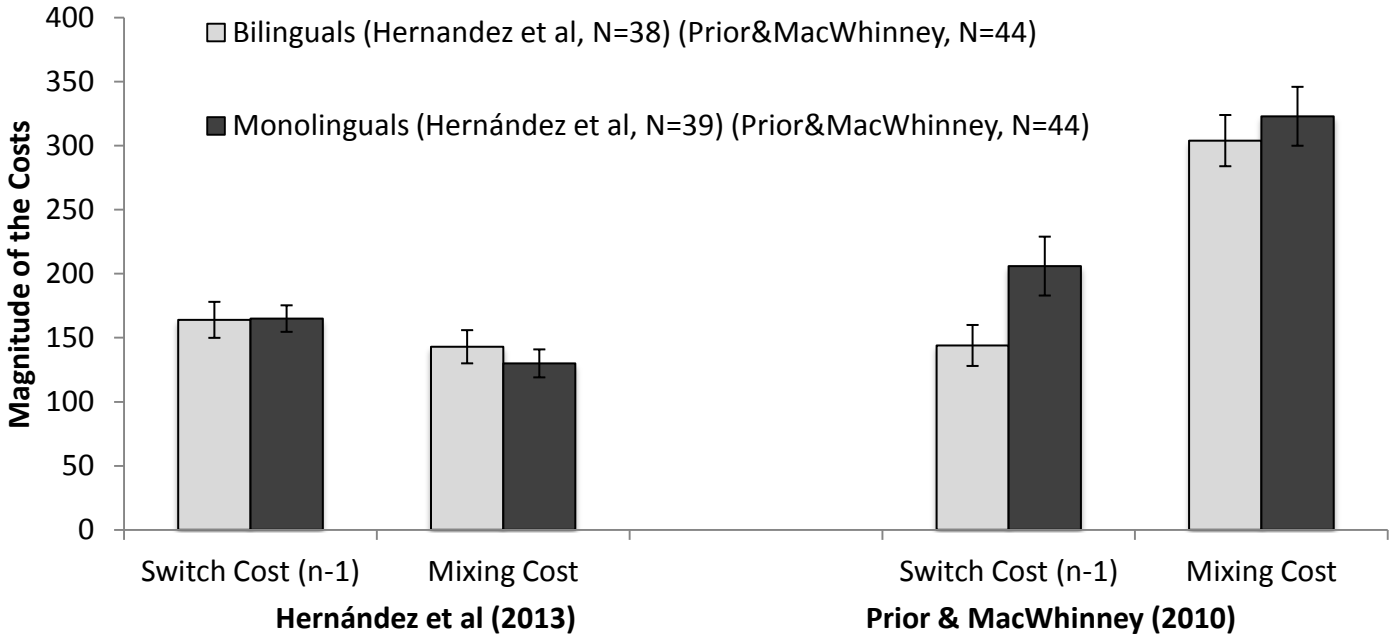
No replication of the reduced switch cost reported by Prior and cols

Attempt of a direct replication of Prior and colleagues

Hernández M., Martin CD., Barceló F., and Costa A. (2013), Journal of Memory and Language

Mixing cost: RTs (Repeat trials) - RTs(Single trials)

Switch cost (n-1): RTs (Switch trials) - RTs(Repeat trials)



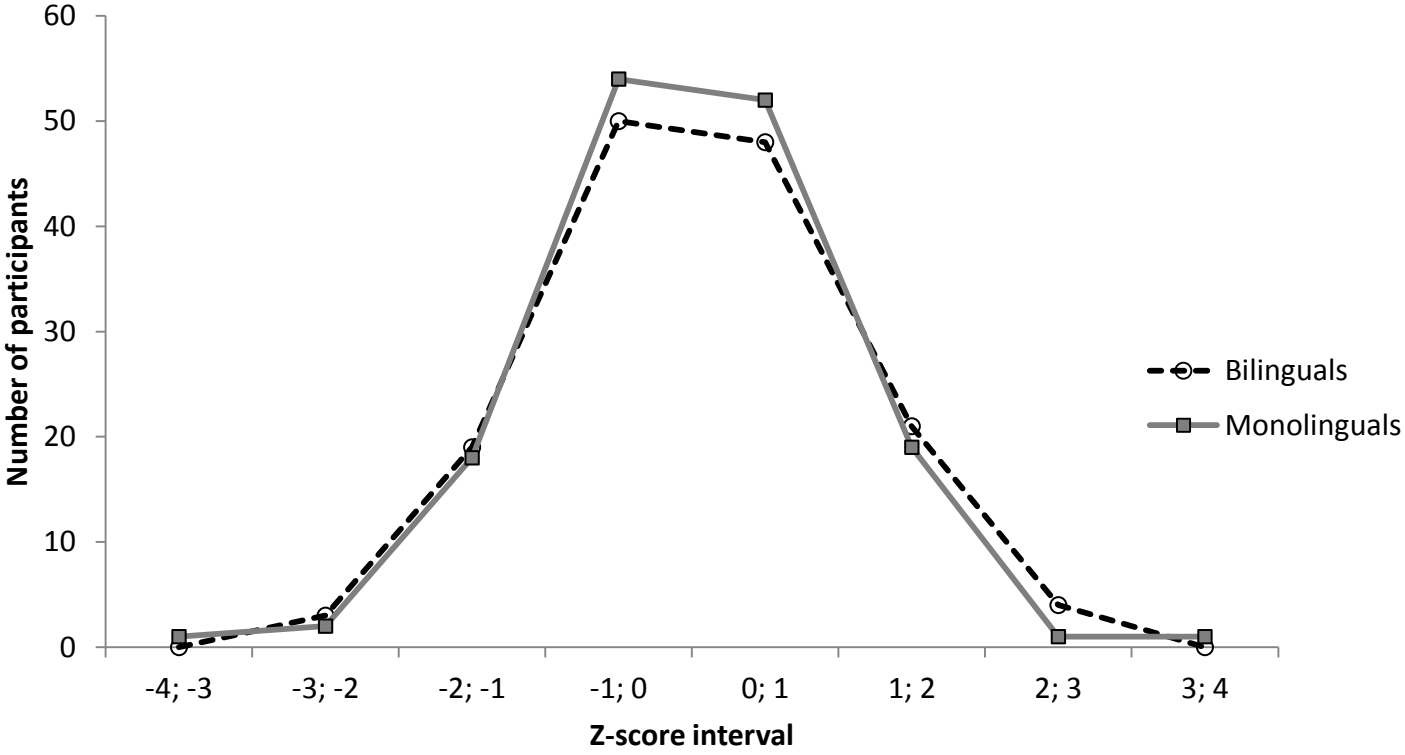
No replication of the reduced switch cost reported by Prior and cols

Where is the bilingual advantage in task-switching?

Hernández M., Martin CD., Barceló F., and Costa A. (2013), Journal of Memory and Language

Omnibus analysis (3 task-switching experiments):
Bilinguals and Monolinguals z-score distribution are similar

292 participants (145 bilinguals and 147 monolinguals)



The case of N -2 repetition cost

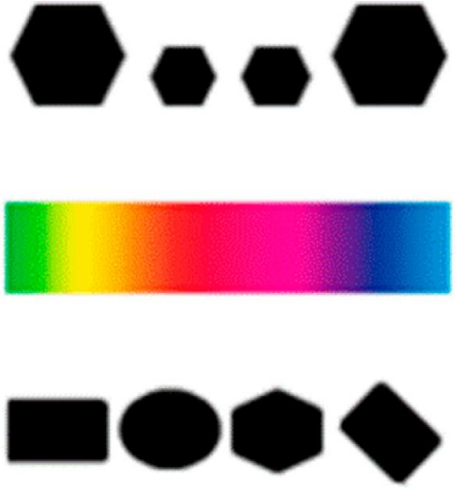
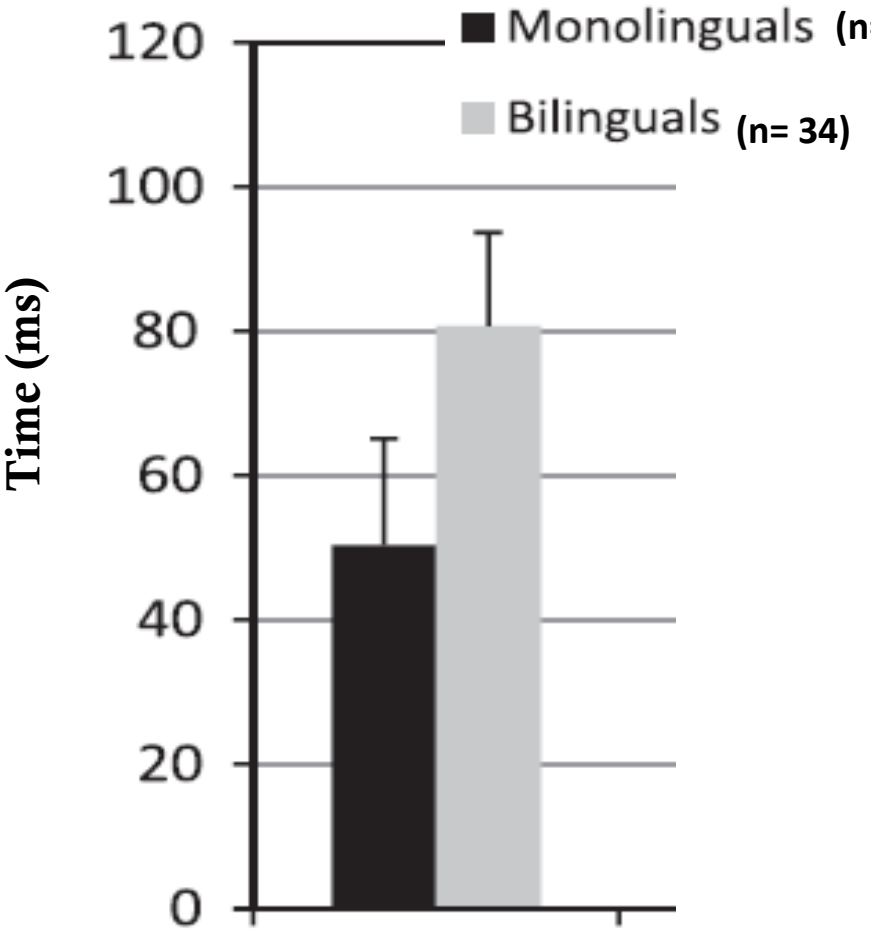


Fig. 1. Task Cues: size, color and shape.

Switching between three task

A B C VS. ABA = n-2 REPETITION COST

The case of N -2 repetition cost

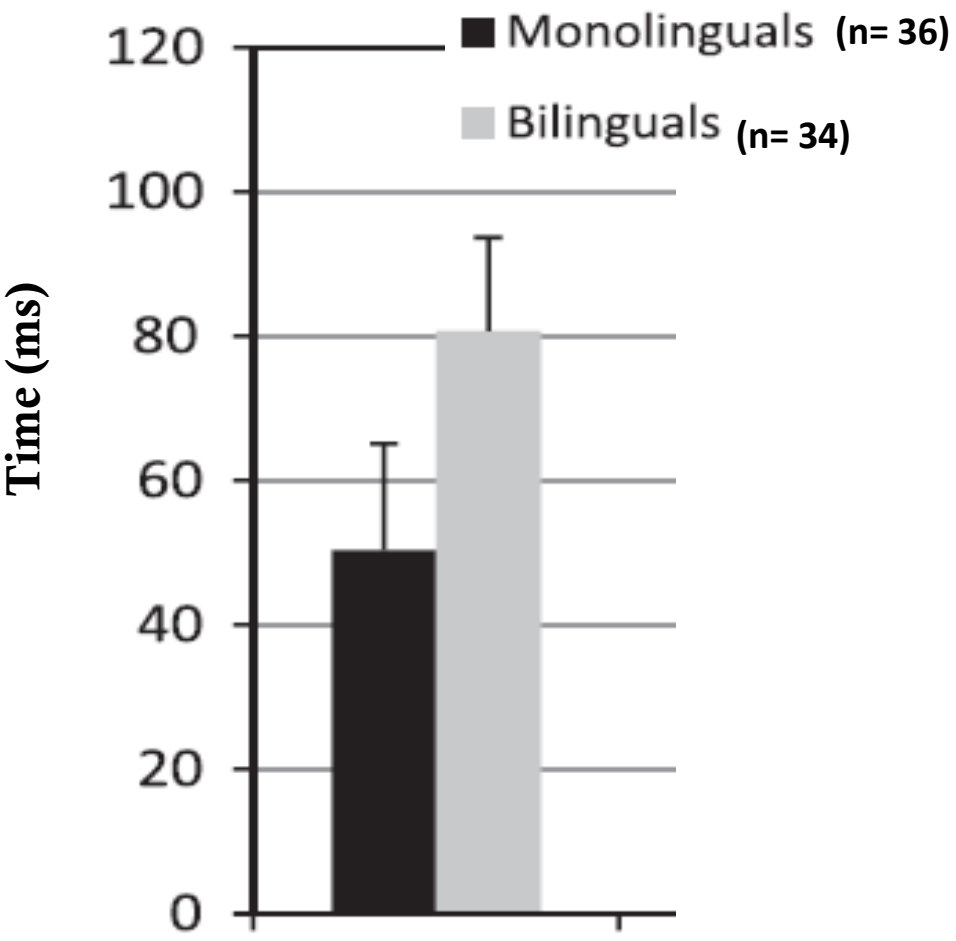


Prior (2012). *Cognition*

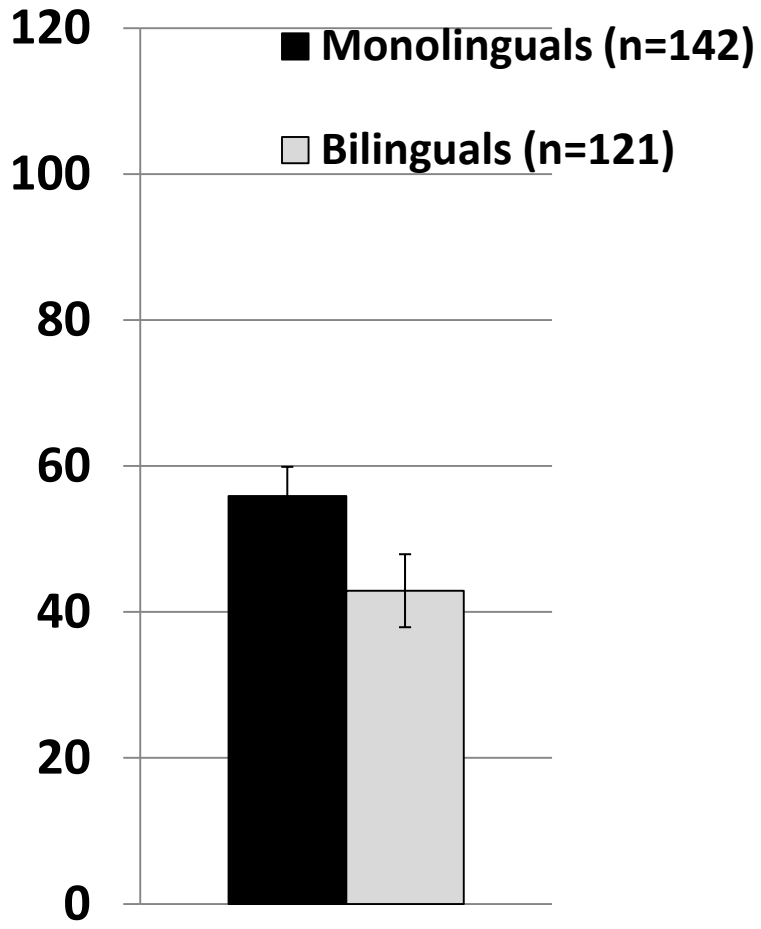
Too much of a good thing: Stronger bilingual inhibiti
leads to larger lag-2 task repetition costs

However…..

The case of N -2 repetition cost



Prior (2012). *Cognition*



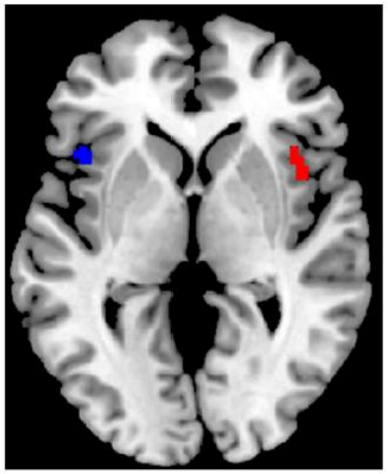
Branzi, Calabria, Gade, Fuentes & Costa *(Under review)*.

Networks involved in Task switching differ btw bilinguals and monolinguals

Garbin G., Sanjuan A., Forn C., Bustamante JC., Rodriguez-Pujadas A., Belloch V., Hernandez M., Costa A., and Ávila C. (2010), Neuroimage

… qualitative differences between bilinguals and monolinguals in the neural substrates of cognitive control

BILINGUALS: the left IFG



MONOLINGUALS:

right inferior frontal gyrus (IFG),

anterior cingulate cortex (ACC), and left inferior parietal lobe → consistent with prior literature

Differences in the IFG (bilinguals activated the left and monolinguals the right) are of particular interest, because the left IFG happens to play a key role in **bilingual language control (bLC).**

In fact, the next study (Rodríguez-Pujadas et al.) goes on the same lines: Bilinguals showed greater activity of two brain areas typically involved in bLC: again the left IFG but also the left caudate)

Potential limitation

Bilinguals' behavioral switch cost = 4 ms (*ns*)

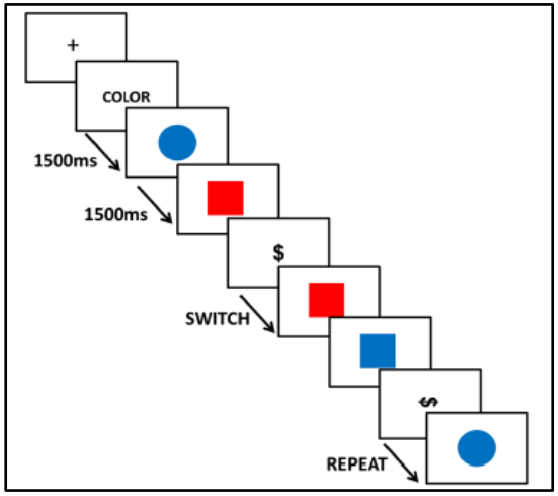
Monolinguals' behavioral switch cost = 32 ms (comparable to prior studies)

→ Perhaps the task was too easy for bilinguals

Networks involved in Task switching differ btw bilinguals and monolinguals

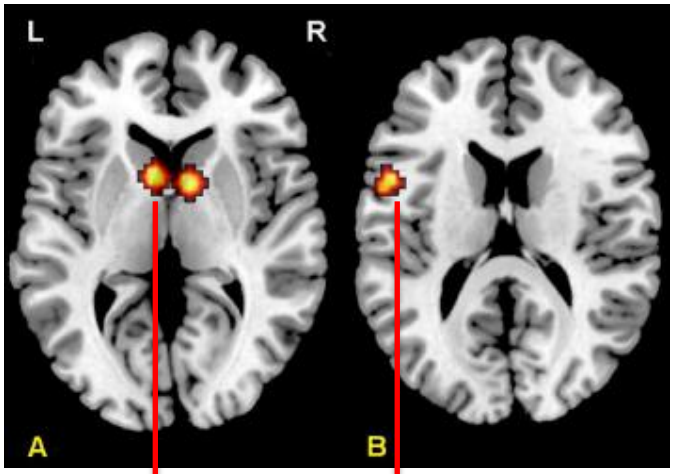
Rodríguez-Pujadas A., Sanjuan A., Ventura-Campos, N., Román P., Martin C., Barceló., F, Costa A., and Ávila C. (2013), PLOSone

Different instantiation of TS



Between-groups comparison:

Specific ROIs associated with both cognitive and language control were selected: *the right and the left IFG, the right and the left caudate, and the ACC*



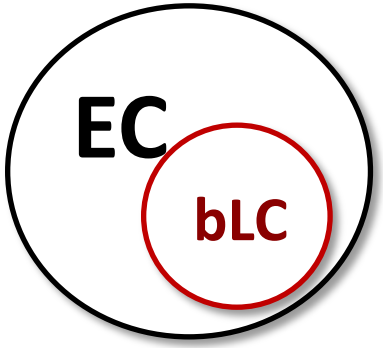
left caudate **left IFG**

ROIs where bilinguals' brain activity > monolinguals'

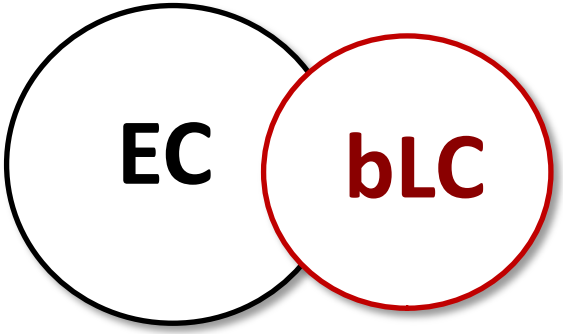
No performance differences but Bilinguals showed increased brain activity in the two brain regions involved in language control: *the left caudate and the left IFG*

The question

What are the common mechanisms between domain-general EC and bilingual language control?



Fully overlapped



Partially overlapped

The approach

Explore associations and dissociations in linguistic and non-linguistic tasks that "supposedly" share a common mechanism.

- Single case studies of patients
- Healthy adults
- Patients with cognitive impairments
- Functional overlap at the brain level
- Differences between bilinguals and monolinguals in switching

Costa & Sebastian-Gallés (2014), Nature Reviews Neuroscience

The answer

The link between bilingual language control and domain executive control is an elusive one, especially if you look at behavioral measures.

It is difficult to find associations across tasks, and sometimes language control and executive control clearly dissociate, especially in impaired individuals…..

Still, the neuroimaging data suggests some sort of overlap, and some differences between monolinguals and bilinguals in the networks involved in executive control.

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http://www.spb.upf.edu/

Thanks for your attention

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