# Understanding the Bilingual Advantage: Dual Mechanisms of Cognitive Control

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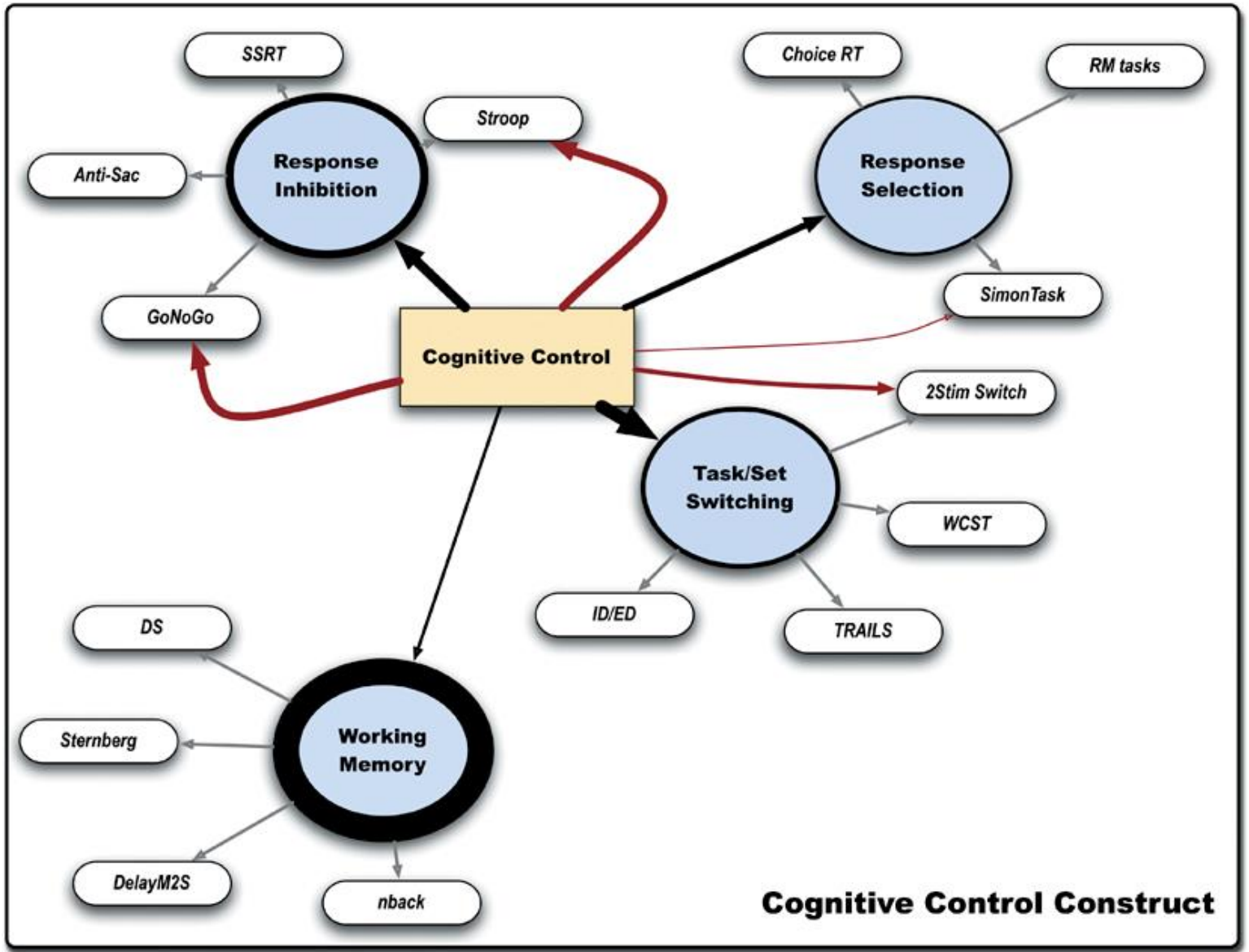
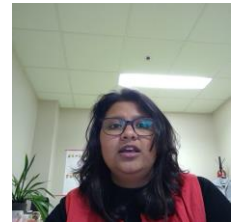
# Cognitive control



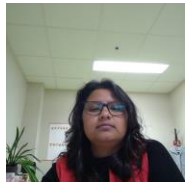



# Wide variety of literature supporting the bilingual advantage…

**Using behavioral and neuroimaging tasks** (Bialystok, Craik, Green, & Gollan, 2009; Bialystok, Craik, Klein, & Viswanathan, 2004; Blumenfeld & Marian, 2013; Grady, Luk, Craik, & Bialystok, 2015; Luk, Bialystok, Craik, & Grady, 2011).

**The bilingual advantage is usually explained by:**

- ✓ *Inhibition* (Green, 1998),
- ✓ *Goal maintenance and monitoring* (Colzato, Bajo, van den Wildenberg, Paolieri, Nieuwenhuis, La Heij, & Hommel, 2008; Costa, Hernández, Costa-Faidella, & Sebastián-Gallés, 2009) or
- ✓ *Conflict monitoring and interference suppression* (Ansaldo, Ghazi-Saidi, & Adrover-Roig, 2015).

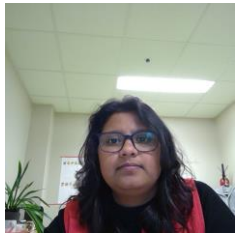


# Bilingual advantage in cognitive control?

- What is this advantage?
  - Faster reaction time
  - Better accuracy

- Why?
  - Juggling between the two languages train the nonlinguistic control mechanism

- How?
  - Is their any strategical difference???



# Dual mechanisms of control (DMC) -Braver (2012)

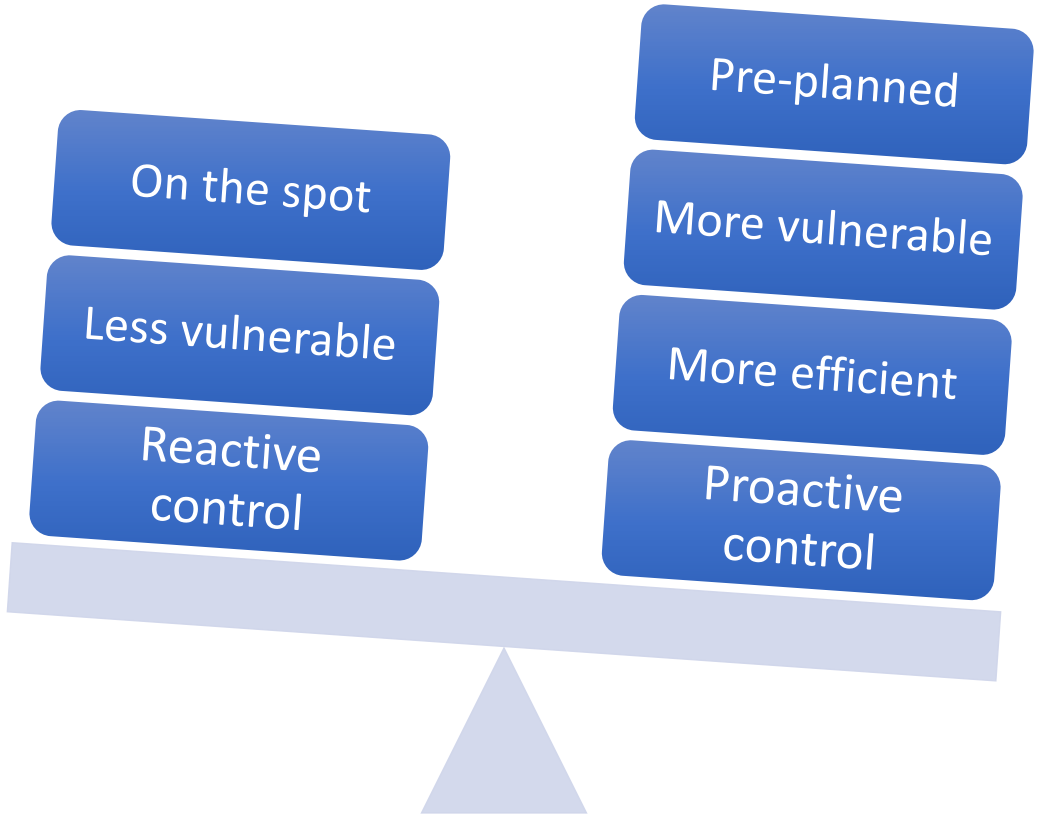
Cognitive control operates at two distinct operating modes

Late correction

Target based performance

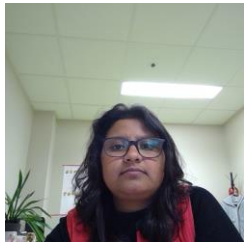
Cue based performance

Early selection



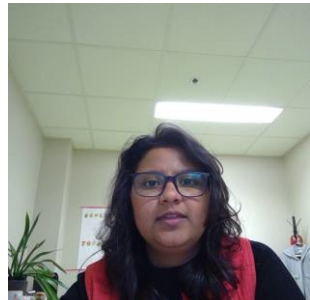

Slow

Fast



# Both forms of cognitive control are beneficial…..

- Preference towards one of the mode of control based on:
  - ✓**Difficulty of the task** (Bialystok et al., 2012)
  - ✓**Age** (Appelbaum, Boehler, Davis, Won, & Woldorff, 2014; Braver, 2012; Braver et al., 2007; Czernochowski, Nessler, & Friedman, 2010),
  - ✓**As a consequence of a disorder** (e.g., schizophrenia or aphasia; Dash & Kar, 2014; Fassbender et al., 2014)
  - ✓**cognitive-linguistic training** (Braver, 2012; Zhang, Kang, Wu, Ma, & Guo, 2015).

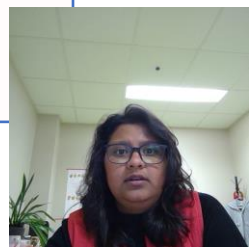


# Different ways in which proactive and reactive control is studied in literature

- Experimental distinction in proactive and reactive control
  - Example AX-continuous performance task

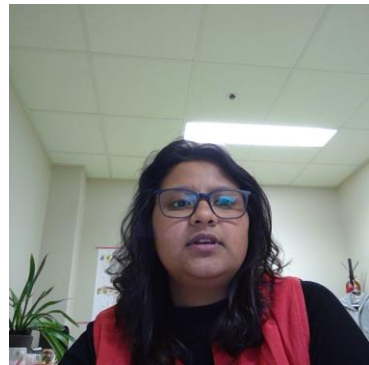
- Experimentally manipulating predictability of the condition

- Analyzing the reaction time distribution
  - ✓Categorize the responses in different RT bins
  - ✓Slow responses – Reactive mode of control
  - ✓Fast responses – proactive  mode of control



# Purpose of this study:

We aim to study the mechanism of cognitive control in bilingual and monolingual population – proactive and reactive control mechanism.

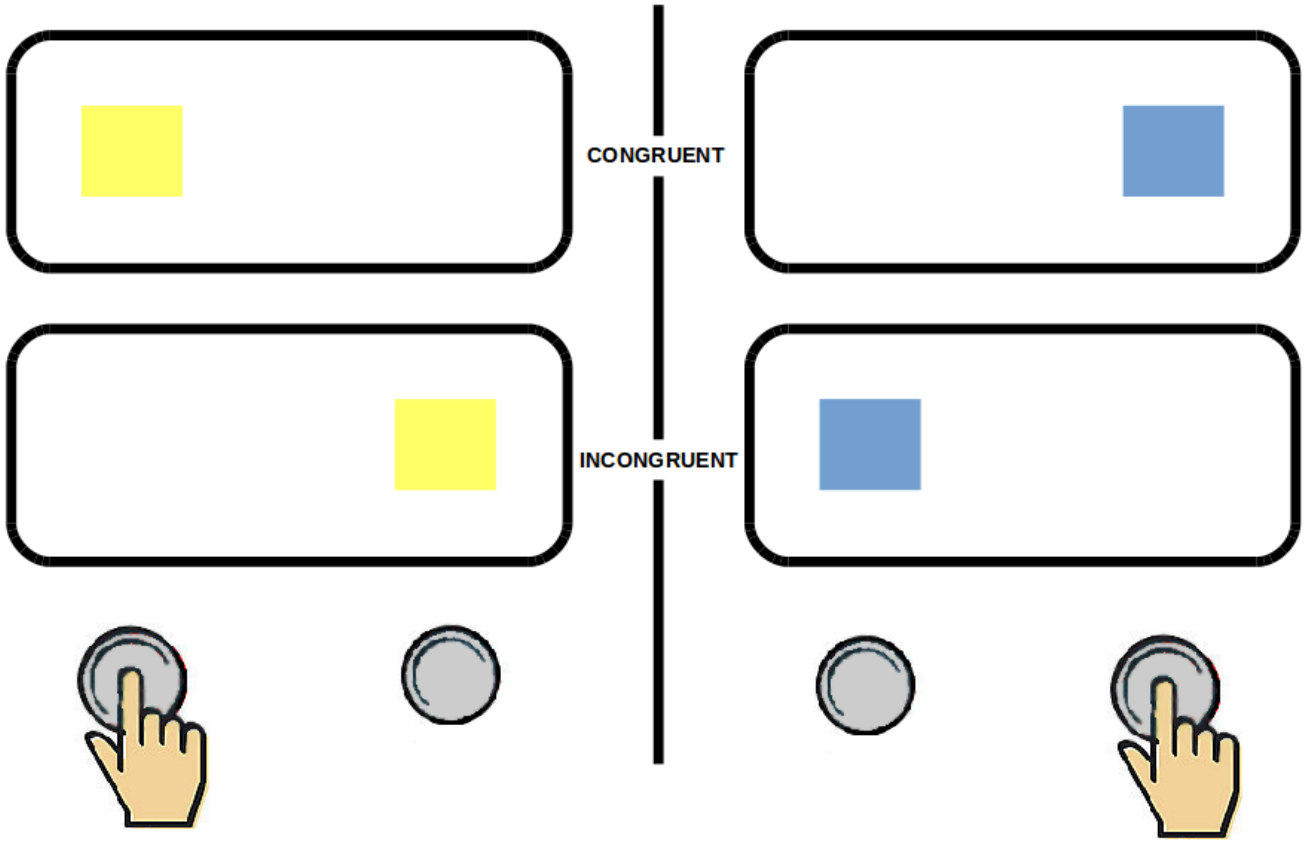


# Participants: 10 elderly French Monolinguals & 10 elderly French-English bilinguals

## Matched and controlled monolingual and bilingual groups

| | Monolingual | Bilingual | Range | *t(p)* |
|---|---|---|---|---|
| Age | 74,5 (7,1) | 74,2 (5,2) | 63-84 | 0,10 (n.s) |
| Education | 16,1 (3,2) | 17,2 (3,9) | 10-25 | 0,67 (n.s) |
| MOCA | 27,7 (1,2) | 27,5 (1,6) | 26-30 | 0,30 (n.s) |
| Depression level (GDS) | 1,5 (1,1) | 1,2 (1,2) | 0-4 | 0,55 (n.s) |
| Talk L2 | 3,7 (2,05) | 8,6 (1,6) | 1-10 | 5,9 (0.000) |
| Understand L2 | 4,5 (2) | 9 (1,5) | 2-10 | 5,5 (0.000) |
| Write L2 | 3,9(2,6) | 8,4 (2,2) | 1-10 | 4,2 (0.001) |

# Experimental task: Simon task

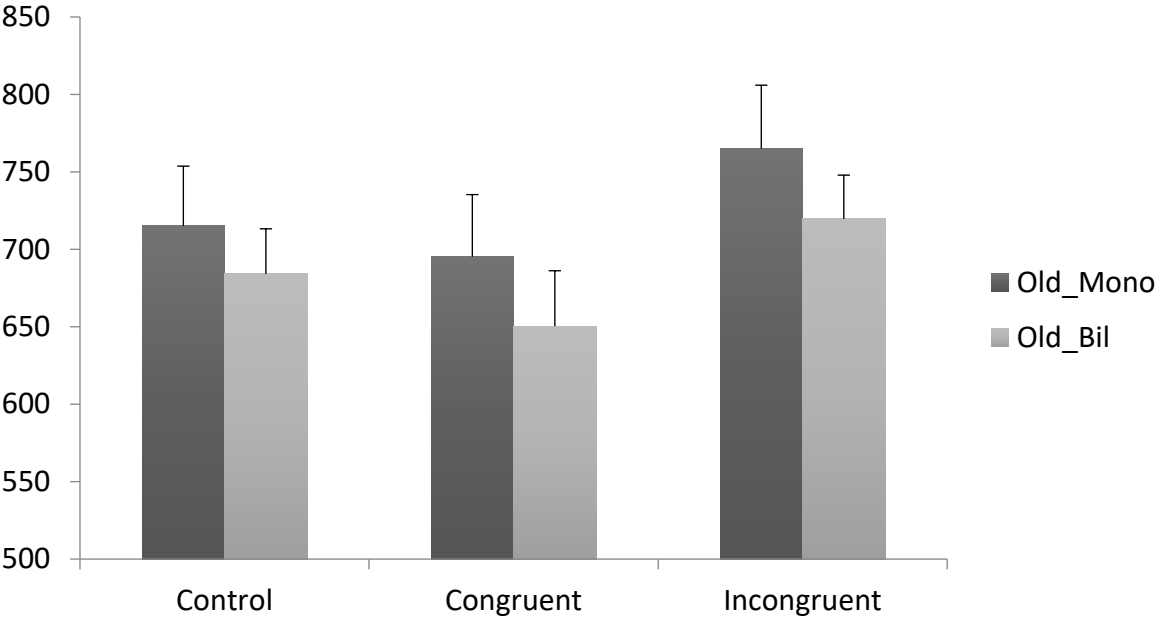



**Interference Suppression** → ACC, Inferior Frontal Dorsolateral Prefrontal ctx

**Motor execution** → Supplementary Motor areas

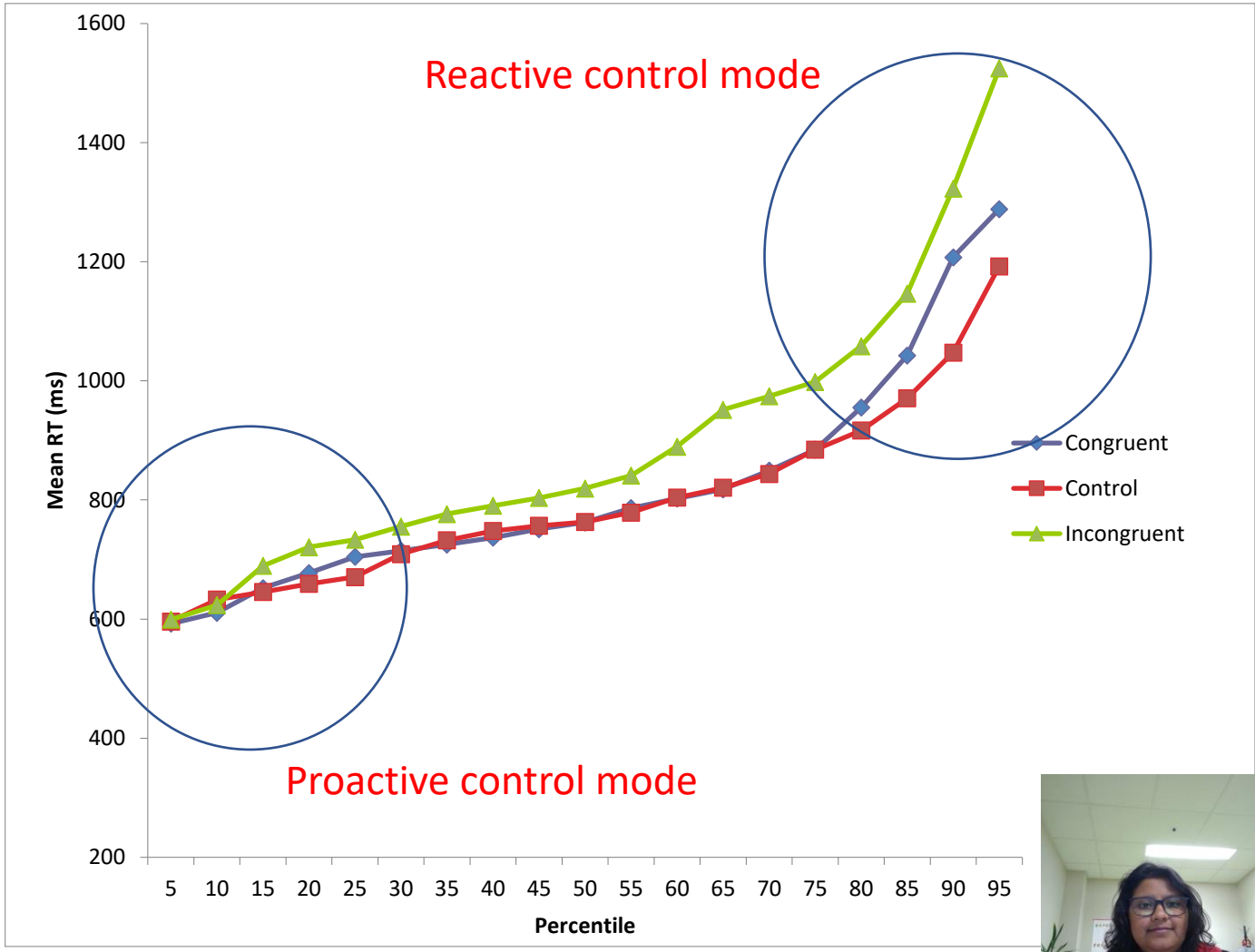
**Visuospatial Processing** → Superior Parietal & Visual Association areas

# Behavioural result




No significant difference between bilinguals and monolinguals on congruency effect measured by mean RTs (Ansaldo et al 2015)
As in earlier work (Braver et al., 2007; Czernochowski et al., 2010), this study examines fast and slow RTs as markers of proactive or reactive modes of control.

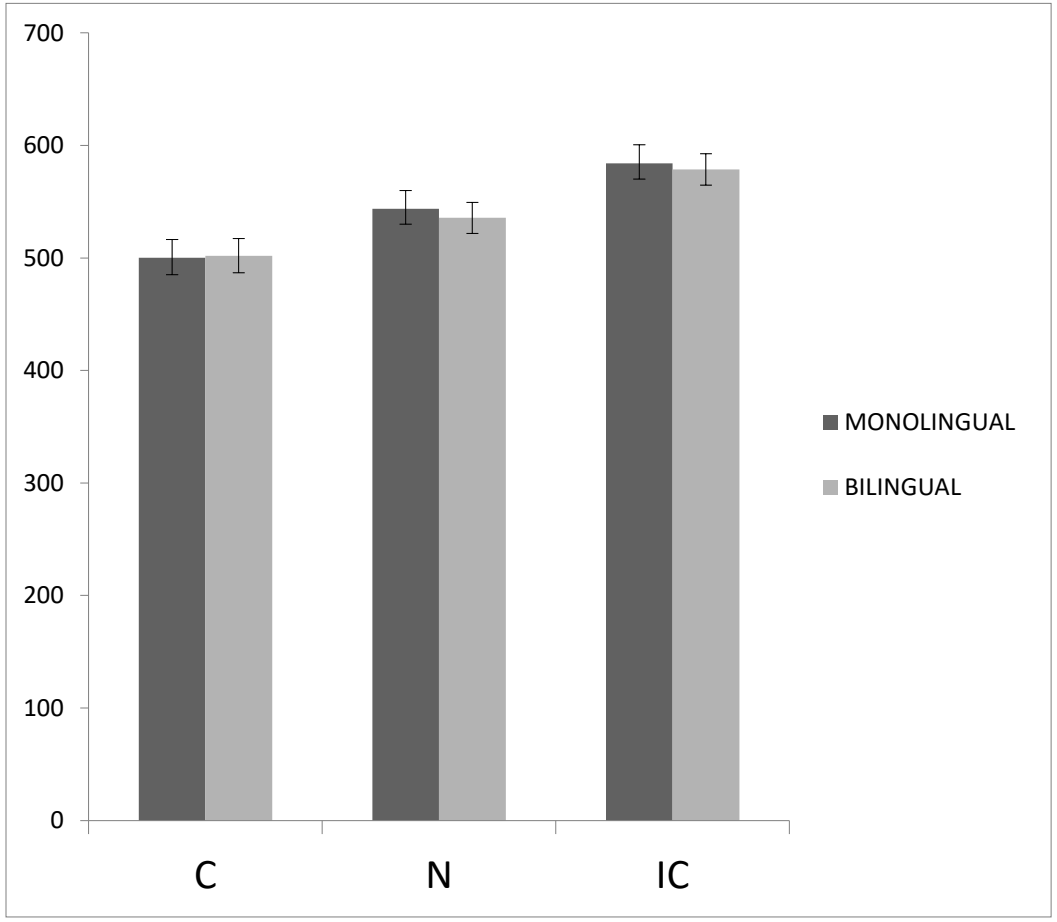
## An example of cumulative frequency distribution



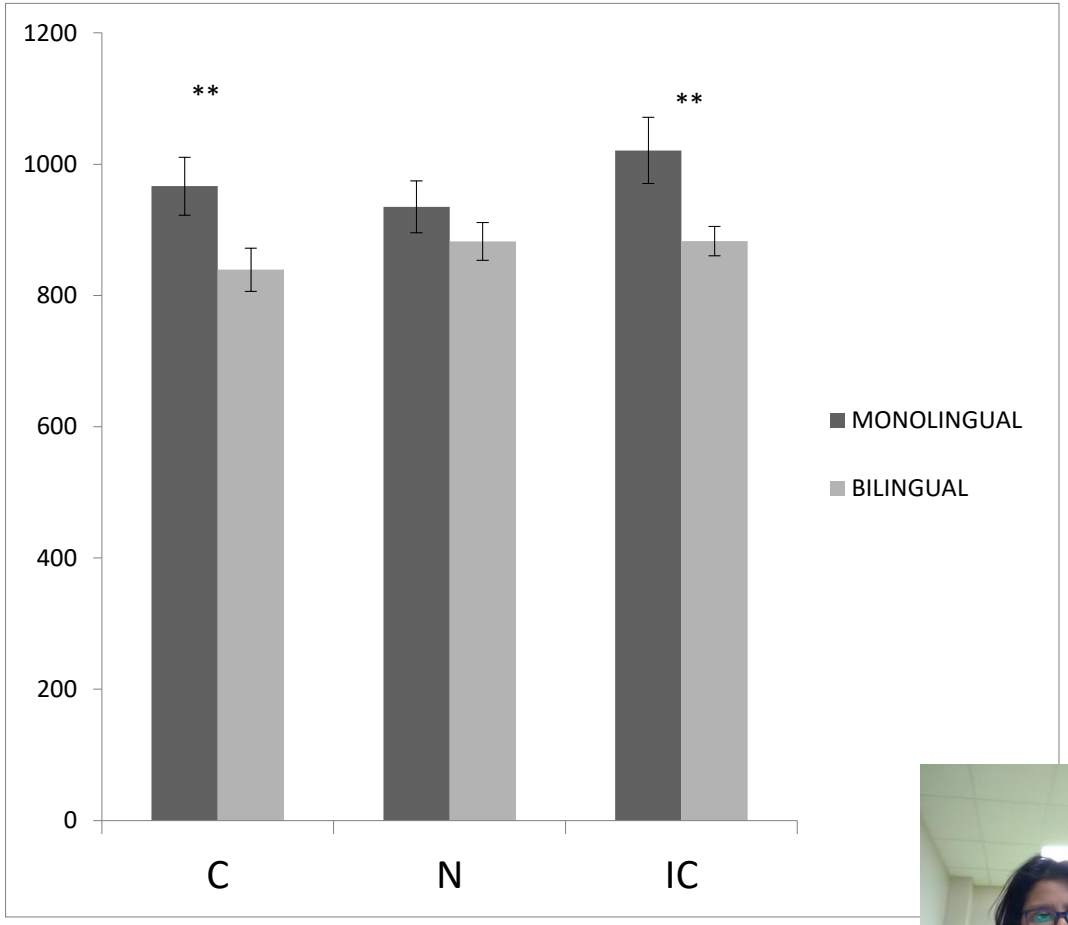
# RT distribution analysis

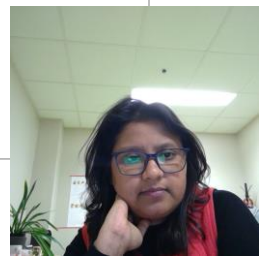
## Design Matrix: 2 groups*3 conditions*2 trial types = significant

Proactive control mode – 5th percentile



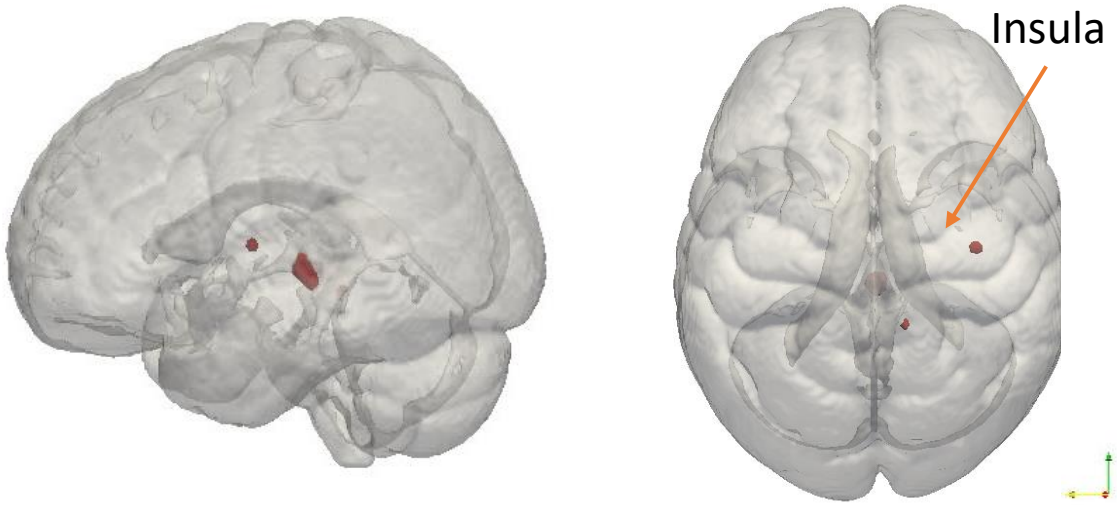

Reactive control mode – 95th percentile



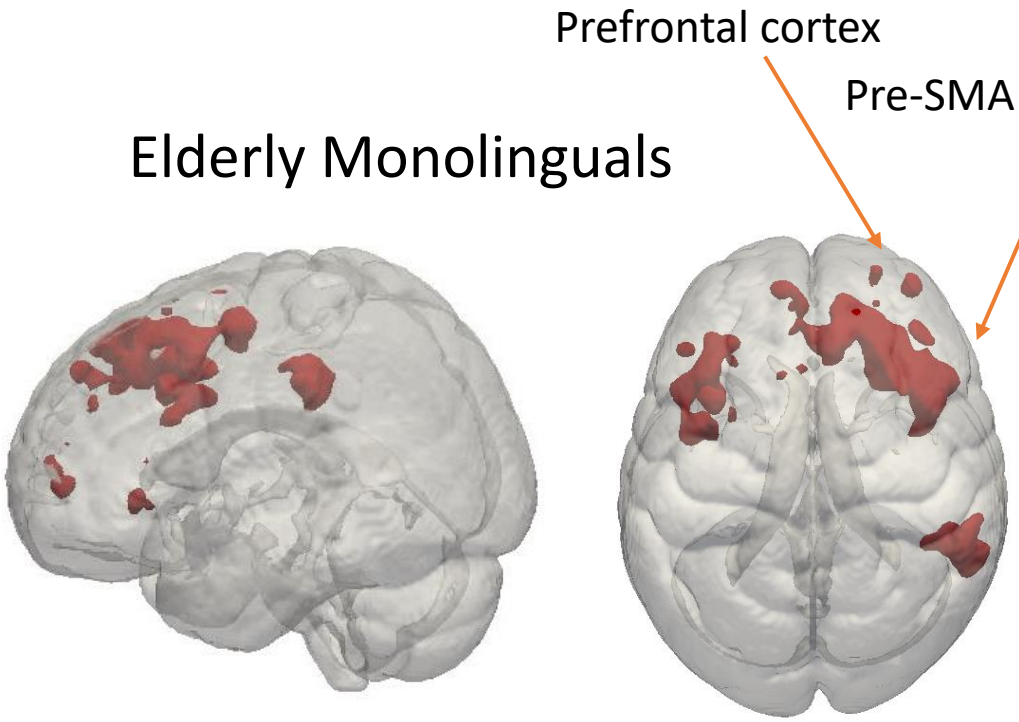



# fMRI results: Proactive mode of control

Elderly Bilinguals




Elderly Monolinguals




Irclbacher et al., 2014 reviewed the studies investigating interference resolution :
Proactive control - Pre SMA, Left DLPFC, Left IFG, inferior parietal regions

Salomon et al., 2016 – role of insula in visual awareness

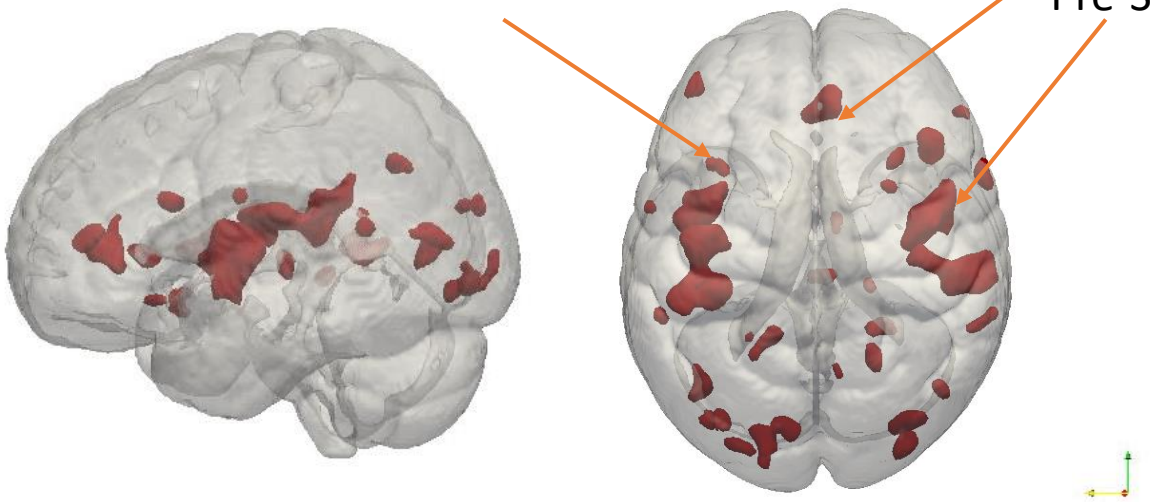
K≥20; p ≤ 0.001

# fMRI results: Reactive mode of control

Elderly Bilinguals

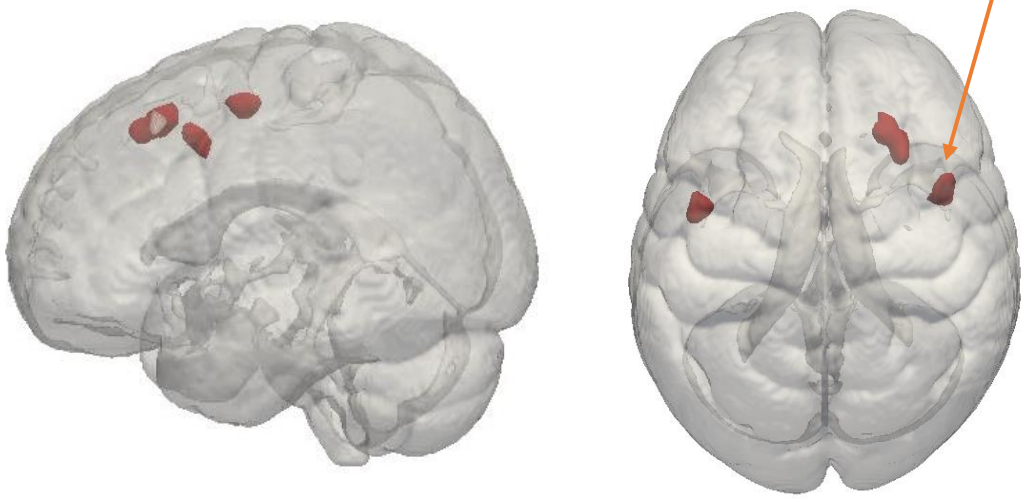
DL and medial PFC

ACC
Pre-SMA



Elderly Monolinguals

Pre-SMA



Irclbacher et al., 2014

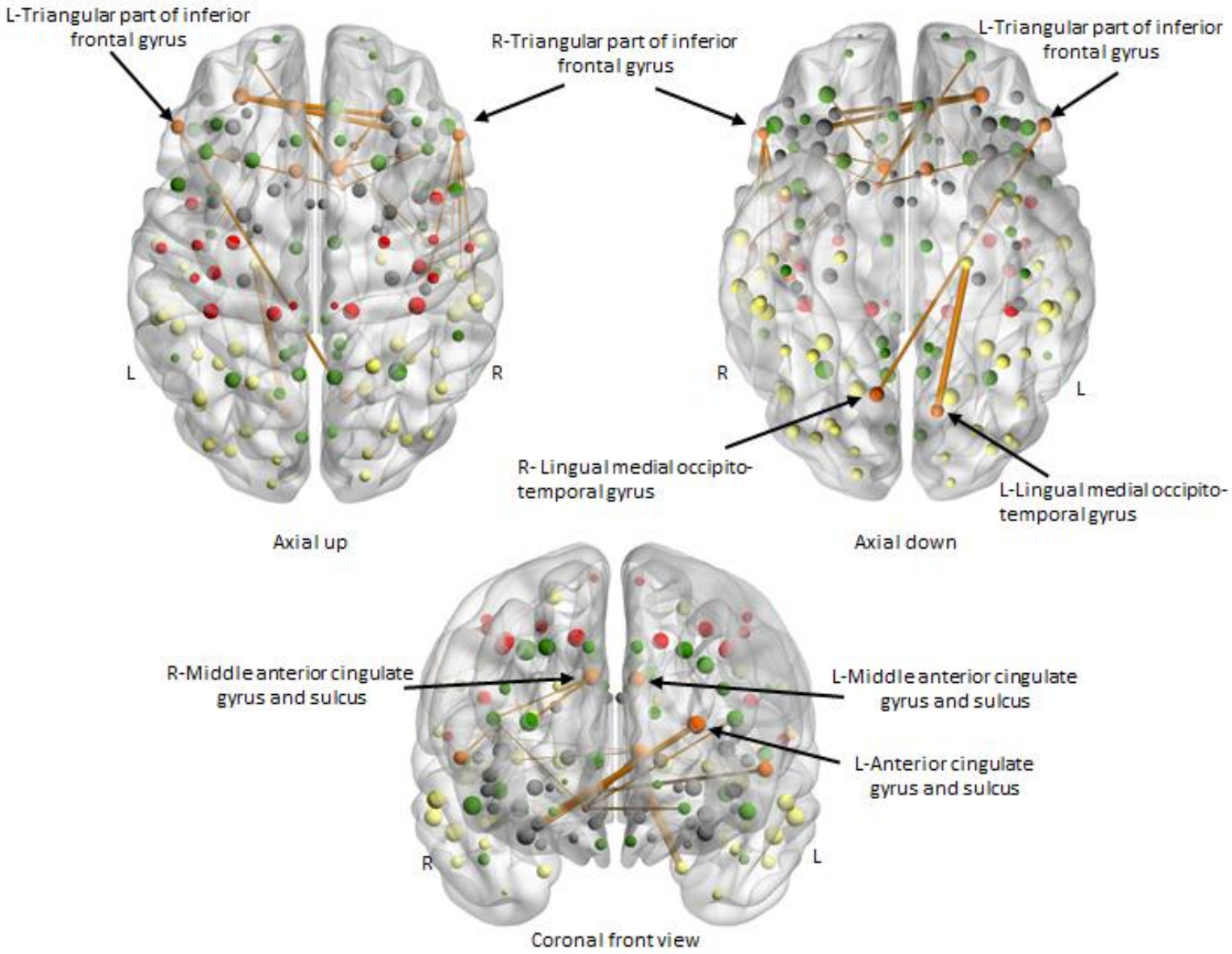
Early reactive - Pre SMA, DLPFC, PPC, Left IFG

Late reactive control- Pre SMA, FPC, ACC, Anterior VLPFC, left IFG, MTL

K≥20; p ≤ 0.001

# Functional connectivity results: Proactive mode of control

(using small world network analysis; Berroir et al., 2017)




**Color code for interpretation:**

- ✓ **Orange:** Spotted nodes (marked in the figure)
- ✓ **Yellow:** Visual processing areas
- ✓ **Red:** Motor processing areas
- ✓ **Green: E**xecutive function areas

**Higher connectivity values** for these spotted/detected ROIs in monolinguals --**need for more synchronization** between detected ROIs and the rest of the brain for monolinguals than for bilinguals ==**Resulting in less neural efficiency.**

**Dash et al., 2019**

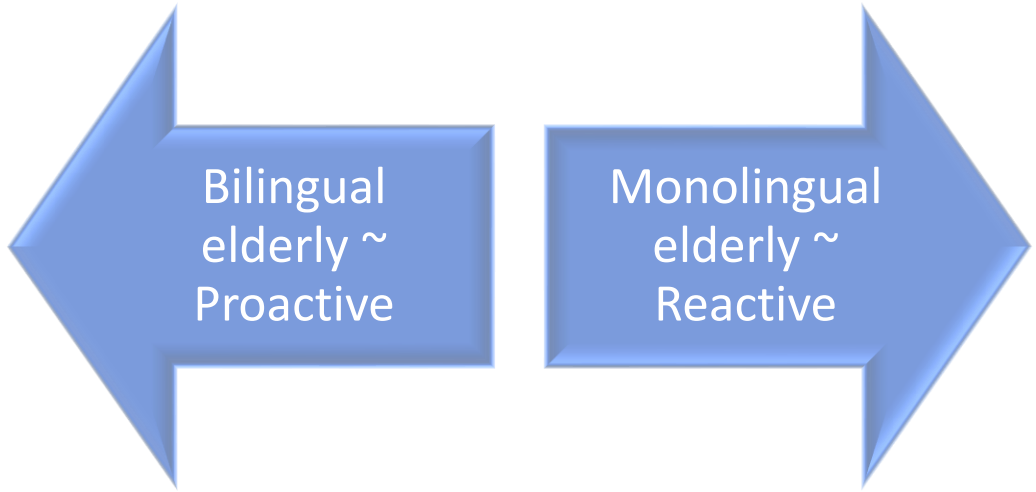
## Summary findings

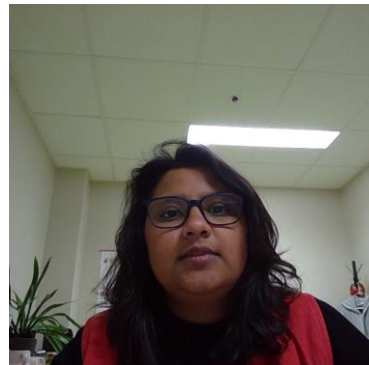
### Proactive mode of control

| | |
|---|---|
| Behavioural RT | Monolingual = Bilinguals |
| Activation | Monolinguals > Bilinguals |
| Degree of connectivity | Monolinguals >Bilinguals |

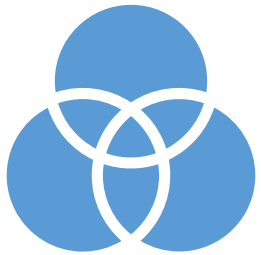
### Reactive mode of control

| | |
|---|---|
| Behavioural RT | Monolinguals > Bilinguals |
| Activation | Monolinguals < Bilinguals |
| Degree of connectivity | Monolinguals = Bilinguals |

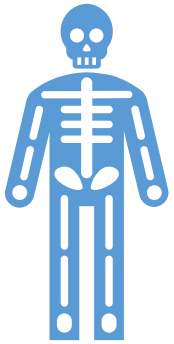


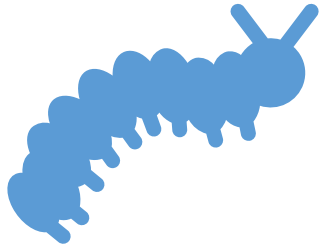
# In Conclusion….



Cognitive control mechanism may operate on a Reactive-Proactive continuum (Braver, 2012)



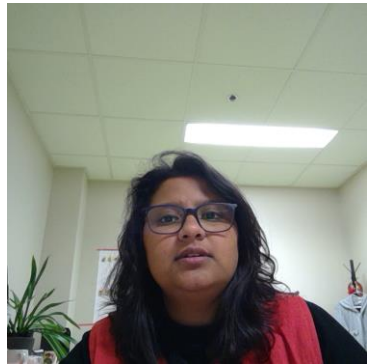
Elderly monolinguals work hard in proactive mode; for elderly bilinguals' proactive mode of control is natural. Thus, less effortful.



Reactive control mode is not a natural strategy for bilinguals, so they have to work hard.

Ageing makes an individual to use more of their **reactive mode of control** BUT bilingualism gives an advantage – in terms of the strategy.

**Ultimately**, what we practice more consumes less brain resources.



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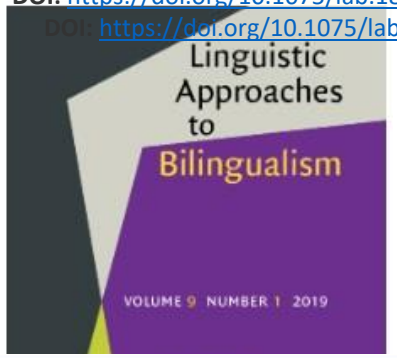


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## A new look at the question of the bilingual advantage

### Dual mechanisms of cognitive control

Tanya Dash
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Ladan Ghazi-Saidi
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Ana Inès Ansaldo

Bilingualism has been associated with age-related cognitive advantage. It is important to study cognitive control mechanisms to better understand this phenomenon. We sought to examine proactive and reactive control, as measured by fast and slow responses, respectively. The neural underpinnings of these modes of control were studied in rigorously matched elderly monolinguals and bilinguals, using fMRI performance on a Simon task. The results indicate that bilinguals performed efficiently in proactive mode, as more activation and connectivity were observed in the monolinguals. On the other hand, the monolinguals functioned more efficiently in reactive mode, recruiting fewer brain areas than the bilinguals. These results suggest that bilinguals' function effortlessly and economically in proactive mode, which is preserved through lifelong use of languages, whereas monolinguals are efficient in reactive mode, which they use more often as a consequence of aging. Thus, frequent use in daily life contributes to efficient functioning in the respective mode of control.

**Keywords:** bilingualism, dual mechanisms of cognitive control, ageing

Thank you for your attention!
Questions?

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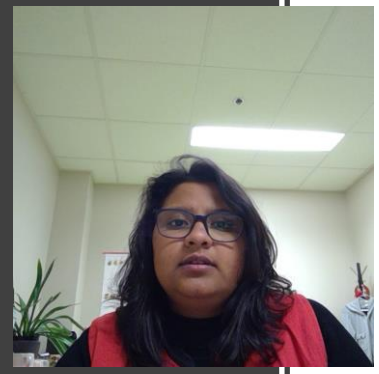

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