Bilingual switching in perception vs. action revealed by MEG

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Introduction

- Our ability to organize thoughts and actions compliant with internally defined goals is commonly referred to as cognitive control (Miller, 2000).
- For multilingual individuals this capacity includes the management of two or more languages.
- Thus, a critical question for understanding the neural architecture of the bilingual brain is whether:

  a) Bilingual language control is part of general cognitive control (Abutalebi et al., 2011)

  or

  b) Bilinguals develop specialized mechanisms to control language?
- Since language-switching occurs in comprehension and production, this question interacts with another unaddressed basic question about the neurobiology of bilingualism: Does language-switching in comprehension and production employ similar brain mechanisms?
- We targeted both questions within the same design, addressing not only the neurobiological similarity of language-switching and non-language switching but also the commonality between language-switching in comprehension and production.
- MEG measurements were analyzed in areas previously implicated in language selection and cognitive control: dorsolateral prefrontal cortex (dlPFC) anterior cinculate cortex (ACC) and left inferior frontal gyrus (LIFG).

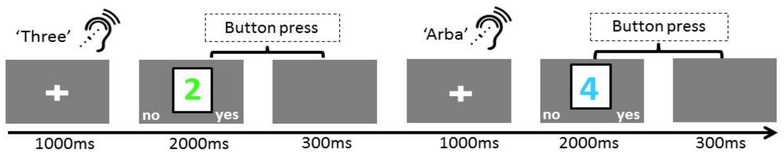
Materials and Methods

- 19 right-handed Arabic-English bilinguals.
- Continuous MEG data acquired during experimental session, with a 208 sensor array.
- Acquisition recording band 0-200Hz, sampling rate of 1000 Hz.
- Four conditions partitioned by block; pre-empted with **condition-specific instruction.**
- Maximally parallel language-switching and category-switching tasks in production and comprehension.
- Selecting playing cards as stimuli allowed us to create different naming task while keeping visual stimulus constant.

1) Production tasks:

1a) Language switching: If the suits are red name the numerosity in Arabic, if they are black, name it in English.

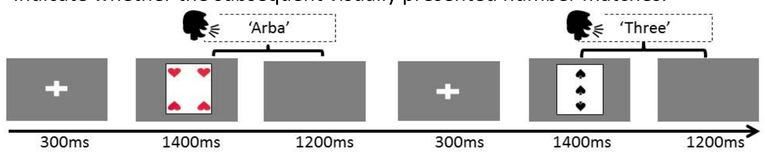
1b) Category switching: If the suits are red name the numerosity, if they are black, name the suit, both in Arabic.



2) Comprehension tasks:

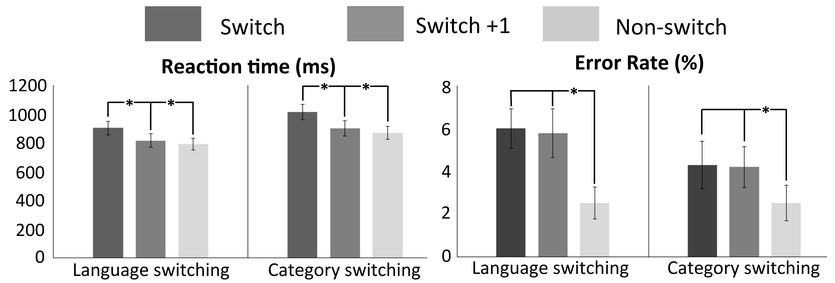
2a) Language switching: Listen to Arabic or English numbers and press the button to indicate whether the subsequent visually presented number matches.

2b) Category switching: Listen to Arabic numbers or colors and press the button to indicate whether the subsequent visually presented number matches.



Behavioral Results

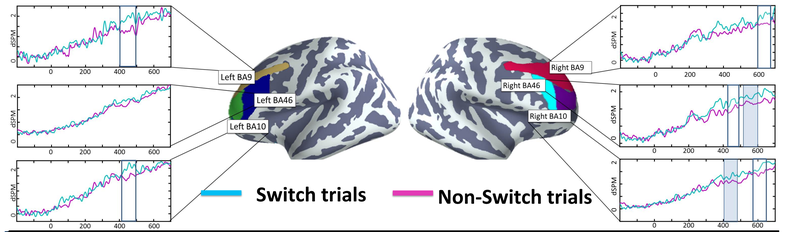
2 x 3 ANOVA: Domain (Language/Category) x Switch: (Switch/Switch+1/Non-switch).

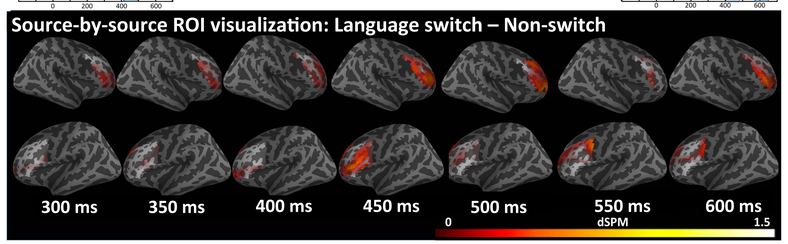


ROI analyses: Switching in Production

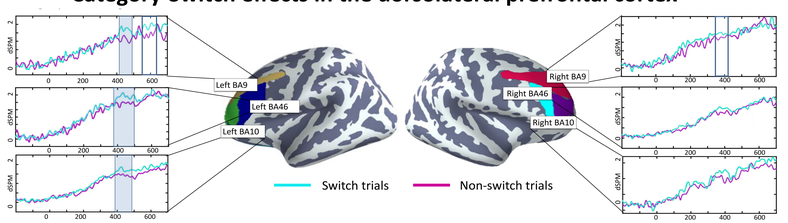
- **2 x 2 ANOVA:** Domain (Language/Category) x Switch: (Switch/Non-switch).
- **Time intervals:** 300:500 and 500:700ms.
- **Main effect of Switch**: p = 0.002

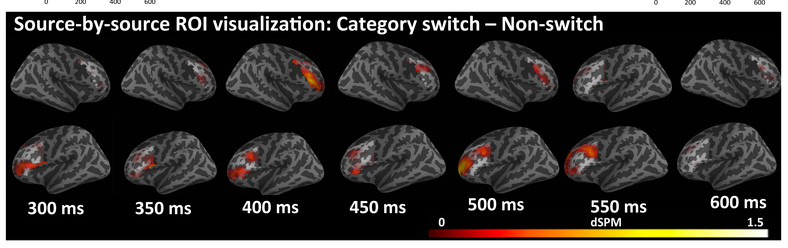
Language-Switch effects in the dorsolateral prefrontal cortex





Category-Switch effects in the dorsolateral prefrontal cortex

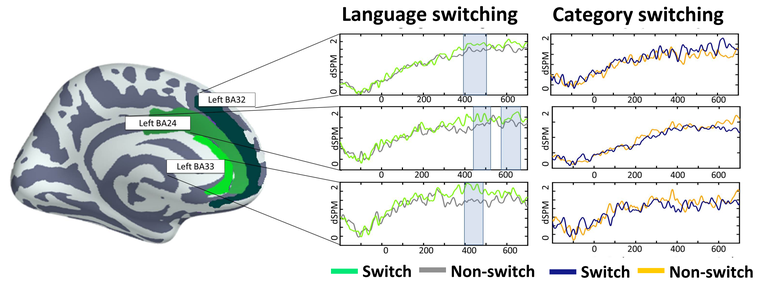


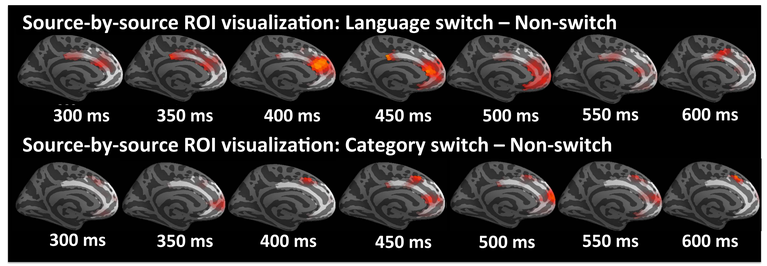


ROI analyses: Switching in Comprehension

- **2 x 2 ANOVA:** Domain (Language/Category) x Switch: (Switch/Non-switch).
- **Time intervals:** 300:500 and 500:700ms.
- **Interaction**: p = 0.01

Language-Switch effects in the anterior cingulate cortex





Conclusions

- Brain areas responsible for language-switching in production and comprehension dissociate even for identical lexical material: While producing switches following a cue recruited the dlPFC bilaterally, comprehending switches engaged the left ACC.
- This suggests that bilinguals may not rely on similar inhibitory mechanisms in production and comprehension (i.e., there is no unique language "switch"), but instead rely on **adaptive cognitive control** which favors the implementation of proactive control when switching languages in production and reactive control when switching in comprehension.
- Consistent with the hypothesis that language control and general cognitive control co-localize, the language switch effects localized in the dlPFC in production also extended to category-switching.
- While the lack of overlap between category and language switching in comprehension suggests that the language switching effect localized in the ACC could in fact be language specific perhaps the specifics of the design precluded us from seeing a shared effect.

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