Differences in neural substrates of comprehension in bilinguals and monolinguals

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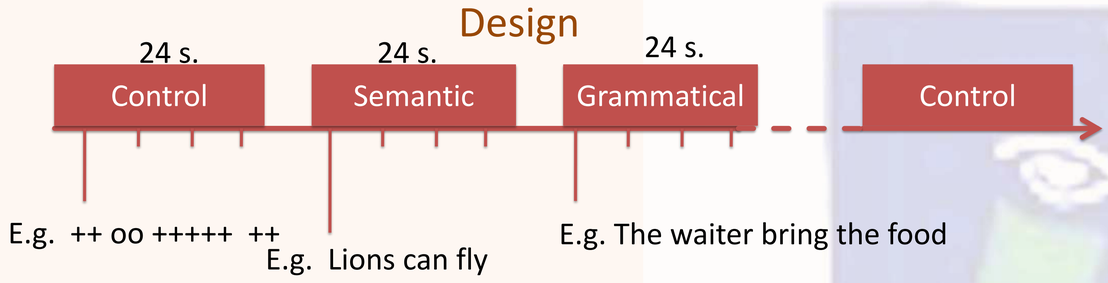
With regards to sentence processing in bilingualism, Kovelman et al., (2008) have shown that bilinguals activate to a higher extent left inferior frontal gyrus in syntactic processing when compared to monolinguals. Such differences have been termed as the "neural signature" of bilingualism. However, it is necessary to distinguish between grammatical and semantic processes in bilingual sentence comprehension as these two levels have been revealed to differ in the cognitive sub operations that they engage (Wartenburger et al., 2003). Our study is devoted to fill this gap in the comparison of monolinguals and bilinguals sentence comprehension.

The task

We used grammatical and semantic judgement tasks (in L1) that were visually presented to Spanish monolinguals and early, high proficient Catalan-Spanish bilinguals. In a grammatical block, sentences were meaningful but could included different types of grammatical violations (disagreement of number or gender). For semantic blocks, the sentences were always grammatically correct but could contain semantic violations.

Design



Acquisition parameters

MR images were collected using a SIEMENS AVANTO 1.5 T scanner (Erlange, Germany). We collected 240 continuous EPI funtional volumes (TR = 3000 ms; TE = 50 ms; FOV: 224mmx224mm; matrix = 64°x64 pixels; slice thickness/gap= 3/0.5 mm; flip angle: 90◦; 35 axial slices).
A morphological volumetric sagittal 3D T1-weighted fast-field echo sequence (TR = 11ms; TE = 4.9 ms; FOV 256mmx234mm; matrix = 256x224; voxel size 1mmx1mmx1mm; number of echoes: 1; slip angle = 15◦).

Analysis

Preprocessing and analyses were performed using SPM5 software (The Wellcome Institute of Neurology, London, UK). Preprocessing included realignment, normalization of images to the MNI space by using the standard EPI template and setting the mean realigned image as reference. Smoothing was applied with Gaussian kernel of 8mm. In the fixed-effect analysis, a full factorial design was set for each subject, modelling control, semantic and grammatical conditions separately. The convolution was performed by using the canonical HRF. At this level of analysis, a t-contrast was defined for each subject as the difference between experimental and control conditions. Posterior random effects analysis included the images from fixed effect to explore within and between groups compararisons.

BILINGUALS **MONOLINGUALS**

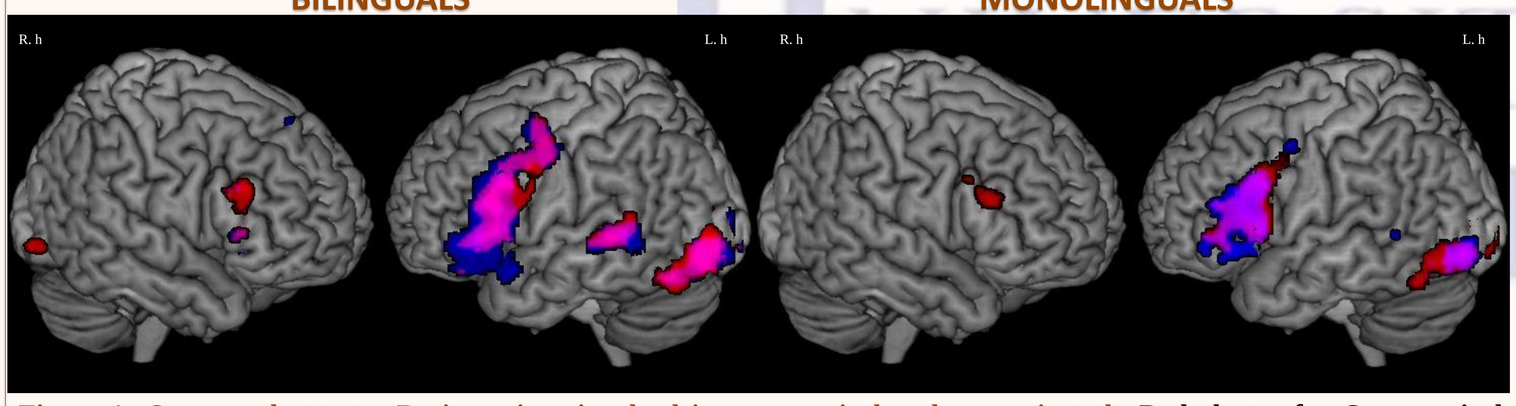


Figure 1: One-sample t-tests: Brain regions involved in grammatical and semantic task. Red cluster for Grammatical condition, blue for Semantic condition and violet/pink for both conditions ($p_{FWE\text{-}cor}<0.05$).

BILINGUALS vs. MONOLINGUALS

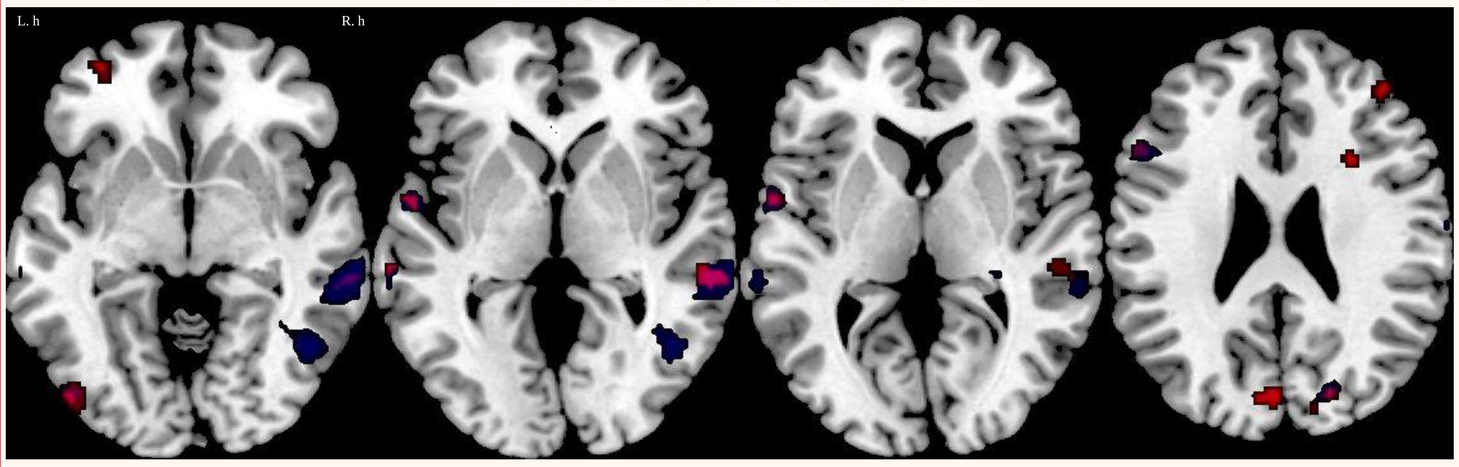


Figure 2: Two-sample t-tests: Bilinguals vs. Monolinguals. Differential involvement of Broca's area and Wernicke's area in bilinguals and monolinguals. Red cluster for Grammatical condition, blue for Semantic condition and violet/pink for both conditions (p<0.005, uncorrected).

fMRI and Behavioural Results

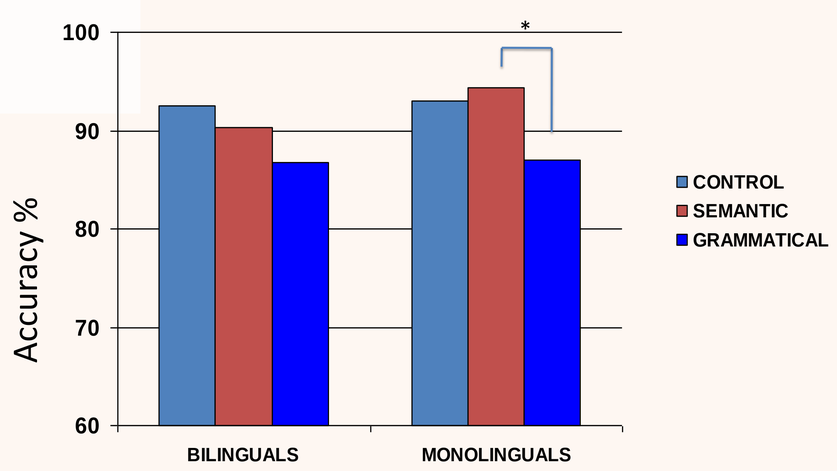


Figure 3: Behavioural performance of Bilinguals and Monolinguals in Grammatical, Semantic and Control conditions. Average values of accuracy (percentage of correct responses) in each group for the three conditions.

Summary and Conclusions

In this study, bilinguals and monolinguals were asked to perform two linguistic tasks in a single language. fMRI results showed different patterns of brain activity between groups. More specifically, bilinguals activated more than monolinguals brain areas related to language (Wernicke's area and Broca's area) in both tasks. On the other hand, results didn't show significant differences in brain activity between semantic and grammatical conditions.

References

Wartenburger I, Heekeren HR, Burchert F, De Bleser R, Villringer A (2003): Grammaticality judgments on sentences with and without movement of phrasal constituents—an event-related fMRI study. J Neurolinguistics 16: 301–314.
Kovelman I, Baker SA, Petitto LA (2008). Bilingual and monolingual brains compared: a functional magnetic resonance imaging investigation of syntactic processing and possible "neural signature" of bilingualism. J Cogn Neurosci 20(1):153-69.