Frontal aslant tract and language production in bimodal and unimodal bilinguals

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A bilingual person needs to select the appropriate language for successful communication. This suggests the presence of an intimate relation between bilingual language processing and control processing [1]. Despite the interest on how bilinguals manage the two languages, how language experience modulates the processes and, in turn, the brain networks involved in cognitive control, is still largely unknown. The present study aims to examine the correlation between the microstructural properties of the Frontal aslant tract (FAT), a withe matter tract connecting the Inferior Frontal Gyrus and the pre-Supplementary Motor Area (SMA) and the SMA [2], and the bilinguals' performance in a picture naming task. We compared the pattern obtained in a group of unimodal bilinguals (L1 Italian, L2 English) and a group of bimodal bilinguals (L1 Italian, L2 Italian Sign Language).

The FAT has been targeted as a relevant fiber supporting selection of actions/programs/representations, both in speech and in the general action domain (for a review, [3]). The comparison between unimodal and bimodal bilinguals (UBs and BBs) allows testing whether control needs differ when the languages do not share modality. From the one side, control needs might be less stringent for BBs than for UBs, given that a sign and a word can be articulated together [4]. From the other side, suppressing an entire modality might require stronger control than suppressing some lexical entries within the same modality.

Here we used diffusion imaging tractography, based on the spherical deconvolution approach [5,6]. The participants were 54 healthy bilinguals (24 BBs and 25 UBs), matched for age and gender. We extracted two tractographic indexes: the Hindrance Modulated Orientational Anisotropy (HMOA) and the normalized number of tracts (nNT). From participants we also collected latency in a picture naming task both in L1 (Italian) and L2 (English/Italian sign language).

Regression models with the tractographic measures as dependent variables were used to estimate the effect of group and the picture naming latencies in L1 and L2. Picture naming latency in L2 was significantly related to the HMOA of the left FAT($t = 2.59$, $p = .0128$). This effect did not depend on L2 modality ($t = .086$). Both the HMOA and nNT of the right FAT showed a significant interaction between groups and naming latency in L1 ($t = 2.83$, $p = .0071$, $t = 2.54$, $p = .0148$, respectively). While for BBs naming latencies in L1 were significantly correlated to the tractographic measures of the right FAT, no correlation was present for UBs. Furthermore, all the correlations found between picture naming latencies and HMOA/nNT were positive, i.e. the longer the response time the larger the HMOA and the higher the nNT.

Both UBs and BBs need to control L1 when speaking in L2. The main effect obtained of L2 latencies on the HMOA of the left FAT suggest the left FAT connects areas used for the control of the spoken language. When speaking in L2, differently from UBs, BBs need to control hands' movements. The interaction obtained between HMOA/nNT of the right FAT and language modality suggests that the right FAT connects areas used for the control the signed language. The direction of the correlation between tractographic and behavioral measures points towards the idea of a dynamical restructuring of brain anatomy associated with L2 acquisition and use [7, 8].

References
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Figure 1.
Correlational pattern between the tractographic and behavioral measures