



# Exploring the Relationship Between Prosodic Cue Production and Functional Connectivity in the Bilingual Brain



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## BACKGROUND

- Prosody = melody and rhythm of speech
  - includes prosodic cues such as fundamental frequency ( $F_0$ ) and duration<sup>1</sup>
- Mastery of prosodic production in multiple languages is difficult, requiring sufficient exposure to each language<sup>2</sup>
  - English (has lexical stress) vs. French (no lexical stress)<sup>3</sup>
- Previous anatomical work on this project suggests that the basal ganglia and cerebellum support mastery of prosodic production in English-French bilinguals<sup>2</sup>
  - Subcortical regions associated with  $F_0$  production
  - Cerebellar regions associated with duration production
- A subcortico-cortico-cerebellar network has been proposed for processing aspects of speech timing such as prosody<sup>4</sup>

## OBJECTIVES

- Investigate the intrinsic functional connectivity supporting mastery of prosodic production in English-French bilinguals
- Identify if there are differences related to use of L1 vs. L2

## PROSODIC CUE PRODUCTION MEASURE

- 15 (L1 English L2 French) bilinguals read 80 sentence pairs (40 per language) with 1 or 2 target word(s) depending on the segmentation, for example:

1. If you would like a **kiwi** I will buy one tomorrow.

2. If you would like a **key** we can duplicate one.

3. Le vendeur **d'horloges** vit à l'hôtel.

4. Le vendeur **d'or loge** à l'hôtel.



- $F_0$  and duration values for the target word(s) were used to characterize participants' ability to produce native-like prosody in both English and French<sup>5</sup>

## NEUROIMAGING METHODS

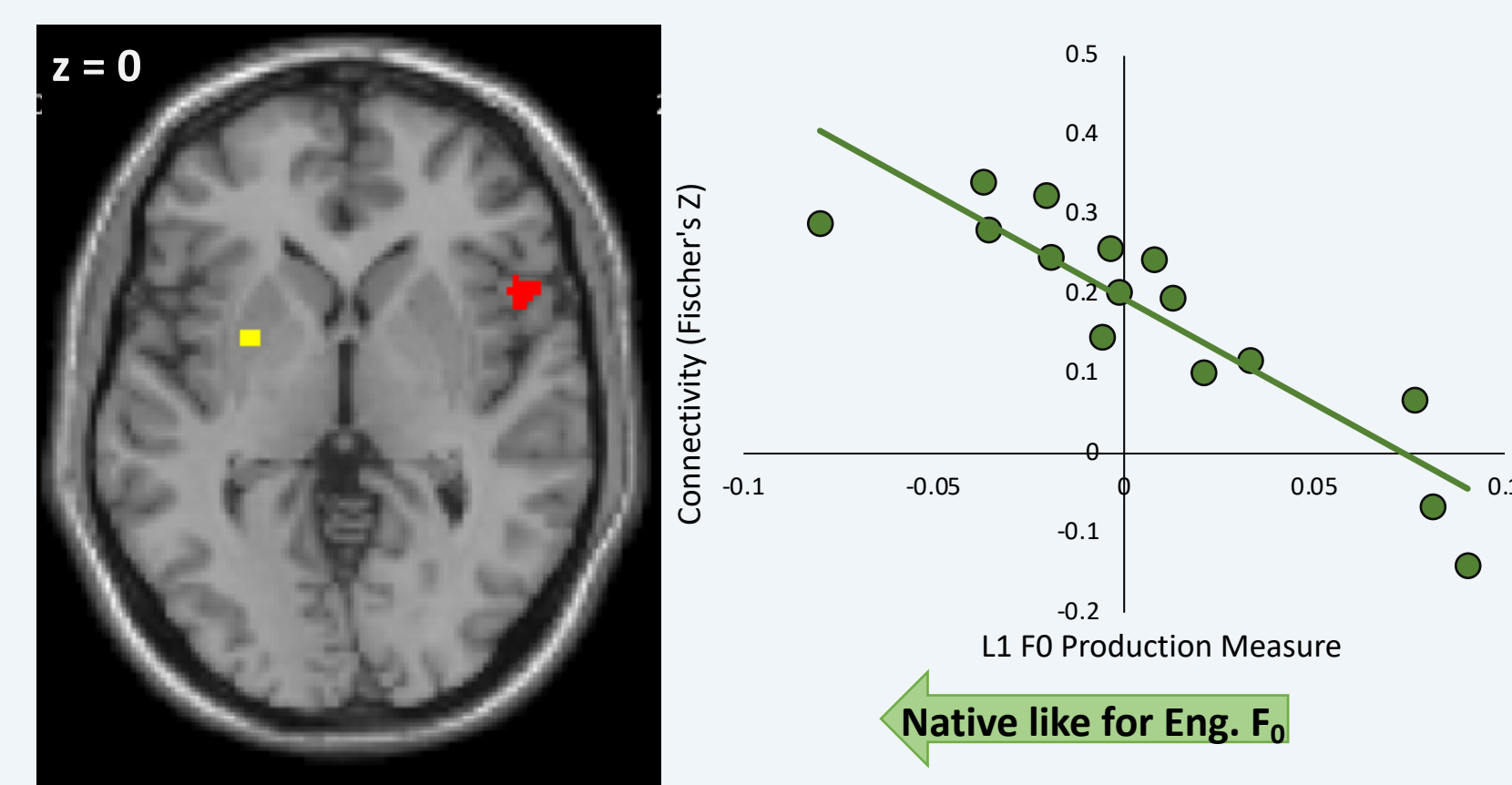
- Data were acquired using a 3T TrioTim Siemens scanner
- Whole-brain seed to voxel analyses were performed using CONN toolbox to relate participants' relative  $F_0$  and duration production values to intrinsic functional connectivity.

## PRELIMINARY RESULTS

- 6mm seeds were created using peak coordinates from previous structural findings in the basal ganglia, cerebellum<sup>2</sup> and literature<sup>4</sup>
- $p < 0.05$ , after corrections for multiple comparisons (FDR for whole brain analysis, Benjamini-Holms for multiple seeds)
- Seeds denoted in yellow, clusters showing signif. connectivity in red

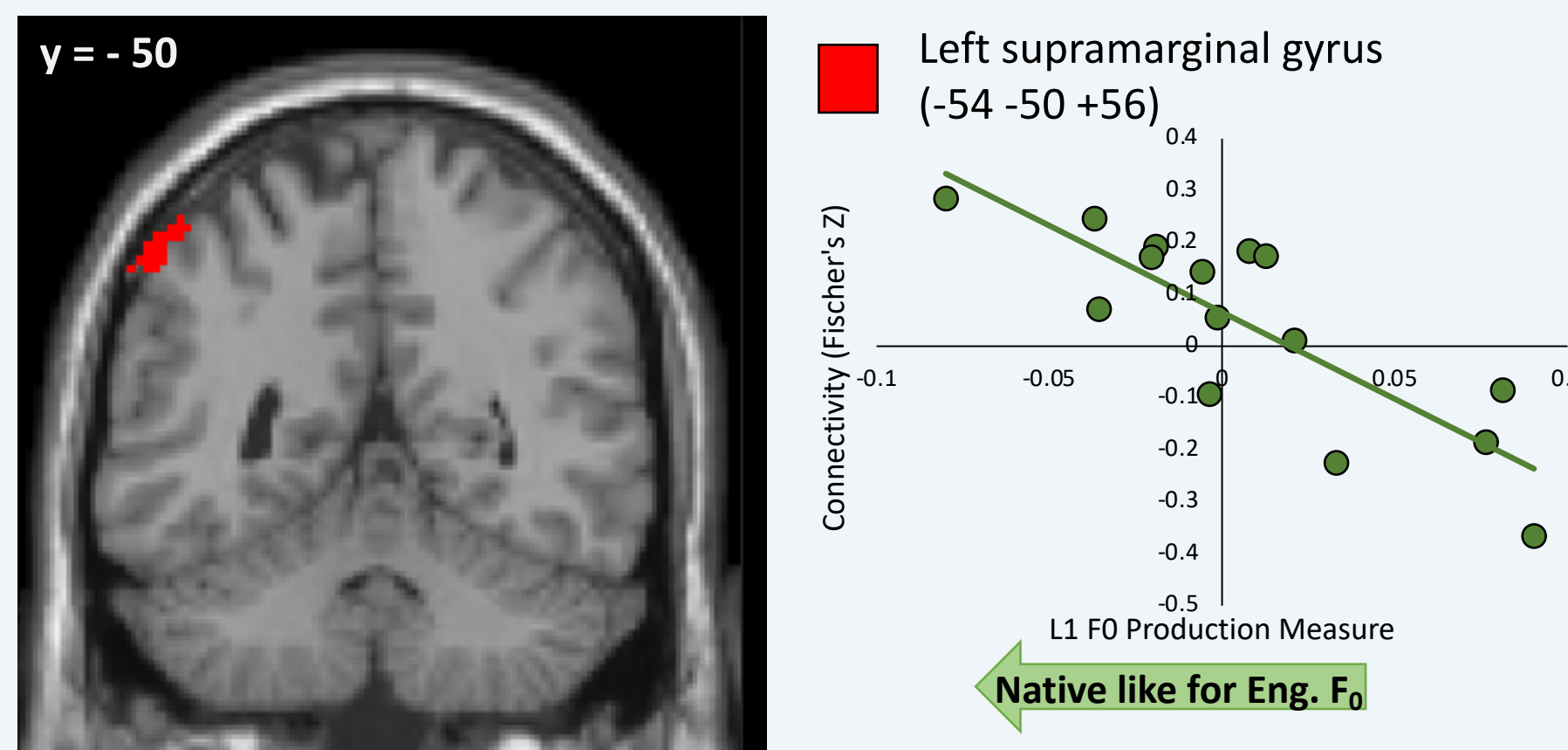
### ENGLISH (L1) $F_0$ PRODUCTION

- Native-like English  $F_0$  associated with increased connectivity between:
  - Left putamen (seed) and the right inferior frontal gyrus (BA44; cluster)



Left putamen  
Right inferior frontal gyrus (BA44)  
(+52 +16+02)

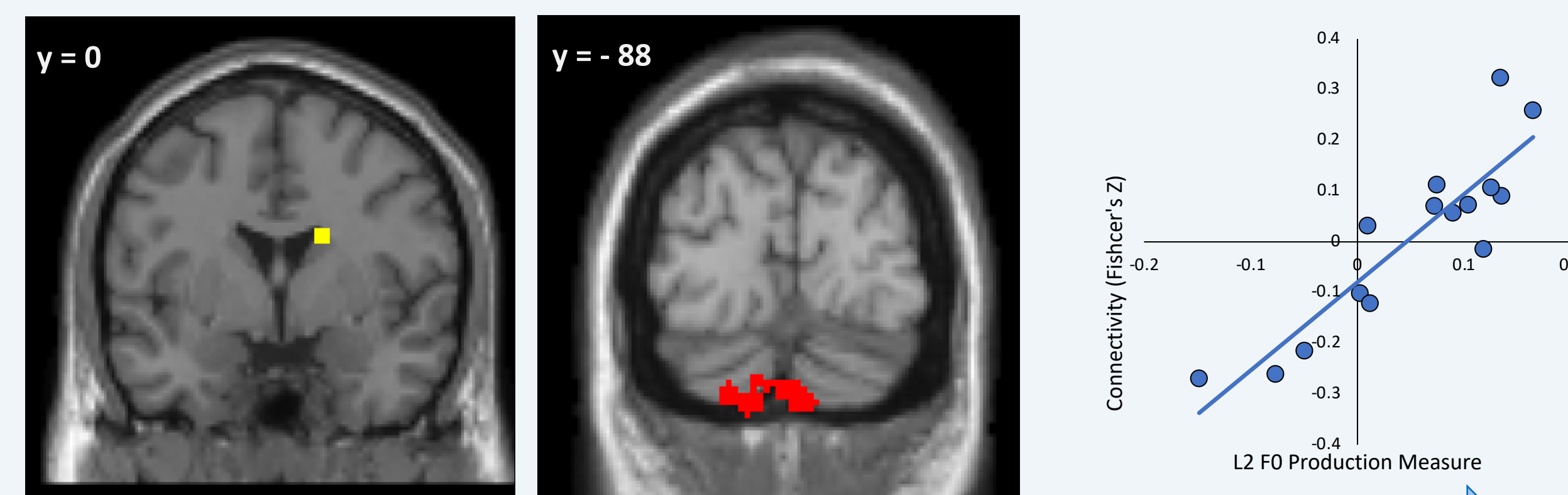
- Left putamen (seed) and the left supramarginal gyrus (cluster)



Left supramarginal gyrus  
(-54 -50 +56)

### FRENCH (L2) $F_0$ PRODUCTION

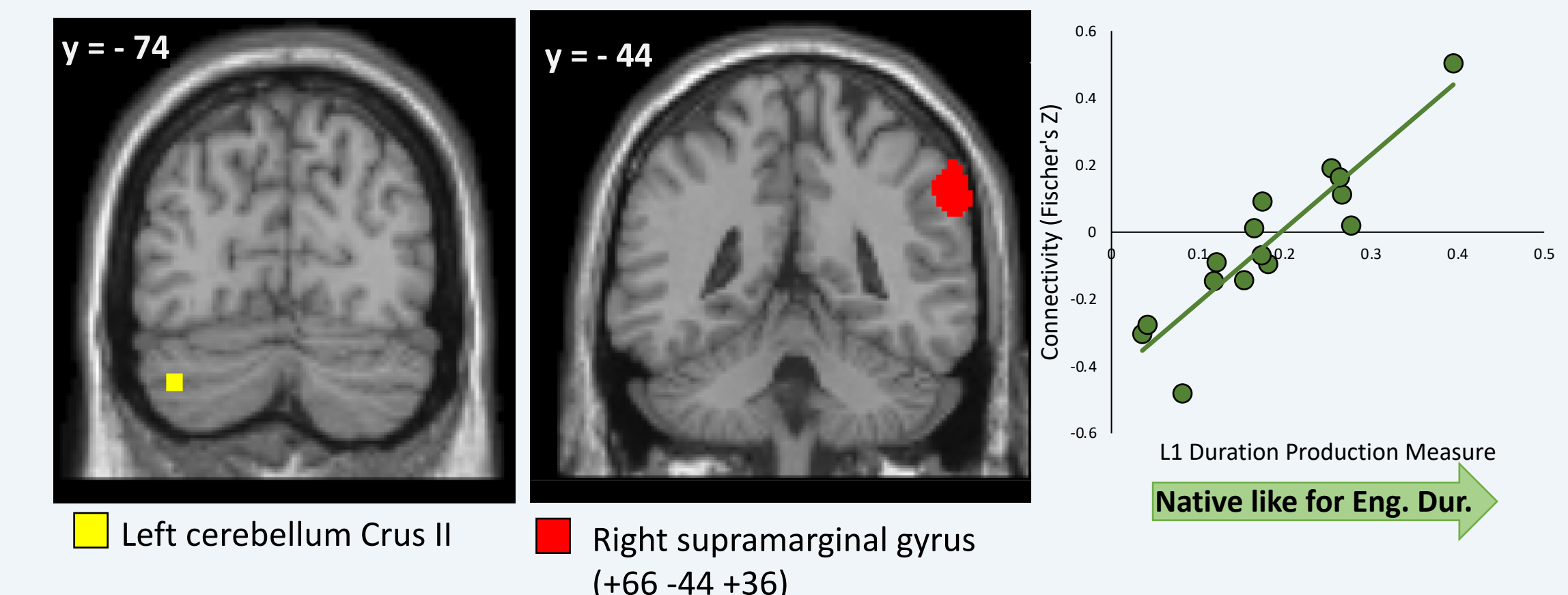
- Native-like French  $F_0$  associated with increased connectivity between:
  - Right caudate (seed) and the cerebellum Crus II (cluster)



Right caudate  
Bilateral cerebellum Crus II  
(+2 -86 -40)

## ENGLISH (L1) DURATION PRODUCTION

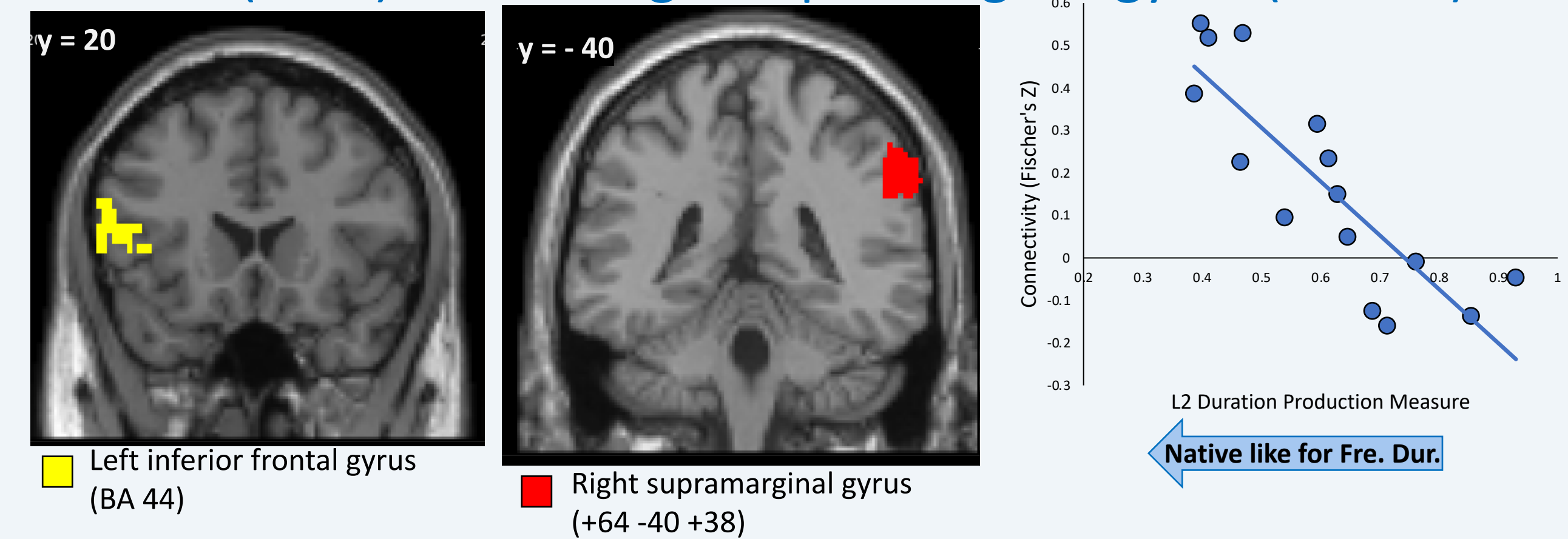
- Native-like English duration associated with increased connectivity between the left cerebellum Crus II (seed) and the supramarginal gyrus (cluster)



Left cerebellum Crus II  
Right supramarginal gyrus  
(+66 -44 +36)

## FRENCH (L2) DURATION PRODUCTION

- Native-like French duration associated with increased connectivity between the left inferior frontal gyrus (IFG) BA44 (seed) and the right supramarginal gyrus (cluster)



Left inferior frontal gyrus  
(BA 44)  
Right supramarginal gyrus  
(+64 -40 +38)

## DISCUSSION

- Further confirms that the basal ganglia and cerebellum support mastery of prosodic production in bilinguals
- Preliminary results provide evidence for the proposed subcortico-cortico-cerebellar network<sup>4</sup>
  - IFG pars opercularis (BA44) only observed in 2 conditions (English  $F_0$ , French duration)
  - Supramarginal gyrus (SMG) involvement observed across multiple conditions (English  $F_0$ , & duration, French duration)
  - SMG may be the primary cortical link in the network

## REFERENCES

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