

Multilingualism in Prefrontal Cortex Activity when Confronted by Nonsensical Speech Patterns



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Introduction

Background

- **Bilinguals** activate distinct areas of their brain while processing language
- Distinction relies on **degree of difference** between languages spoken
 - Languages with the **same alphabet** (ex. English and French) won't activate distinct cortical areas while languages with **different lexical morphologies** (ex. English and Chinese) will
 - Latter group exhibits **bilateral activation** when reading pseudowords while former does not

Objective

- Determine whether activity in the **prefrontal cortex** differs between monolinguals and polyglots when instructed to produce a **nonsensical speech pattern**

Results

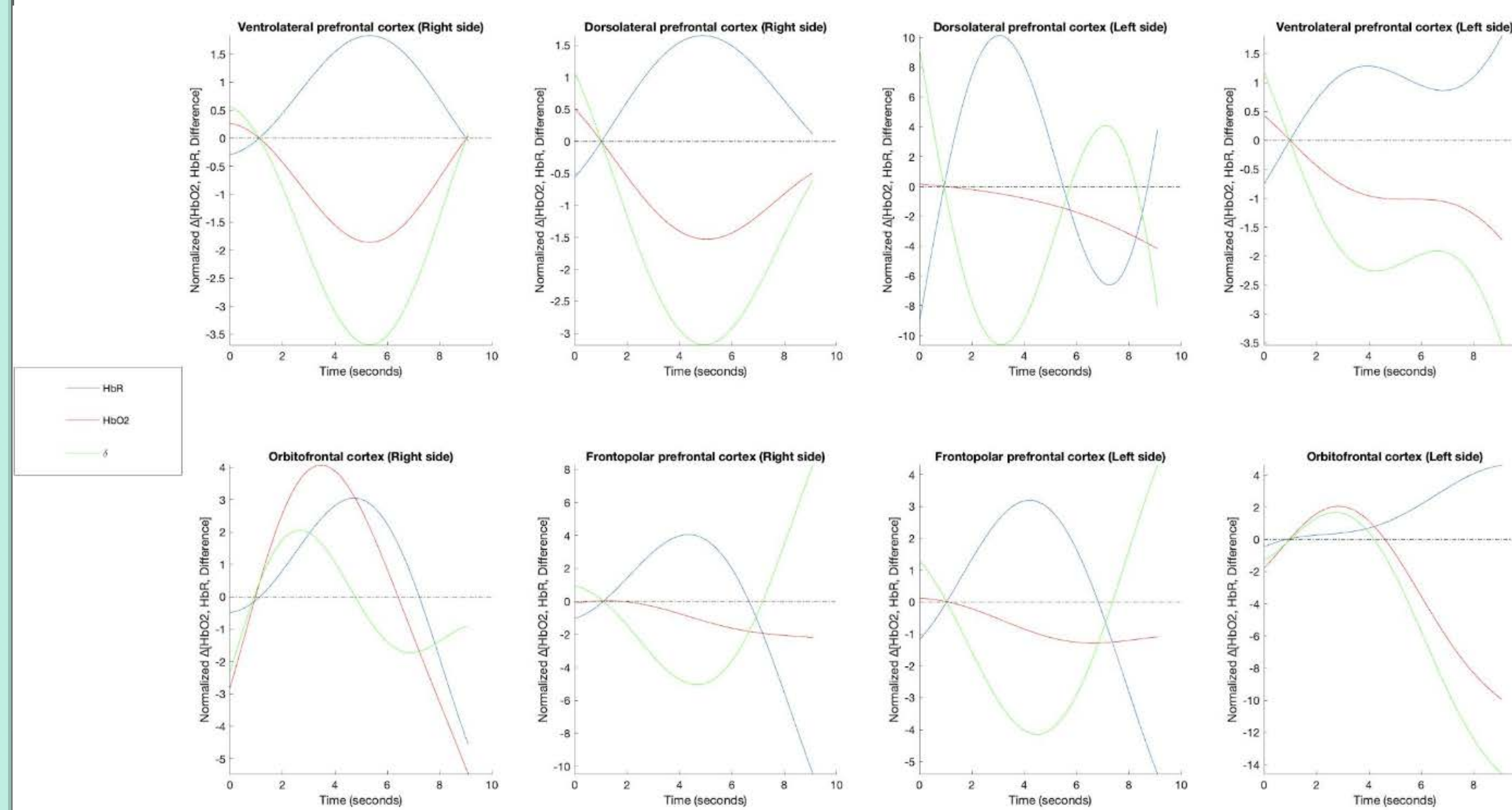


Figure 3: Prefrontal Cortex activity in a bilingual while performing task 18

Language status was not a significant predictor of total brain activity while speaking and singing nonsensical speech patterns, $F(6, 15) = 1.063a$, $p=0.429$; Pillai's Trace=0.313, partial $\eta^2 = .313$.

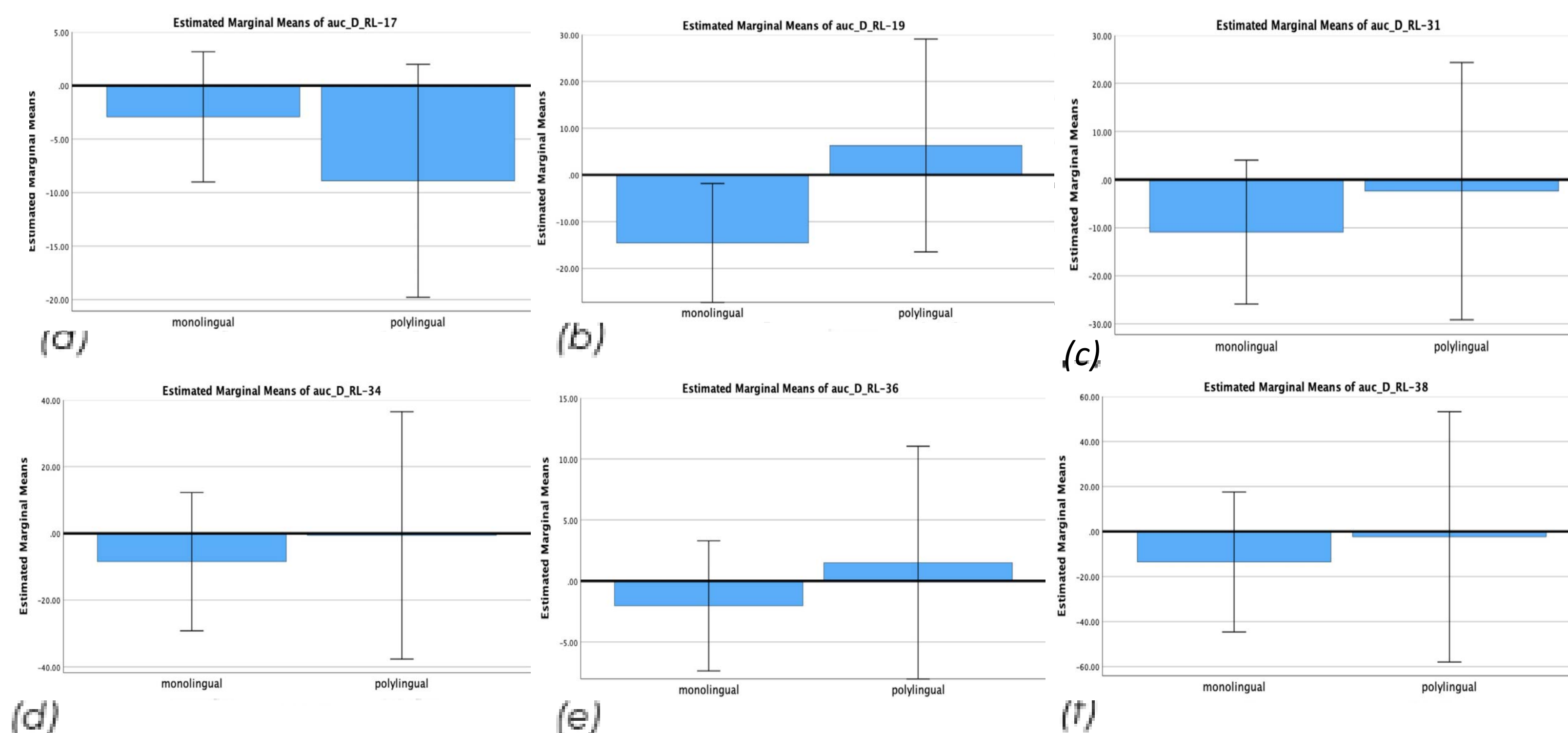


Figure 4: (a) mean activity between groups in task 7, (b) mean activity between groups in task 9, (c) mean activity between groups in task 11, (d) mean activity between groups in task 14, (e) mean activity between groups in task 16, (f) mean activity between groups in task 18

Conclusions

Discussion

- No significant difference in total amount of brain activity between monolinguals and bilinguals
 - Executive function in young adults is at its peak, explaining the absence of variation in total brain activity
- Substantial margins of error in bilingual group denotes that brain activation could vary depending on the language an individual spoke besides English

Limitations

- Small sample size of both groups could have led to insignificant results
- Bilinguals' language spoken besides English unknown

Future Directions

- Performing similar experiment in a larger sample of young adults
 - Controlling for second language spoken
 - Monitoring separate regions rather than total brain activity

References

1. Liu X, Hu L, Qu J, Zhang S, Su X, Li A, Mei L. Neural similarities and differences between native and second languages in the bilateral fusiform cortex in Chinese-English bilinguals. *Neuropsychologia*. 2023 Jan 28;179:108464. doi:10.1016/j.neuropsychologia.2022.108464. Epub 2022 Dec 21. PMID: 36565993.
2. Sun X, Marks RA, Zhang K, Yu CL, Eggleston RL, Nickerson N, Chou TL, Hu XS, Tardif T, Satterfield T, Kovelman I. Brain bases of English morphological processing: A comparison between Chinese-English, Spanish-English bilingual, and English monolingual children. *DevSci*. 2023 Jan;26(1):e13251. doi:10.1111/desc.13251. Epub 2022 Mar 1. PMID: 35188687; PMCID: PMC9615011.
3. Zhan M, Pallier C, Agrawal A, Dehaene S, Cohen L. Does the visual word form area split in bilingual readers? A millimeter-scale 7-T fMRI study. *Sci Adv*. 2023 Apr 5;9(14):eadf6140. doi:10.1126/sciadv.adf6140. Epub 2023 Apr 5. PMID: 37018408; PMCID: PMC10075963.

Methods

Measures

- Participants instructed to speak and sing random words and pseudowords (Tasks 7, 9, 11, 14, 16, 18)
- fNIRS headband measured Blood Oxygen Level Dependent (BOLD) activity in 8 areas of the prefrontal cortex

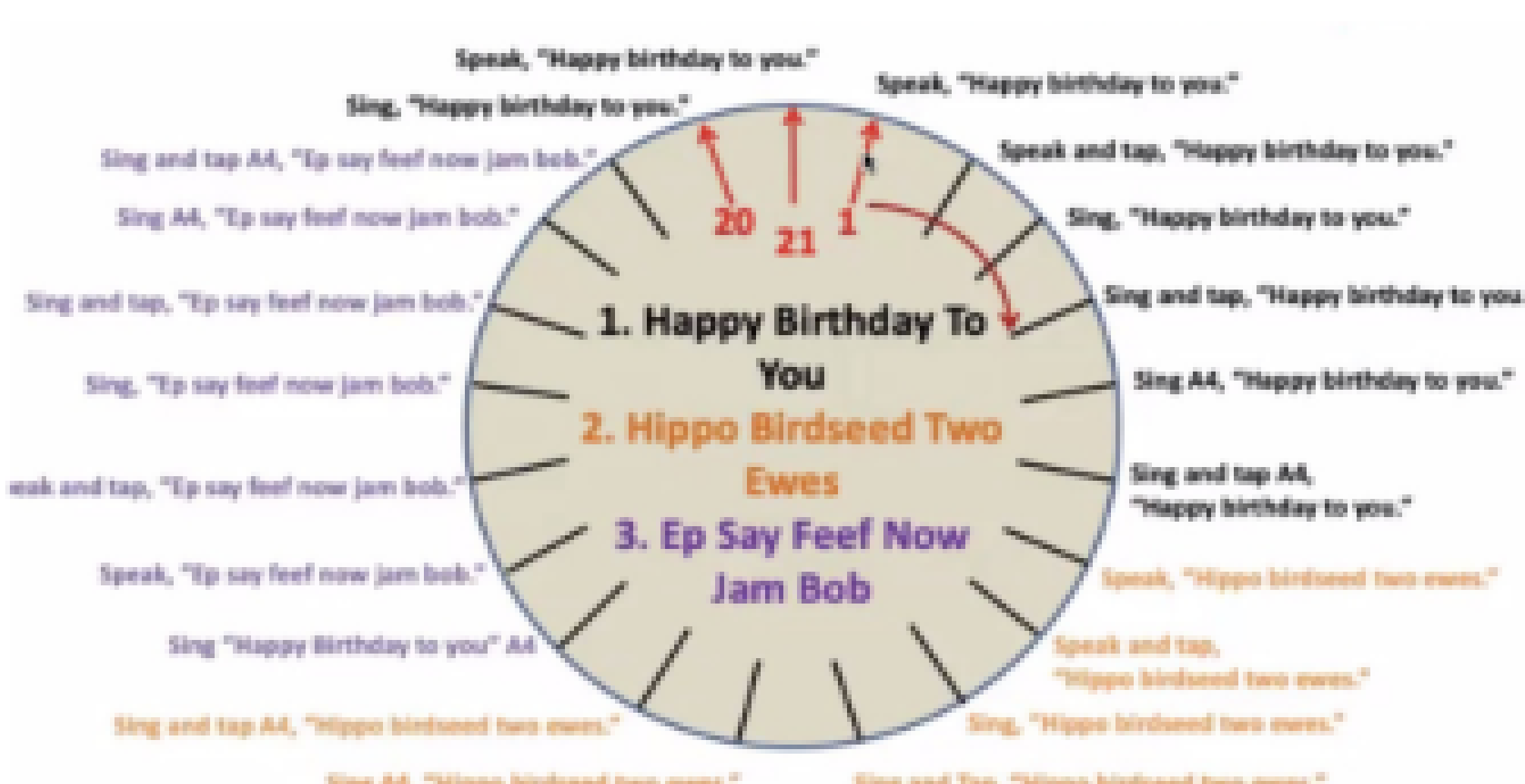


Figure 1: List of Tasks completed by subjects

Participants

- 16 English monolinguals and 5 bilinguals

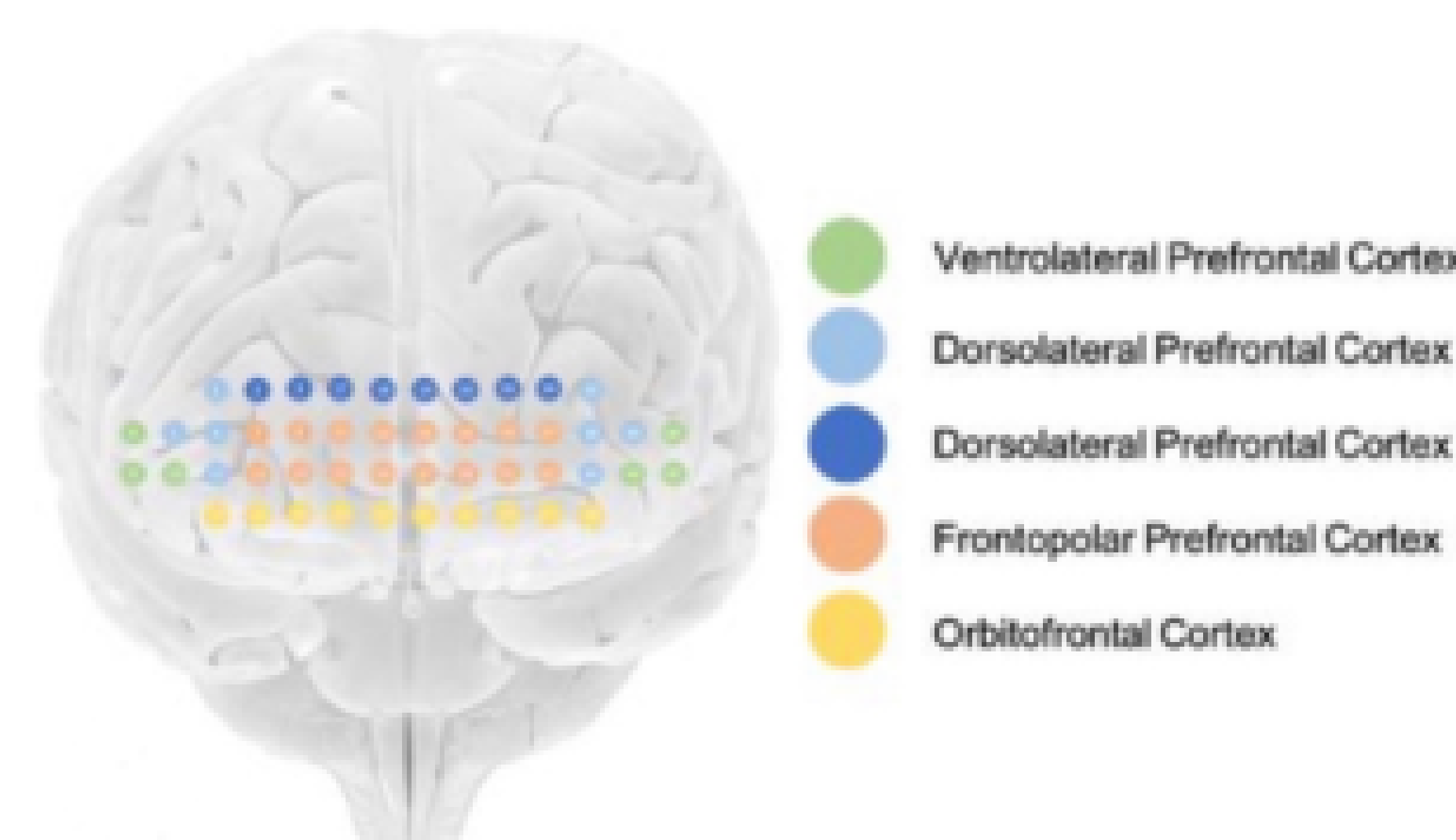


Figure 2: 8 regions measured in the prefrontal cortex

Data Analysis

- Raw data processed through NIRSIT to retrieve graphs
- One-way MANOVA through SPSS

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