

Brain Activity During Verbal Fluency Tasks In Monolinguals And Bilinguals: A HD-DOT Investigation



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INTRODUCTION

Verbal fluency tasks (VFTs) can detect early signs of Alzheimer’s disease. In bilinguals, it can be hard to determine whether poor performance is due to language barriers, dementia, or both. It is also unclear whether the same brain regions are used during VFTs across language backgrounds. This project investigates the potential of high-density diffuse optical tomography (HD-DOT), combined with VFTs, to aid early dementia detection across language backgrounds.

RQ1. Do Monolinguals and Bilinguals use the same brain areas during VFTs?

RQ2. Does this vary by the assessment language?

METHODS

60 bilinguals (34 Chinese, 26 Somali) and 17 English monolinguals completed VFTs in English and their first language (Chinese/ Somali) using a 54 tile full-head LUMO HD-DOT system.

Data was preprocessed and block averaged to derive the mean HbO and HbR concentrations before and during the task.

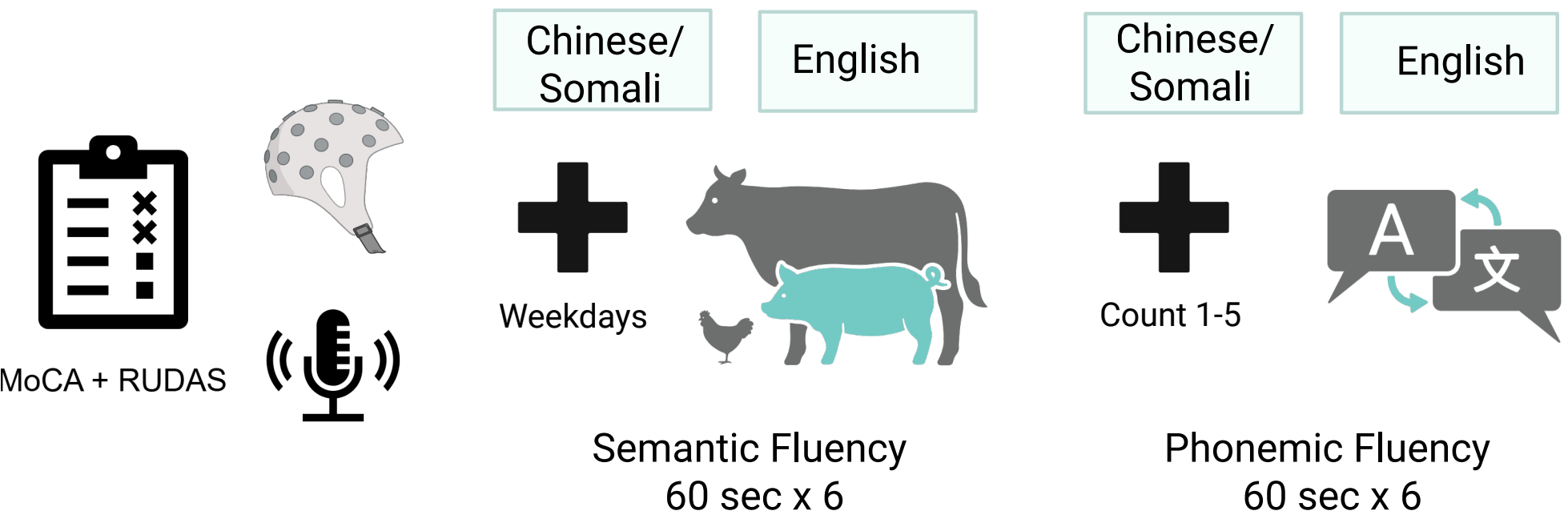


Figure 1. Overview of data collection. Participants completed a cognitive assessment, followed by fNIRS and audio recording during verbal fluency tasks. The task and language order was randomised across individuals

	Monolingual	Chinese Bilinguals	Somali Bilinguals	Differences 1= Mono vs Chinese, 2 = Mono vs Somali, 3= Chinese vs Somali
n	17	34	28	
Age	63.1 (13.1)	58.7 (11.6)	43.9 (9.5)	¹ ns ² p<.001*** ³ p<.001***
Sex	35.3% male	26.5% male	57.1% male	p=.05
Education	19.9 (4.1)	15.9 (4.2)	13.3 (6.7)	¹ p=.03* ² p<.001*** ³ ns
English Proficiency	17 First Language	1 Basic 9 Good 12 Very Good 12 Fluent	4 Basic 9 Good 5 Very Good 8 Fluent 2 First Language	-
English AoA	0 (0)	10.9 (4)	13.6 (9.7)	¹ p<.001*** ² p<.001*** ³ ns
Immersion years	62.1 (13.3)	33.7 (16.2)	22.7 (10.4)	¹ p<.001*** ² p<.001*** ³ p=.006*
MoCA /29	27.1 (2.2)	25.1 (1.9)	22.5 (3.7)	¹ p=.05* ² p<.001*** ³ p=.001**

Table 1. Table of participant demographics

RESULTS

Signal quality was significantly worse in the bilingual ethnic minority communities at all channel lengths, largely due to the differences in hair texture, colour, and skin tone known to impact HD-DOT data acquisition (Figure 2).

To assess the differences in activation between monolinguals and bilinguals, t-tests were conducted between the mean change in HbO concentrations from baseline (-2-0 sec) to task (5-55 sec) in each bilingual cohort compared to monolinguals.

During **phonemic** tasks, bilinguals exhibit **greater increases in HbO** concentration in the **right posterior frontal region**, with no major differences between the assessment language (Figure 3).

During **semantic** tasks, bilinguals exhibit significantly greater increases in HbO concentration across the bilateral frontal and parietal regions (Figure 4). Both bilingual cohorts exhibit more diffuse increased activation in English tasks relative to their first language.

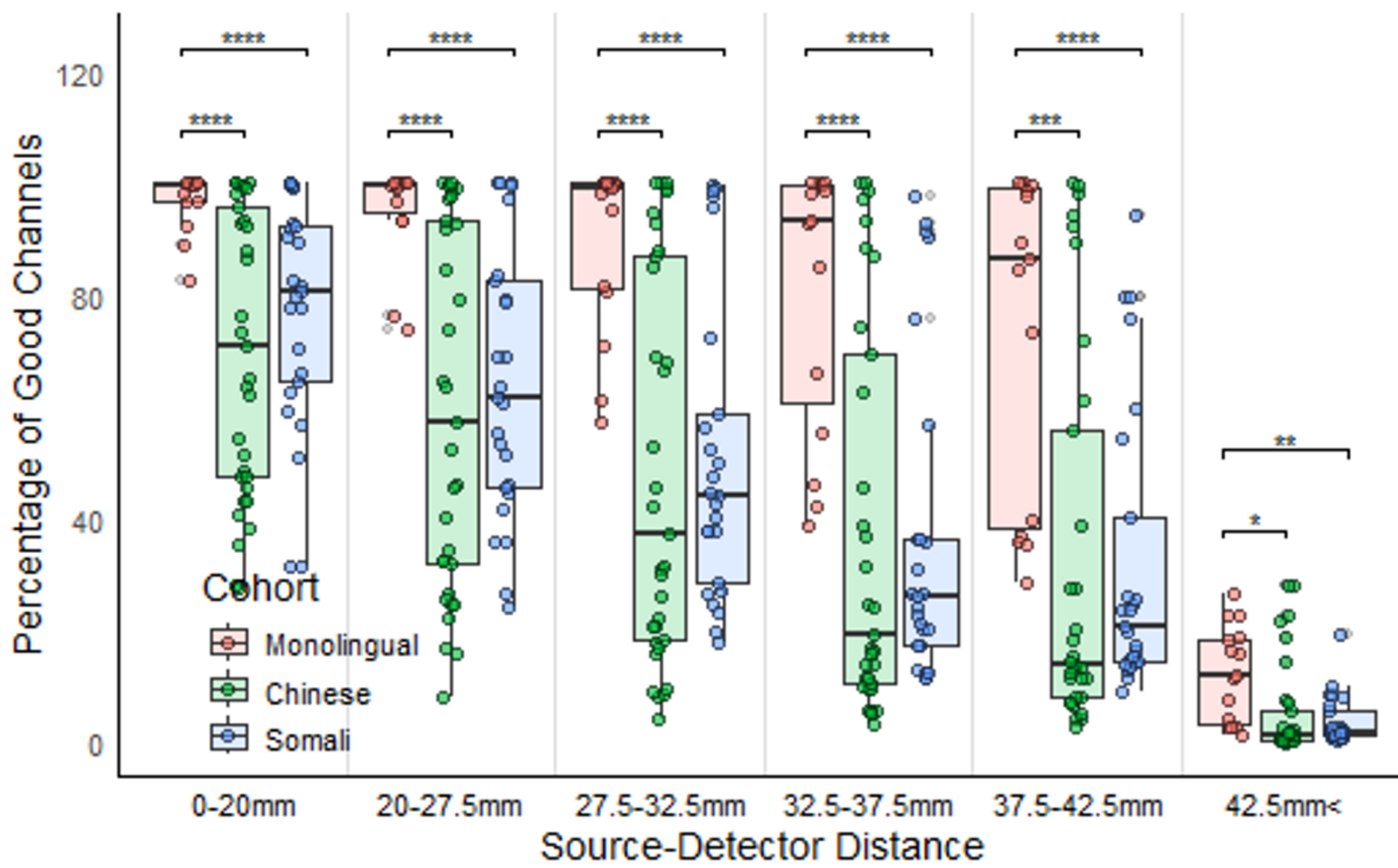


Figure 2. Boxplot showing the percentage of channels at each signal-detector distance that met signal pruning criteria in each cohort, derived using DOT_HUB_dataQualityCheck function.

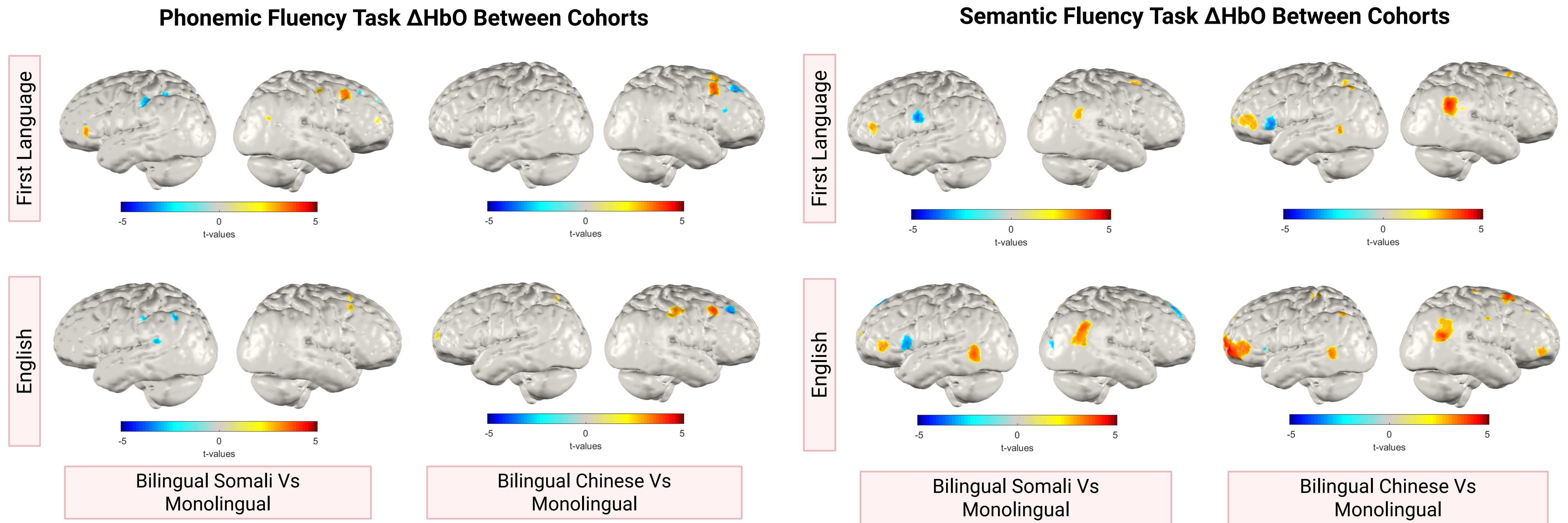


Figure 3. HD-DOT reconstruction of t-stats between change in HbO concentration from baseline (-2 to 0 sec) to task (5-55 sec) in each Bilingual Group compared to Monolinguals. T-stats are uncorrected, thresholded at $p < .01$

Figure 4. HD-DOT reconstruction of t-stats between change in HbO concentration from baseline (-2 to 0 sec) to task (5-55 sec) in each Bilingual Group compared to Monolinguals. T-stats are uncorrected, thresholded at $p < .01$

CONCLUSION

Bilinguals exhibit **similar** patterns of activation to monolinguals during **phonemic VFTS**, and similar activity when completing the assessment **in both languages**. In comparison, bilinguals engage **frontal** and **parietal** regions during **semantic VFTS** significantly more than Monolinguals, especially **when completing in English**. Hence, language background may impact the clinical utility of VFTs given their engagement of brain regions affected later in Alzheimer’s disease. HD-DOT may be a useful tool to aid in detection of changes, but more inclusive design is needed for better data collection across demographics. Ongoing work will assess activation in patients with Dementia.

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