Temporal Dynamics of Bilingual Language Processing as a New Lens into Human Brain Lateralization: An fNIRS Study

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QUESTION

What are the neural origins of hemispheric lateralization for human language?

Monolinguals show largely left hemisphere (LH) lateralization for language processing e.g., Superior Temporal Gyrus (STG; BA 21/22), Left Inferior Frontal Gyrus (LIFG; BA 44/45)[1,2,3] **Box 1**

New Finding in Bilinguals: Bilinguals show greater extent and variability of neural recruitment in LH language areas and their right hemisphere (RH) homologues for language processing[3]

New Question: Why does bilingualism yield greater bilateral activation vs monolingualism?

Novel Approach: Temporal dynamics of LH and RH contributions to language processing as a lens into greater bilingual bilateral activation

HYPOTHESES

H1 Early bilingual language experience places additional processing demands on the developing brain requiring the recruitment of additional RH resources

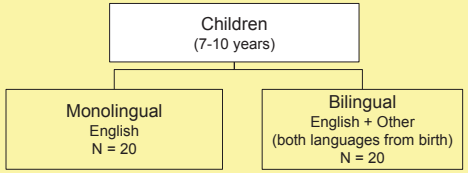
P1 *Temporal Asynchrony* - LH activity followed by RH activity

H2 Early bilingual language experience provides neural stimulation to language processing pathways, making possible enhanced development of both hemispheres

P2 *Temporal Synchrony* - Simultaneous LH and RH activity

METHOD

Participants

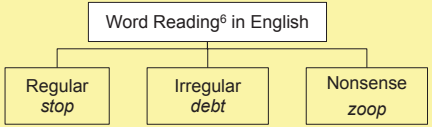


Hitachi ETG 4000
46 Channel

Task

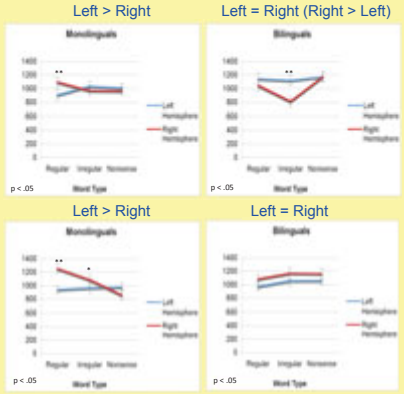
Near Infrared Spectroscopy (fNIRS)[4,5]

Advance: Superior temporal resolution (10Hz) permits optimal temporal analysis necessary for this research question



NEUROIMAGING RESULTS

Early bilinguals show greater temporal synchrony in LH and RH



Inferior Frontal Gyrus

Monolinguals: Faster time-to-peak change in HbO in LH vs RH

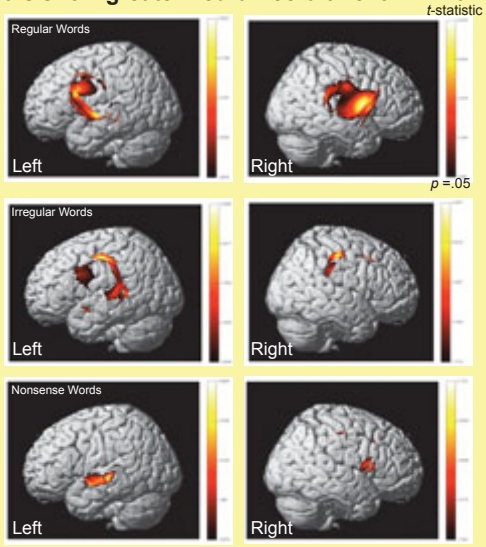
Bilinguals: Simultaneous time-to-peak change in HbO in LH and RH (faster time-to-peak change in HbO in RH for irregular words)

Superior Temporal Gyrus

Monolinguals: Faster time-to-peak change in HbO in LH vs RH

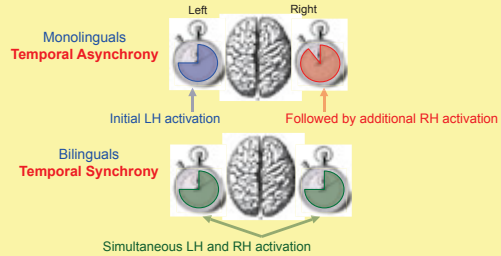
Bilinguals: Simultaneous time-to-peak change in HbO in LH and RH

Early bilinguals show greater neural recruitment in LH and RH



CONCLUSION

Bilinguals showed greater temporal synchrony in left and right IFG and STG for language processing vs monolinguals



Supports H2

Synchronous temporal accessing of the two hemispheres suggests early life bilingual language experience may support more equal and efficient hemispheric involvement, and may give the bilingual a language and reading advantage

New Questions: Origin of laterality in our species?

Do all human infants begin life with language capacity lateralized to LH, with bilinguals recruiting extra RH as a result of enriched early life language experience?

Or, do all human infants being life with language capacity represented bilaterally with monolinguals attenuating language capacity primarily to LH as a result of reduced early life language experience?

REFERENCES

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BOX 1