Neural Correlates of Syntactic Processing in Monolingual and Bilingual Children using Functional Near Infrared Spectroscopy (fNIRS) Imaging

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QUESTION

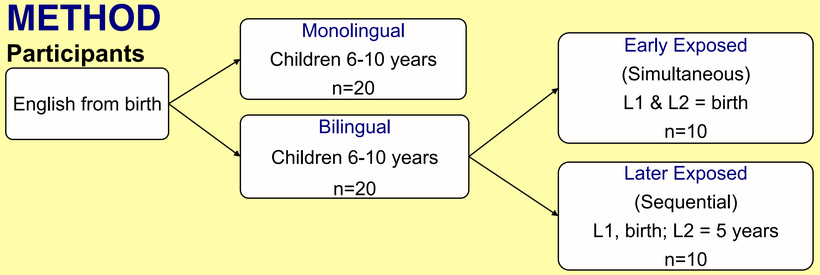
Do differences in early life language experience (bilingual vs. monolingual) change patterns of neural activity in classic language and cognitive tissue?

HYPOTHESES

Bilingualism reflects more robust language specific activity (Broca's Area, BA; Superior Temporal Gyrus, STG)[1,2] or, reflects a cognitive general 'dual task' activity (Dorsolateral Prefrontal Cortex, DLPFC), or, reflects increased cognitive and language specific resources relative to monolingualism

METHOD

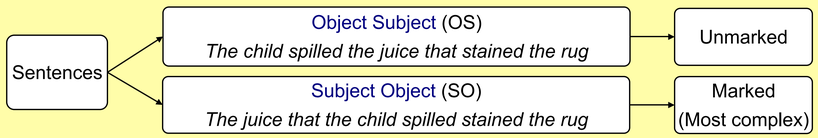
Participants



Bilingual = English + French, as well as English + Other language

Task

Plausibility judgment of relative clause sentences[3]

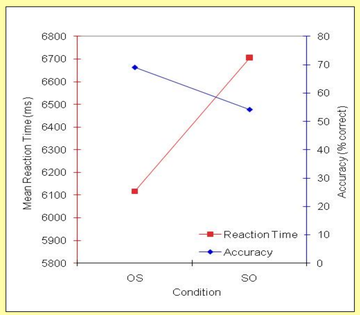


Neuroimaging Functional Near Infrared Spectroscopy fNIRS

RESULTS BEHAVIOURAL

Sentence Differences

All participants showed increased reaction times (red) and greater errors (blue) for the complex SO sentences

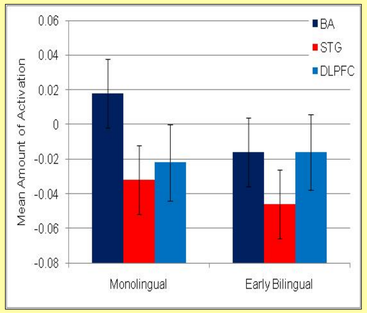


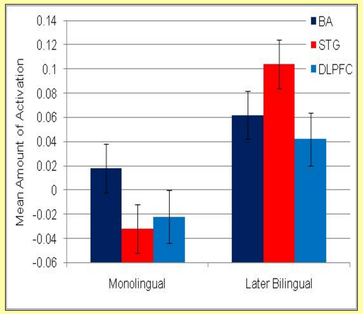
RESULTS NEUROIMAGING

Bilingual Age Of First Exposure To New Language Impacts Brain Organization

Early Exposed → Same pattern of brain activity as monolinguals

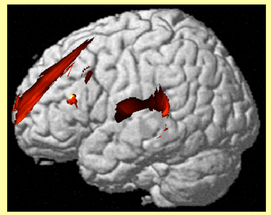
Later Exposed → Different pattern of brain activity as monolinguals



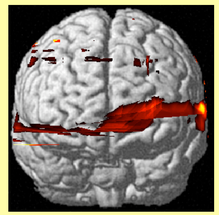


No significant differences in pattern of neural activity between monolinguals & early exposed bilinguals (in BA, STG & DLPFC)

Later exposed bilinguals show increased neural activity in the frontal & temporal lobes relative to both monolinguals & early exposed bilinguals



Left Hemisphere



Frontal Lobe

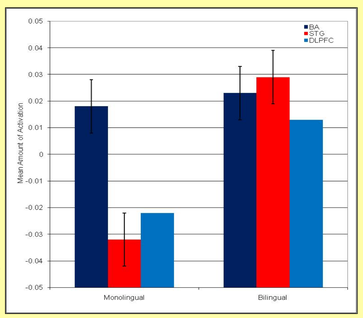
Controversy in the Field

What neural resources facilitate Bilingual language use?

Frequent Answer – Bilingualism is more *effortful* because it appears to use greater neural resources compared to monolinguals

Disambiguating the Controversy

Why? Here, only when we combined all early and later exposed bilinguals does it appear as if bilinguals exhibited greater neural resources



CONCLUSION

In this first-time study of the brains of bilingual children reading, we found that early exposure to two languages yields comparable use of the classic language brain structures as seen in monolingual children

Supports the Hypothesis that bilingualism is predominantly a language specific activity, with greater neural activity (more extensive 'extent and variability') in classic language brain structures, which may lead to enhanced linguistic processing[1]

Later exposed bilinguals show different patterns of neural activity in tissue commensurate with increased demands on executive functions and language processing

No evidence for neural trauma due to early bilingual language exposure

New evidence that Bilingual language learning abides by principles of maturation and sensitive period hypothesis

REFERENCES

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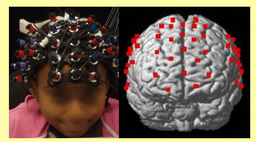
What is fNIRS?

Measures oxygenated, deoxygenated blood, and BOLD
Advance - Tolerates movement
Good spatial (~4 cm) & temporal (10 Hz) resolution[4]

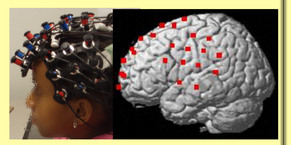
New Data Analysis

Advance - Statistical Parametric Mapping for NIRS (NIRS-SPM[5])
Multilevel Modeling

Hitachi ETG 4000
48 Channel



Frontal Placement



Lateral Placement