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Bilingualism enhances preterm-born children's executive function: An fNIRSstudy

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Bilingualism enhances preterm-born children's executive function: An fNIRS study

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Introduction

- Executive function is critical for goal-directed problem solving and attention, and is a foundational tenet for learning throughout the lifespan (Zelazo, 2015).
- Research in the field of linguistics and cognitive psychology show that bilingualism can significantly enhance executive function (e.g. Bialystok, 2010).

This study is the first to compare executive functioning among monolinguals (English only), bilinguals (full productive ability in both Spanish and English), and Heritage Speakers (varying levels of proficiency; incomplete acquisition). Executive function is measured by standard validated assessments and also via Functional Near-Infrared Spectroscopy (fNIRS).

Research Questions:

1. Are there differences in EF in monolingual versus bilingual preterm-born children, as measured by the DCCS task and the GNG task?
2. Are there differences in the neural recruitment of EF in monolingual versus bilingual preterm-born children during the DCCS and GNG task, as measured by functional Near-Infrared Spectroscopy (fNIRS)?

Methods

Participants:
16 preterm born children. 9 bilingual, 7 monolinugal. Match on birth characteristics (Gestational age, acuity, birth weight, LOS
Language category:
- ❖ Monolingual: English
- ❖ Heritage Speaker: English and receptive Spanish
- ❖ Bilingual: English and Spanish, daily production in both

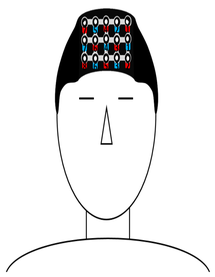
Triangulated measures of bilingualism:
- *Peabody Picture Vocabulary Test 4th Ed. (PPVT)*
- *Test de Vocabulario de Imágenes Peabody (TVIP)*
- *Parent Report*

Behavioral Measurements of E.F.:
Go/No-Go Task
- Inhibitory control and response
- Accuracy and average reaction time/stimulus

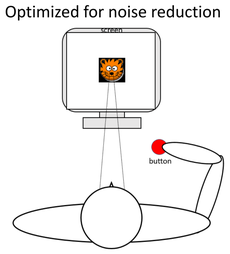
Dimensional Card Change Sort (DCCS) Task
- Cognitive flexibility
- Accuracy, number of cards sorted/block and average reaction time/card

Neural E.F. data
fNIRS
- Neural activation patterns
- Prefrontal cortex
- OxyHb, DeoxyHb, & Hbtotal concentration levels
- NIRx: NIRScout 16-24

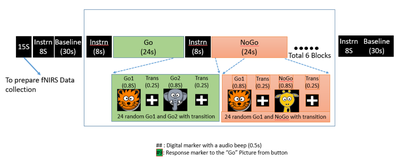
Prefrontal cortex optode and headband setup. 8 sources and 7 detectors



Experimental setup for Go/No-Go Protocol for fNIRS. Optimized for noise reduction

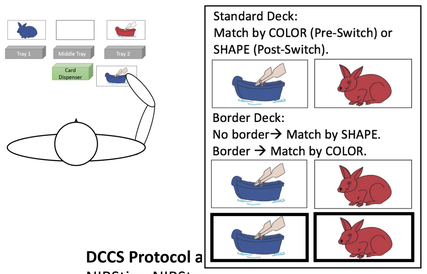


Go/No-Go Protocol adapted for fNIRS. NIRStim. NIRStar.

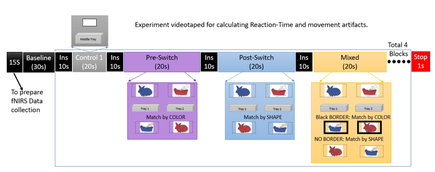


Experimental setup for DCCS Protocol for fNIRS. Optimized for noise reduction

DCCS Standard and Border Version. Test cards used and rules

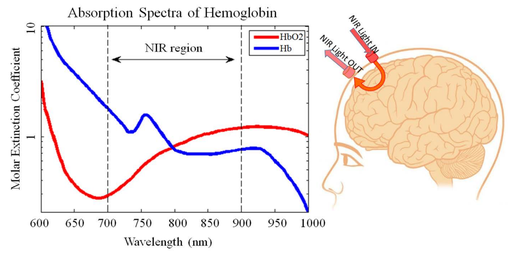


DCCS Protocol a
NIRStim. NIRStar.

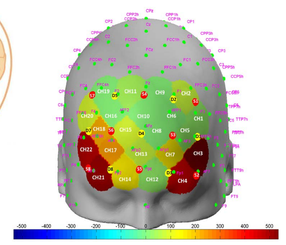


Results

fNIRS



Statistical Parametric Mapping (f-static map for 1 subject). Location of fNIRS sources, detectors, and channels



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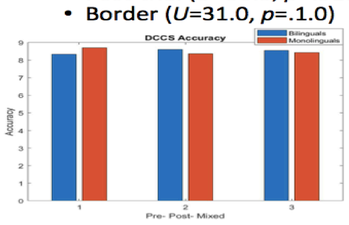
Population Descriptors

Group Means	Gestational age (weeks)	Birth Weight (g)	Length of Stay (days)
Bilingual	29.9	1450	57.9
Monolingual	31.2	1517	47.7

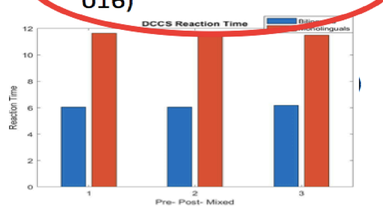
- No significant difference in preterm birth weight, gestational age, length of stay, presence or grade of IVH, nor oxygen at day 28
- Also no significant difference in SES, operationalized as parental highest year of education completed

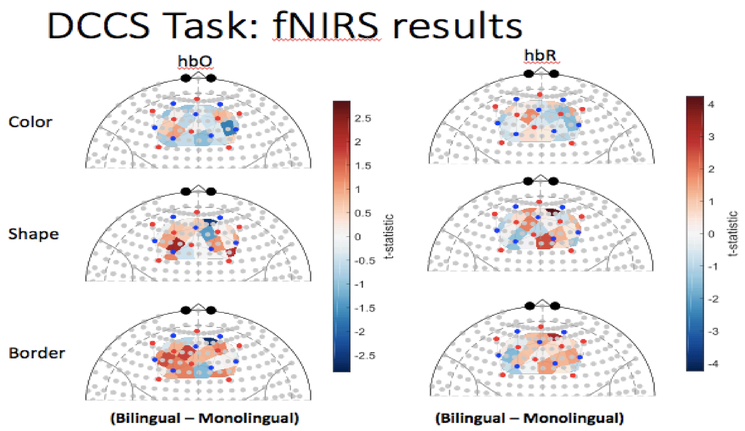
DCCS Task

Accuracy
- Both groups similar across trial types
  - Pre-trial (*U*=30.0, *p*=.918)
  - Post-trial (*U*=30.5, *p*=.918)
  - Border (*U*=31.0, *p*=.1.0)



Reaction time
- Bilingual children significantly faster
  - Pre-trial (*U*=9.50, *p*=.016)



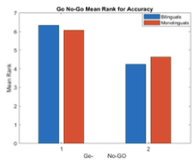


Oxyhemoglobin:
- in both the border and color dimensions, the bilingual preterm-born children showed significantly lower changes in hbO when compared to the monolingual preterm-born children
- No significant changes in hbO observed in the shape dimension.

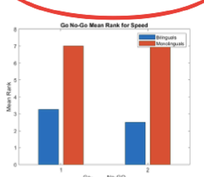
Deoxy-hemoglobin:
- The monolingual children showed significant increases in hbR levels while the bilingual group showed significant decreases in hbR levels – for all dimensions

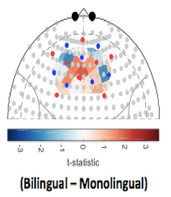
Go/No-Go Task

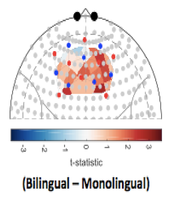
Accuracy
- Both groups similar in accuracy
  - Go-Trial (*U*=7.0, *p*=.352)
  - No-Go (*U*=8.5, *p*=.476)



Reaction time
- Bilingual children significantly faster
  - Go-Trial (*U*=3.0, *p*=.057)
  - No-Go (*U*=0.0, *p*=.010)







- Both groups performed similarly in terms of accuracy
- Bilingual preterm-born children were significantly *faster* – on both tests of EF

Oxyhemoglobin: The bilingual preterm-born children showed a significantly greater decrease in hbO levels when compared to the monolingual preterm-born children.
Deoxy-hemoglobin: The monolingual preterm-born children showed significant increases in hbR levels while bilingual group showed a significant decrease in hbR levels.

These data indicate:
- The neural correlates of executive functioning are different depending on one's language profile
- Bilinguals recruit less OxyHb when having to engage in inhibition (they were also the fastest)
- Monolinguals generally needed more hbO for both tasks

Conclusions

Behaviorally, the bilingual preterm-borm children were significantly faster than the monolingual preterm-born children at tasks of EF

Neurally, these results imply that monolingual preterm-born children need to recruit significantly more hbO to be able to perform tasks of EF.

What's more, bilinguals recruited neural tissue **differently** from monolinguals. Possibly, less effort required necessitates less oxygenated hemoglobin levels.

Given that bilingualism confers significant health benefits, it is worth exploring how we can change the national discourse around bilingual curricula in public education given our results:

1. In accordance with past literature, there does seem to be a bilingual 'edge' in E.F. especially in speed of task performance for preterm children
2. This study also contributes to psycholinguistic theory: productive, creative capacity in the L2 may be a required threshold to reap the benefits of bilingualism

Acknowledgements and References

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