



The impact of age of language exposure on spatial working memory using fNIRS neuroimaging



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Question
Is there a critical period for Spatial Cognition?

- H1 No (Predicted)
- H2 Yes (Spatial cognition is vulnerable to the critical period)

Innovation Natural Signed Languages

Linguistic Language IS under critical period

But... Spatial. Cognition is not within a critical period



Hitachi ETG 4000 3x11, Frontal Array, DLPFC and VLPFC



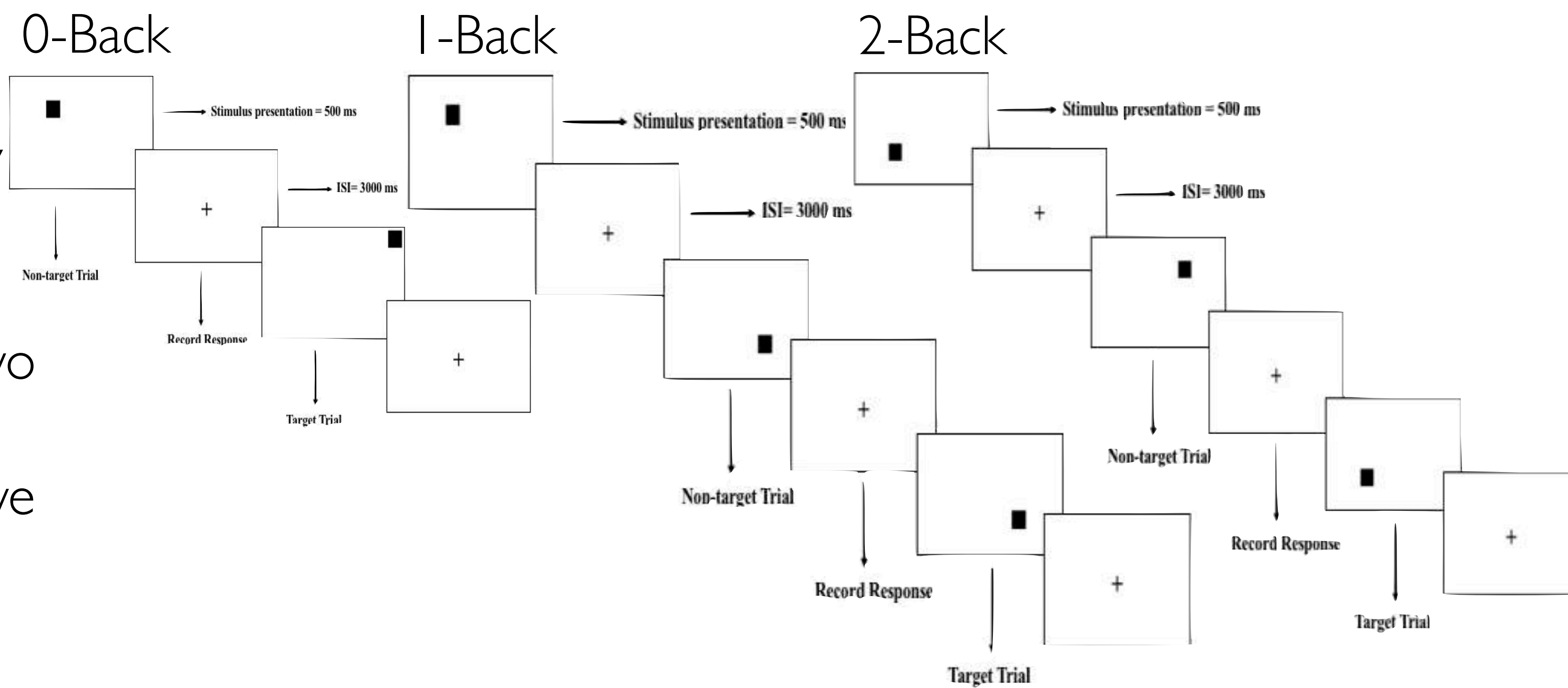
Participants
Hearing 3 Groups (5 per group) Native, Fluent, New Signers

Background

• Spatial cognition is argued to be a capacity that is not vulnerable to sensitive periods in development as shown in mice studies¹

Human signed languages permit a new way to examine the malleability of other higher cognitive functions—here, spatial cognition—and permit insights into the brain's structural and functional plasticity

• human language learning is widely understood to be highly impacted by the age of first language and second language exposure; early exposure to two languages produces positive, robust impact on neurocognitive development, even possibly prolonging the sensitive period of human language learning²



Three Conditions, Block Design, Spatial N-Back

Surprise Results

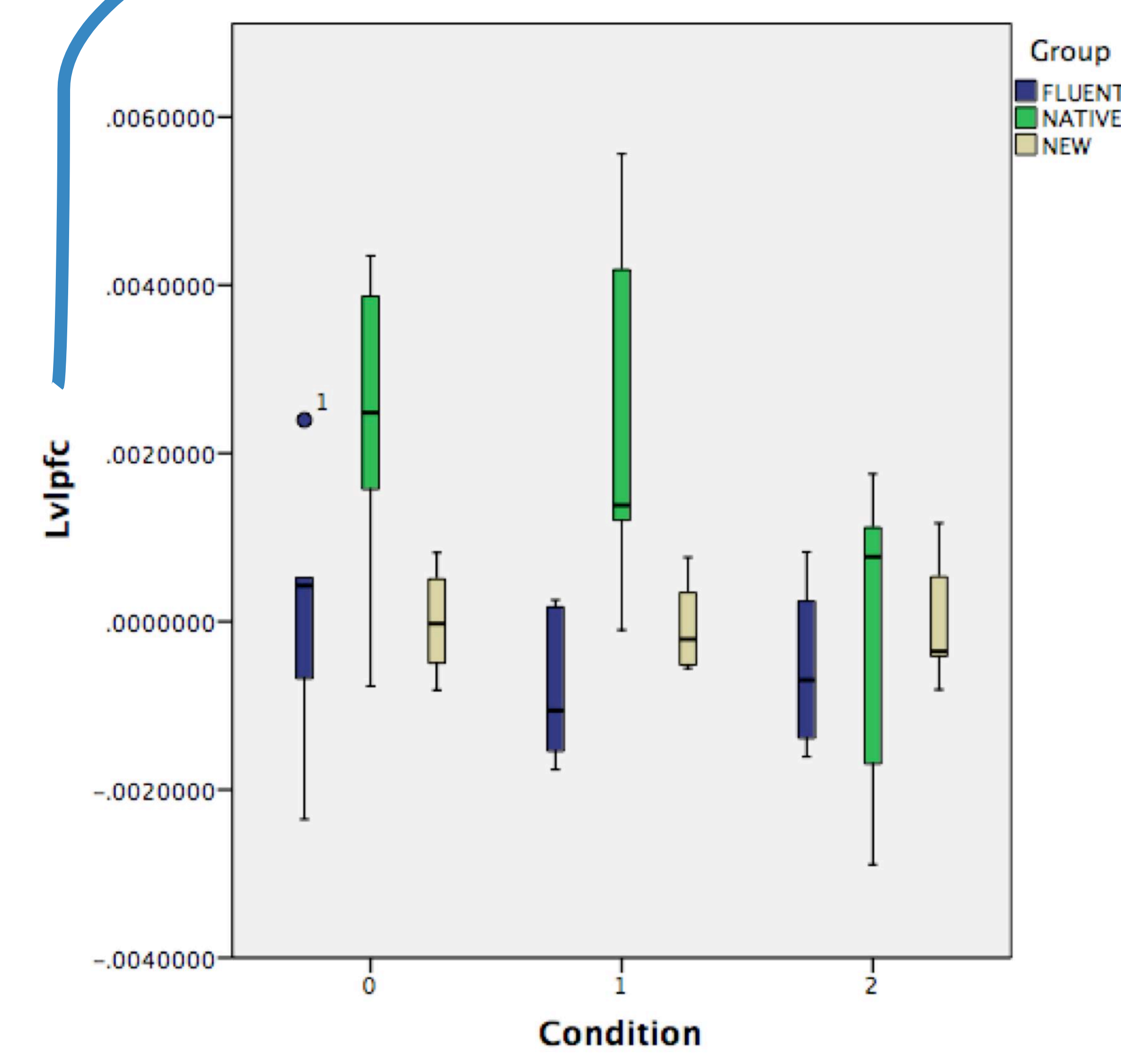
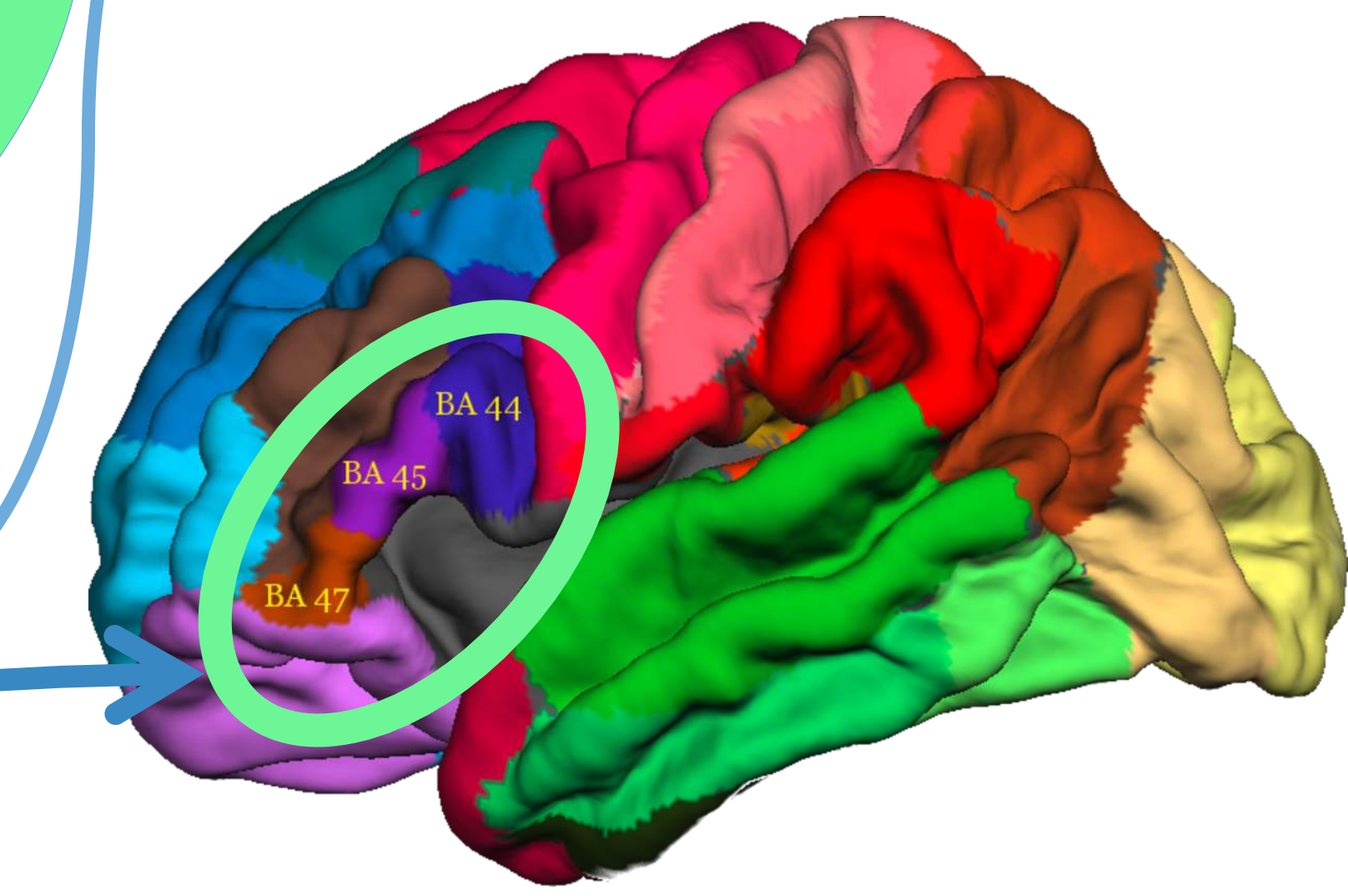
Spatial Cognition does appear to be impacted by critical periods

Behavioral

- No statistically significant interaction between N-back condition and group scores
- Main effect of n-back condition on scores, $F(4, 24) = 11.812, p < .001$, partial $\eta^2 = .496$.
- Scores dropped as the difficulty increased.
- There were no differences between groups in n-back scores.

Neuroimaging

- No statistically significant interaction between the N-back condition and groups on HbO activation in L and R-DLPC, and R-VLPFC.
- Statistically significant interaction between N-back condition and groups on HbO activation in the L-VLPC, $F(4, 24) = 4.579, p = .007$, partial $\eta^2 = .433$.
- Statistically significant main effect of groups on HbO activation for 1-back, $F(2, 12) = 6.412, p = .013$, partial $\eta^2 = .517$.
- 1-back, HbO activation in the left VLPFC was statistically significantly greater in the native signers ($M = .0032, SE = .00094, p = .013$) compared to fluent signers



Major Significance

- Preliminary findings suggest that brain sites underlying spatial working memory is vulnerable to the critical period
- The findings advance scientific debate about the nature of the flexibility and reversibility of sensitive periods in adult learning

References

- ¹Yang, Z. & Tang, A. C. (2011). Novelty-induced enhancement in spatial memory: Is infancy a critical period? *Behavioural Brain Research*, 219(1), 47-54.
- ²Jasinska, K. K. & Petitto, L. A. (2013). How age of bilingual exposure can change the neural systems for language in the developing brain: a functional near infrared spectroscopy investigation of syntactic processing in monolingual and bilingual children. *Developmental Cognitive Neuroscience*, 6, 87-101.