

INTRODUCTION

- This study examined behavioral as well as neurophysiological data of English monolingual, Chinese-English bilingual children and Chinese-English bilingual adults in a sentence comprehension task;
- The tasks included four sentence types: Subject Verb Object (SVO), Passive (PAS), Subject Relative (SR) and Object Relative (OR) and a control condition;

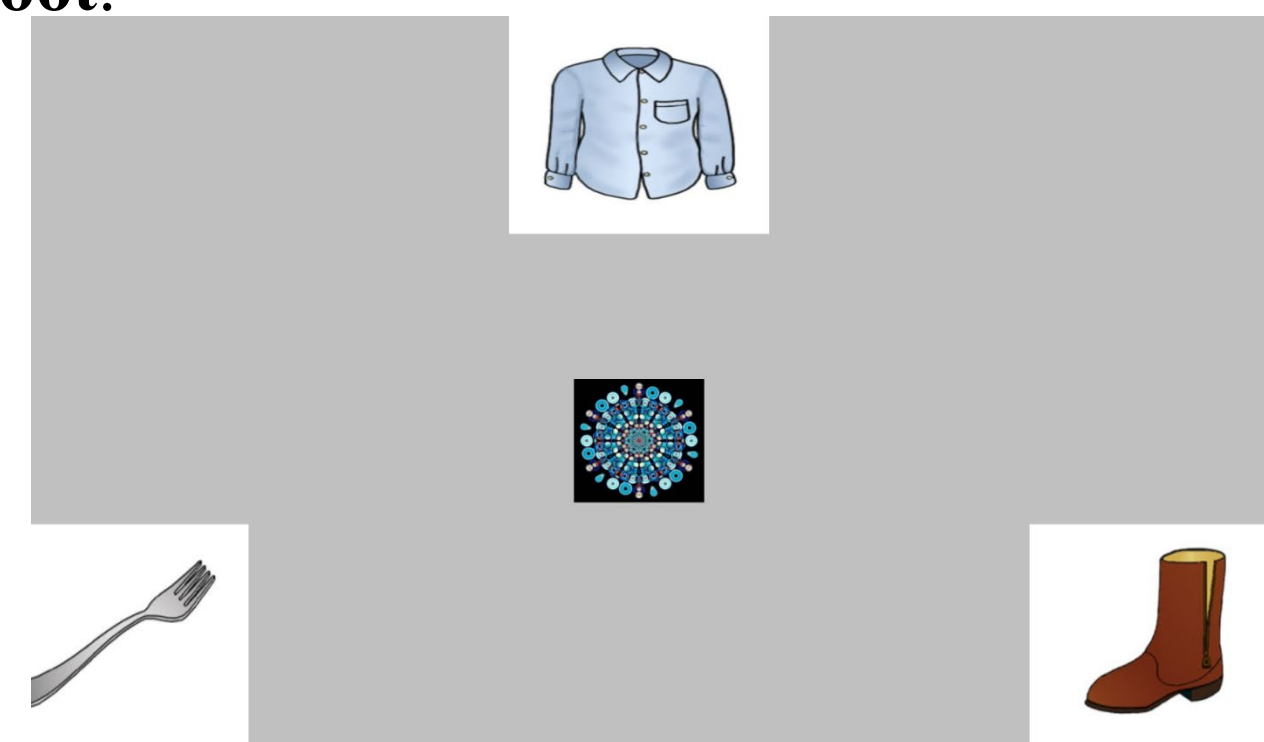
Purpose

- To compare the mechanisms underlying the processing of canonical (SVO, SR) and noncanonical sentences (PAS, OR) and to examine whether monolinguals and bilinguals process structurally complex sentences via different cortical networks and whether Age of Acquisition is a factor to influence sentence processing.

Tasks

“Whatdunit?” paradigm (Montgomery, 2015)

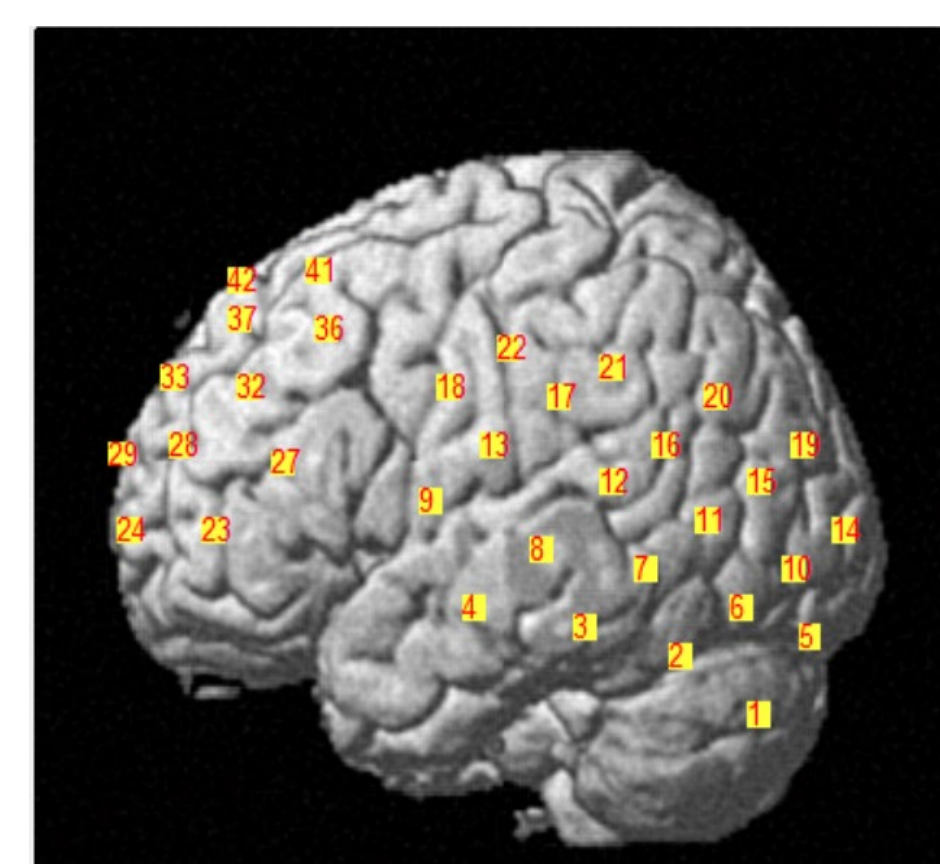
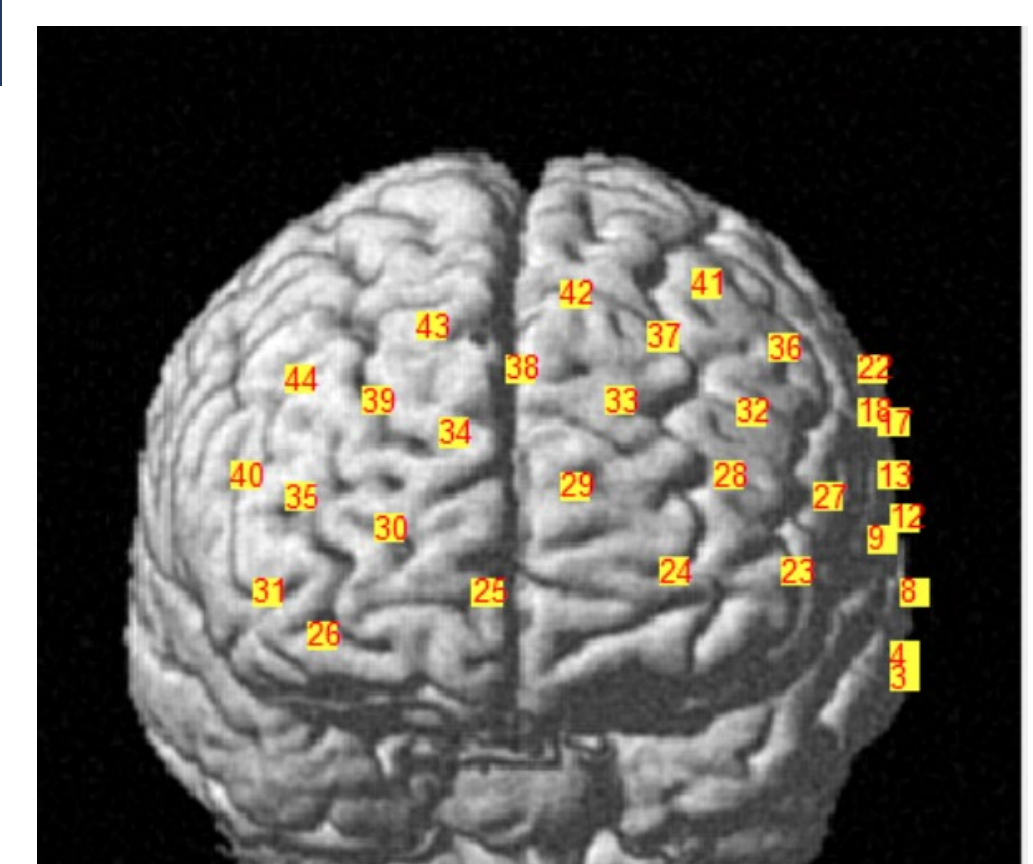
- Participants listened to sentences controlled for semantic plausibility and sentence length
- Participants selected the agent of the sentence by clicking on the picture of the agent
- Canonical:
 - Subject Verb Object (SVO)** – “The **boot** moved the **fork** behind the very bright cold **shirt**.”
 - Subject Relative Clause (SR)** – “The **boot** that wiped the **fork** near the **shirt** was bright.”
- Noncanonical:
 - Passive (PAS)** – “The **boot** was bathed by the **fork** under the hot **shirt**.”
 - Object Relative Clause (OR)** – “The **boot** that the **fork** pressed near the **shirt** was bright.”
- Control:
 - “Please click the **boot**.”



fNIRS

- Hitachi ETG-4000
 - Data binned offline into 10ms intervals and analyses based on predefined time periods of interest.
- Used to determine whether our participants present similar or different neural activation patterns during sentence comprehension tasks.
- Measures the amount of neural activation in various cortical areas during the language comprehension tasks, which can be interpreted as cognitive effort.
- Cap setup: 44 channels using two 3x5 arrays across the left temporal and frontal areas.

44 Channels



PARTICIPANTS

- 43 participants:
- Monolingual (n=15) - English-speaking children
 - Chinese-English bilingual children (n=16)
 - The children groups did not differ significantly in age, sex, or family annual income. They did differ in mother's education.
 - Chinese-English bilingual adults (n=12)

ANALYSES & RESULTS

Behavioral Results

- One-way and repeated-measure ANOVAs were used to compare behavioral results of accuracy among the three groups.
 - All groups performed better on canonical sentences (SR, SVO) than noncanonical sentences (PAS, OR);
 - No significant differences were found among groups

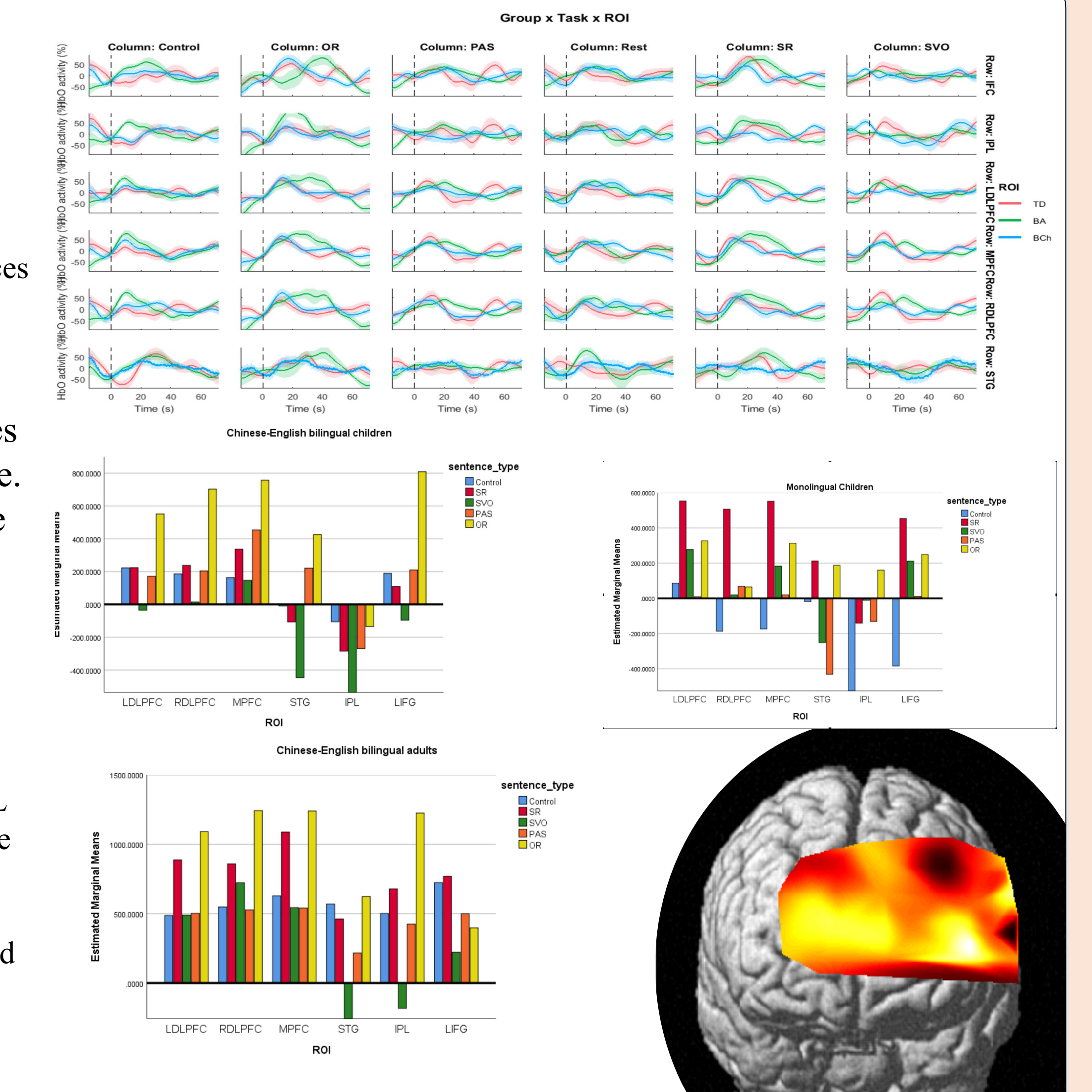
Neuroimaging Results

- After using wavelet filtering to preprocess the raw data, an analysis of time series was conducted to calculate the value of brain activation under each sentence type.
- A repeated-measure ANOVA was used to analyze fNIRS data with sentence type and ROIs as within-subject and group as the between-subject factor.
 - A main effect of sentence type was found;
 - A main effect of ROIs was found;
 - A main effect of group was found;
 - No main effects were found for interactions.
- Post-Hoc Comparison
 - Bilingual adults evidenced more brain activation in LDLPFC, RDLPFC, MPFC, and LIPL than both monolingual children and bilingual children; there were no significant difference between monolingual children and bilingual children.
 - OR sentences corresponded with more brain activation in LDLPFC, RDLPFC, MPFC, LSTG and LIPL than control, SVO, and PAS sentence types; moreover, OR also evidenced more activation in LIFG than SVO.
 - Compared to SVO, PAS evidenced more activation in LSTG.
 - No significant difference between SR and OR sentence types.

Regions of Interests (ROIs)

Six ROIs:

- Left Inferior Frontal Gyrus (LIFG)
- Left Superior Temporal Gyrus (LSTG)
- Middle Prefrontal Cortex (MPFC)
- Left Inferior Parietal Lobule (LIPL)
- Left Dorsolateral Prefrontal Cortex (LDLPFC)
- Right Dorsolateral Prefrontal Cortex (RDLPFC)



DISCUSSION

- More activation of adults and no difference between monolingual children and bilingual children indicate that
 - Early bilinguals processed the four English sentence types like monolinguals'
 - Age of Acquisition (AoA) is a factor in language processing which aligns with prior studies (e.g., Suh et al., 2007; Yokoyama, et al., 2006; Zhang, Xu, Chen, & Wang, 2016).
- OR sentences evidenced more activation in LDLPFC, RDLPFC, MPFC, LSTG and LIPL and more activation of LSTG for PAS than SVO
 - More cognitive control was utilized for processing noncanonical sentences.
- No difference between SR and OR
 - Participants performed relative clauses similarly. Further studies are needed to examine whether clauses are more difficult to process no matter they are canonical or noncanonical.

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