

Persistent Markers of Developmentally Typical Syntax Errors in Adult Behavior and Neurophysiology

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Background

An **Optional Infinitive (OI)** stage marks language acquisition in many languages. Children ages 2-4 use *nonfinite (infinitival)* verb-forms and finite verb-forms interchangeably in contexts requiring finite forms.¹⁻³ In English, children's errors include omissions of past-tense /-ed/, 3rd singular /-s/, and auxiliary /to be/.

While OI is widely studied in language development, little is known about its neural basis.

Question

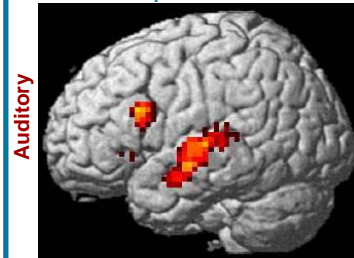
What are the neural correlates of Optional Infinitive in the adult brain?

Predictions

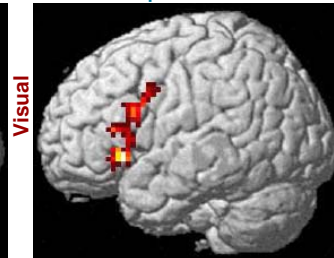
Sentences with Developmental (Optional Infinitive) errors should elicit different brain activations as compared to sentences with errors that are not made during development.

Results

Developmental (OI) Errors > Non-Developmental Errors

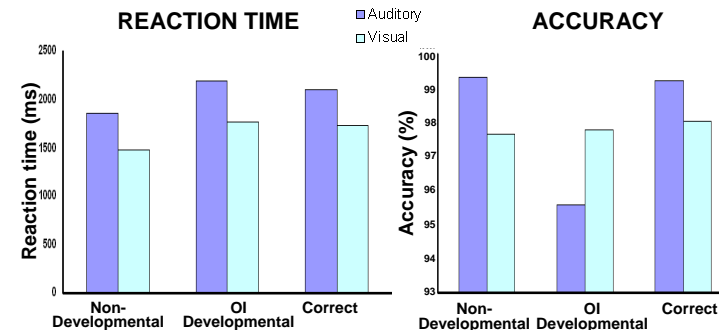


Developmental (OI) Errors > Non-Developmental Errors



Sentences with Developmental-Optional Infinitive errors yielded greater activation in Left IFG relative to Non-Developmental errors and Correct sentences in both Auditory and Visual sentence presentations ($p < 0.01$ FDR)

Our analytical innovation afforded improved statistical significance from $p < 0.01$ uncorrected to $p < 0.001$, FWE $p < 0.01$.



Participants were significantly **slower** when judging Developmental-OI errors ($p < 0.01$) in both Auditory and Visual modalities.

Participants were **less accurate** when judging Developmental-OI errors in Auditory but not in Visual modality.

Methods

GRAMMATICALITY JUDGMENT TASK

Auditory and visual presentation

DEVELOPMENTAL Optional Infinitive (OI) Errors

Errors children make in development¹⁻³

Yesterday I *enjoy* the music *omitted -ed*
She *empty* the trash daily *omitted -s*
He *the* tallest in town *omitted "to be"*

NON-DEVELOPMENTAL (Non-OI) Errors

Errors children do not make in development¹⁻³

They *are ring* the bell *omitted -ing*
They *am eating* their snack *bad agreement*

CORRECT Sentences

I *am brushing* my teeth
Last week I *saw* Dad

Participants:

25 healthy adults (mean age = 25)

fMRI Imaging

Visually-presented sentences:
continuous acquisition

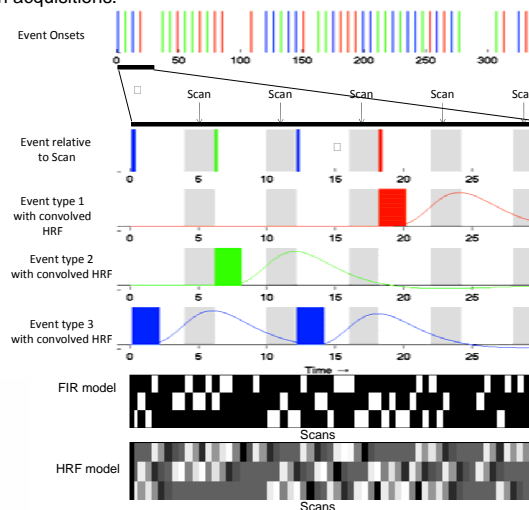
Auditorily-presented sentences:
sparse sampling

Analytical Innovation of Sparse Design (Ghosh, 2009⁴)

Sparse/silent acquisition

Ideal for auditory and speech studies: stimuli can be presented and the participant's response recorded during the silence between acquisitions.

- For each condition of interest we created a time series representing the **onsets of each event** convolved with a boxcar whose length corresponded to the duration of the event.
- The resulting time series were then **convolved** with a canonical hemodynamic response function to generate a simulated BOLD response for that condition.
- This time series was then sampled (without low-pass filtering) at the time-points when the scanner data were actually acquired. The resulting vectors for each condition were used as regressors in the GLM analysis.



Discussion

This study shows that processing OI grammatical errors in adulthood results in increased response time and LIFG activation relative to other grammatical errors that are not made in childhood.

These findings suggest that the OI stage of child development influences grammatical mental and neural function in adulthood.

Future studies of children will draw on these data to show how neurophysiological changes in LIFG correspond to patterns of syntactic acquisition, including the specific grammar deficits associated with SLI and autism-spectrum disorders.

References

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Acknowledgments

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