On the basis of sonority restrictions

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Syllable structure

• Language surveys:


Syllable structure

- **Language surveys:**

Sonority restrictions on onset clusters

- Sonority is a scalar *phonological* property that constrains syllable
- All grammars *universally* favor onsets with large sonority clines


Predictions

- **Systematicity**: Syllable shape is systematically constrained
- **Level**: Phonology
- **Scope**: universal
• Are speakers sensitive to the structure of syllables they have never heard before?

Syllable hierarchy

Blif \textgreater \textit{bnif} \textgreater \textit{bdif} \textgreater \textit{lbif}

Large rise \textgreater \textit{small rise} \textgreater \textit{plateau} \textgreater \textit{fall}

English \rightarrow \textit{Ill-formed}

• Behavioral findings
• Brain response
Grammatical repair

- Repair ~Ill-formedness

\[ b_{ena} > b_{eda} > l_{Eba} \]

- Repair \rightarrow misidentification
Experiment 1: Syllable count

One/two syllables?

blif
Experiment 1: syllable count
Experiment 1: syllable count
responses to monosyllables

Small sonority distances are misidentified

- $bl>bn>bd>lb$

- $ml>md$

- $pn>fn$

- $bz>bd$
Predictions

• ✓ Systematicity:
  – Syllable shape is systematically constrained

• Level: Phonology
• Scope: universal
Why are ill-formed syllables misidentified?
Why are ill-formed syllables misidentified?

\[ *lb > *bd > *bn > *bl \]

Universal Grammar

[Image of a engine]
Why are ill-formed syllables misidentified?

- Single engine?
- Grammar?
- Universal Grammar?

Conspiracy theory
fMRI study

Syllable count under the magnet

Berent, Pan, Zhao, Epstein, Bennett Deshpande, Seethamraju & Stern (2014). PloS one
fMRI study

Syllable count under the magnet

Berent, Pan, Zhao, Epstein, Bennett Deshpande, Seethamraju & Stern (2014). PloS one
Broca’s area

Berent, Pan, Zhao, Epstein, Bennett Deshpande Seethamraju & Stern (2014). *PloS one*
Why are ill-formed syllables misidentified?

$*lb > *bd > *bn > *bl$

Covert motor simulation:
- Rare syllables are disliked because they are harder to simulate
Speech perception triggers articulatory action

Speech perception engages congruent motor areas

Stimulation of the relevant articulators selectively modulates the perception of congruent speech signs

Speech Production

Motor stimulation

Speech perception

Are the errors with lbif due to motor simulation?


Repetitive Transcranial magnetic stimulation (rTMS)

Transcranial Magnetic stimulation (TMS)

Predictions of motor account

Motor demands

Motor hemodynamic response

Sensitivity (d’)

Motor demands

Motor hemodynamic response

Motor demands

Motor hemodynamic response

Motor demands

Motor hemodynamic response

Motor demands

Motor hemodynamic response

Motor demands

Motor hemodynamic response

Motor demands

Motor hemodynamic response
Results

![Graph showing d' (sensitivity) for syllable types](image)

- **Syllable type**
  - blif
  - bnif
  - bdif
  - lbif

- **Sham**

Results

![Graph showing the comparison between sham and TMS treatments across different syllable types. The x-axis represents syllable types (blif, bnif, bdif, lbif) and the y-axis represents d' (sensitivity). The graph shows a clear distinction between well-formed and ill-formed syllables for both sham and TMS conditions.]

Results

(a) Y = -12mm Left Hemisphere X = -48mm

(b) Left Lip [-48, -12, 39]

- BOLD percentage change
- Monosyllables
- Disyllables
- Blif, bnif, bdif

TMS study coordinate
X = -59mm
Y = -5mm
Z = 39mm
Why are ill-formed onsets misidentified?

- *Lbif* does not elicit greater motor demands
- *Lbif* is disliked despite motor disruption

Motor simulation
Why are ill-formed onsets misidentified?

Some errors are phonetic


• Others are phonological
  – Obtain when acoustic phonetic cues are
  • Statistically *controlled*


• *Absent*: for printed materials


Identity task with printed words

\[ \text{lbif} \rightarrow 2.5 \text{ S's} \rightarrow \text{LEBIF} \rightarrow \begin{cases} \text{Same} \rightarrow 1 \\ \text{different} \rightarrow 2 \end{cases} \]
Why are ill-formed onsets misidentified?

Sonority effects with other syllable types (printed):

- **mla>mda**

- **bza>bda**

Why is *lb* dispreferred?

*lb*

**Language faculty**

Motor simulation

Experience with similar words show block


Language universals at birth

Gómez, Berent, Benavides-Varela, Bion, Cattarossi, Nespor, Mehler, (2014). PNAS.
Language universals at birth

$\Delta$ (Ill-formed-well formed) 

$\Delta$ lbif-blif

A

Left Superior | Right Superior

$\Delta$Hb [mmol/mm]

Left Inferior | Right Inferior

$\Delta$Hb [mmol/mm]

Oxyhemoglobin

deoxyhemoglobin

$\Delta$ (Ill-formed-well formed) 

$\Delta$ bdif-blif

B

Left Superior | Right Superior

$\Delta$Hb [mmol/mm]

Left Inferior | Right Inferior

$\Delta$Hb [mmol/mm]

Gómez, Berent, Benavides-Varela, Bion, Cattarossi, Nespor, Mehler, (2014). PNAS.
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• ✓**Scope:** universal
**Syllable structure**

- **Language surveys:**


Thank you!

Collaborators

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Why $lbif$ = misidentified?

- $L bif$ is difficult to simulate $\rightarrow$ errors
- $L bif$ is “too difficult” to simulate $\rightarrow$ no motor action for $lbif$
  
  - Tacit assumption:
    - Difficulty of motor plan is determined without reliance on action
    - This assumption violates the definition of simulation as action based