Understanding the time course of written compound word production

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Outline

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Compound Morphology

- Compounding is considered one of the most fundamental morphological processes
- It enables languages and language-users to make new words from existing words
- Morphological productivity results in morphological families (e.g., fastball, handball)

Compound Morphology

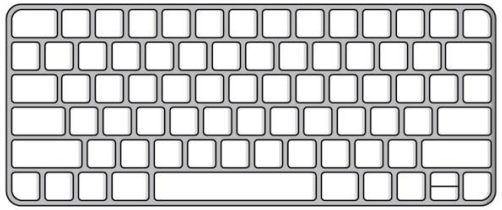
- We investigate whether properties of these morphological families can influence the production of compounds and even individual constituents within those compounds
- Compound word typing has been an effective way to examine the role of morphology in production planning and execution.
- There is evidence that compound processing depends on the properties of their parts both as whole-words and compound constituents across the language.

Compound Morphology and Typing

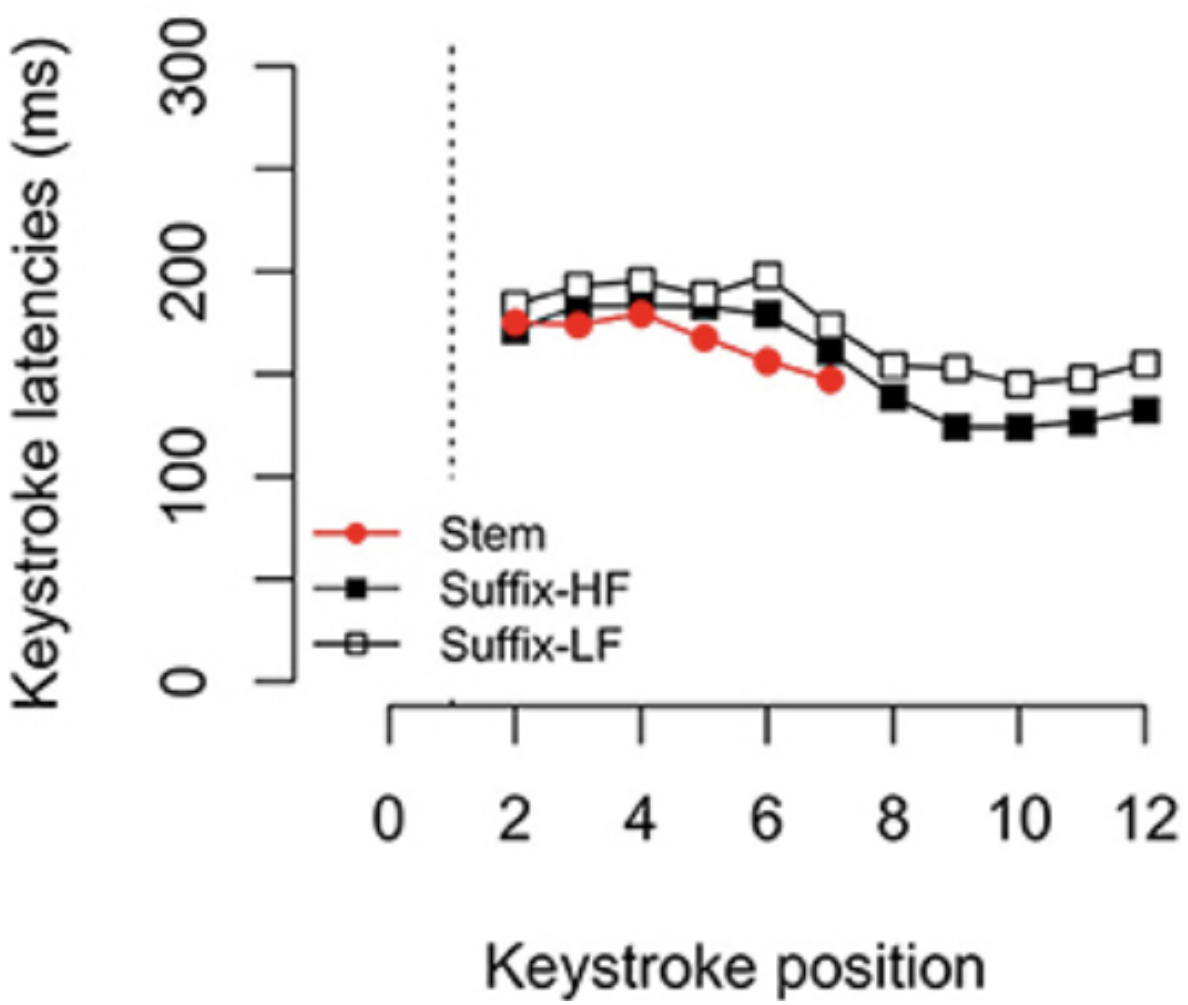
- Our knowledge of morphological structure is reflected in inter-keystroke interval (IKI) timing
- Only compounds (e.g., fastball) show longer IKIs between constituents (e.g., ‘fast’ and ‘ball’)
- Classical interpretation: slowing at boundary attributed to segmentation into morphological constituents
  - No slowing at at the boundary for stems and suffixes (e.g., foot + er) (Feldman et al., 2019)
- Our goal is to investigate linguistic constraints on the slowing that arises at the constituent boundary
- Could the boundary effect be semantic in nature?

The Typing Task

- Inter-keystroke interval timing provides a window onto on-line production processes
- IKIs are sensitive to:
  - Syllabic and morphological structure (Will et al., 2006)
  - Lexical properties (e.g., frequency)
  - Ease of processing (Gallant, 2023)
  - Constituent properties (e.g., semantic transparency) (Libben et al., 2014)
  - Morpheme Properties (e.g., suffix frequency) (Feldman et al., 2019)

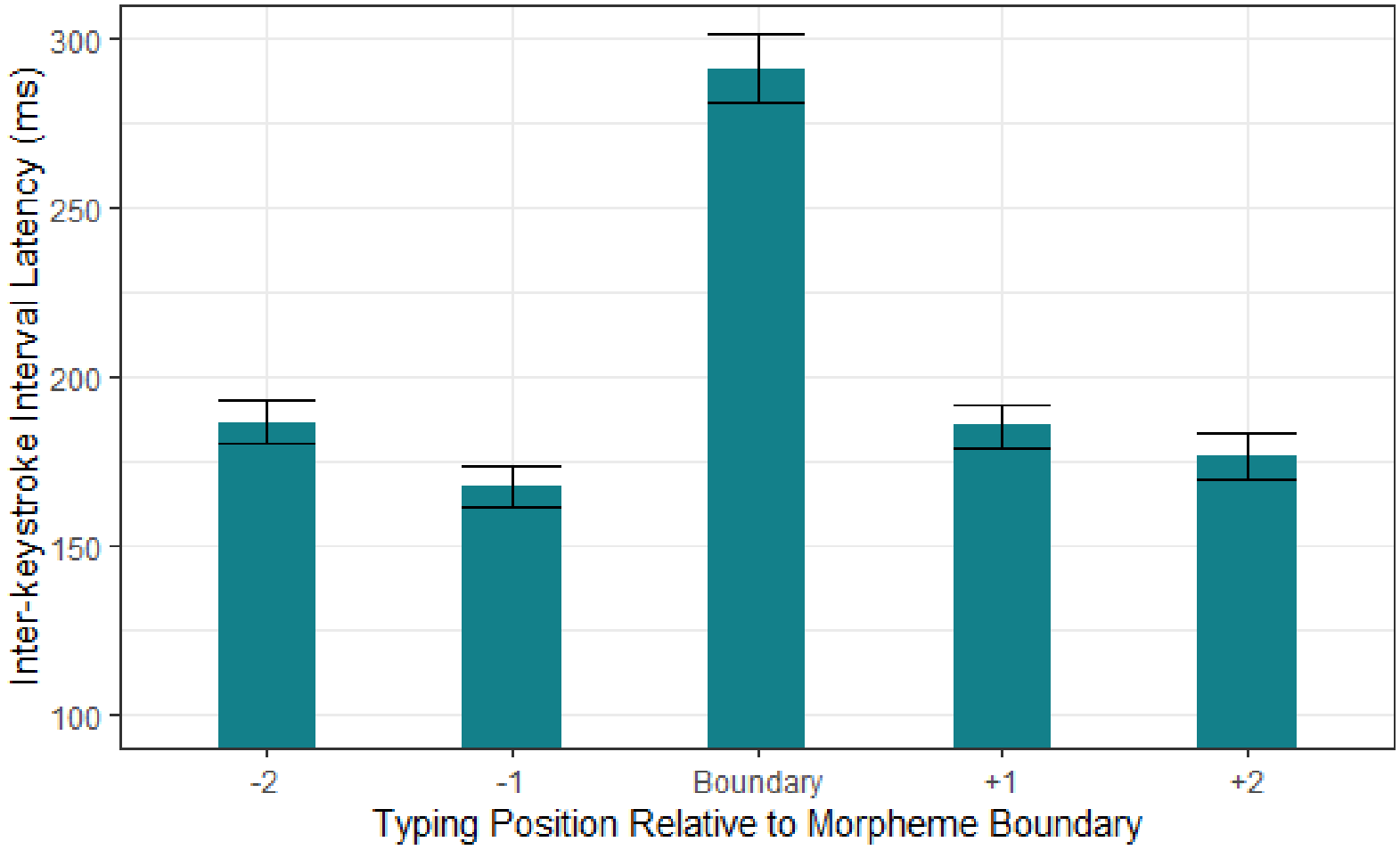


IKI at the Stem-Suffix Boundary



(Feldman et al., 2019)

IKI at Constituent Boundary



(Libben, Gallant & Dressler, 2021)

Further Investigation of Boundary Effects

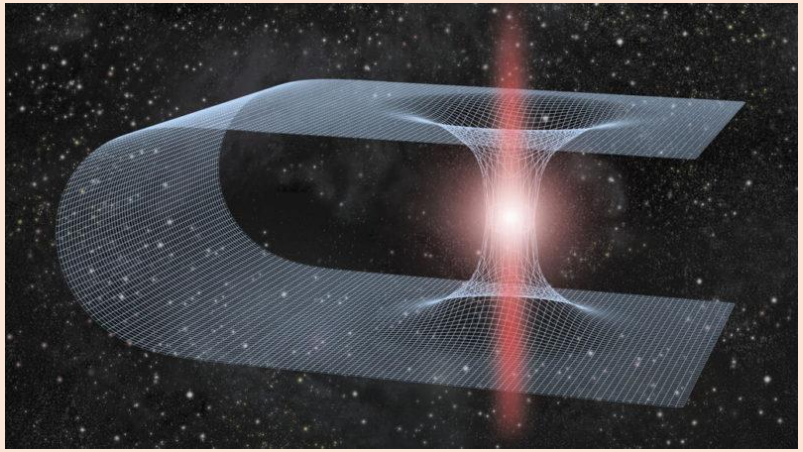
- Boundary effects are easy to detect when both components are words- meaningful on their own
- What linguistic attributes of constituents could influence slowing at the boundary?
  - Constituent frequency as a word?
  - Meaning in isolation vs in compound?
  - Morphological family size?
  - Meaning in isolation vs meaning in the morphological family?
- Are these boundary effects simply the result of segmentation or do they reveal something about how compound words are represented and produced?

Morphological Transcendence

- Meaning of a morphological constituent as a free-word and as a constituent are not necessarily consistent (e.g., note vs keynote)
- These meanings can become less consistent as family size grows
- Gunther and Marelli (2021) approximate the degree of consistency between morphological constituent and free-word meaning using a distributional semantic approach
- Modifier consistency, as a family-wise property, may influence the way that compounds are produced

Worm (free-word)

worm- (as-modifier)



Wormhole

Wormseed

Wormwood

rain (free word)

rain-
(as-modifier)

Rainstorm

Raincoat

Rainbow

Method

- Participants: 156 Native English speakers.
- Procedure: Type-to-copy task (3 blocks)
- Stimuli:
  - Four compound types varying in whole-word and constituent lexicality. All compounds were eight letters in length. All constituents were four letters in length.
  - Modifiers in compound pairs varied by whole-word and constituent properties

Compound Stimuli

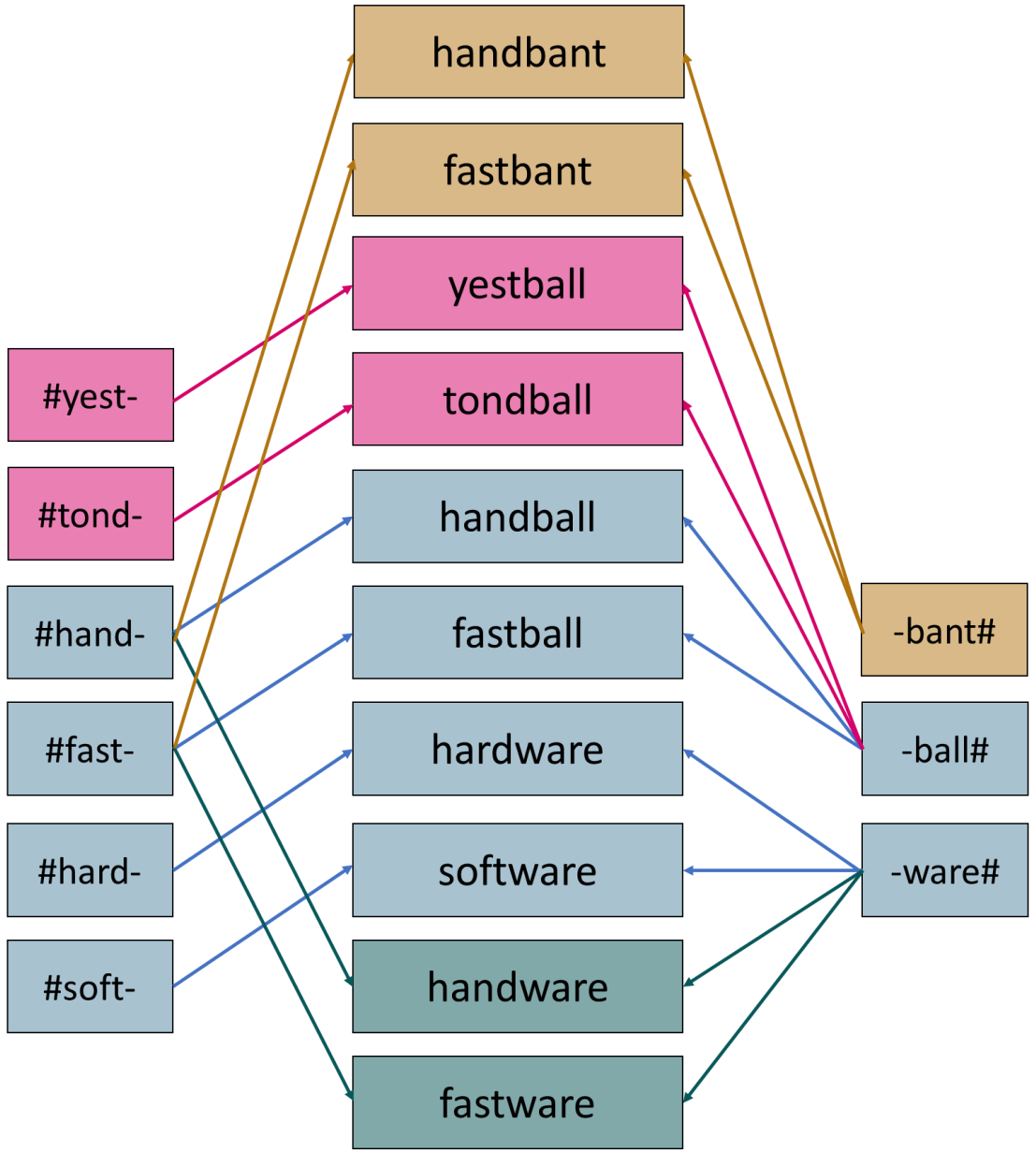
COMP	**FAM SIZE MODIFIER**	FAM SIZE HEAD	COMPOUND Freq	MODIFIER Word Freq	**MODIFIER Consistency Gunther & Marelli (2021)**
callback	**1**	44	1136	1136	**0.26**
playback	**29**	44	7395	84068	**0.35**
suitcase	**1**	12	6709	6709	**0.19**
bookcase	**23**	12	1890	91873	**0.29**
hosepipe	**1**	11	881	881	**0.41**
windpipe	**25**	11	601	25091	**0.22**
drumbeat	**3**	7	520	1559	**0.28**
downbeat	**14**	7	330	40506	**0.12**

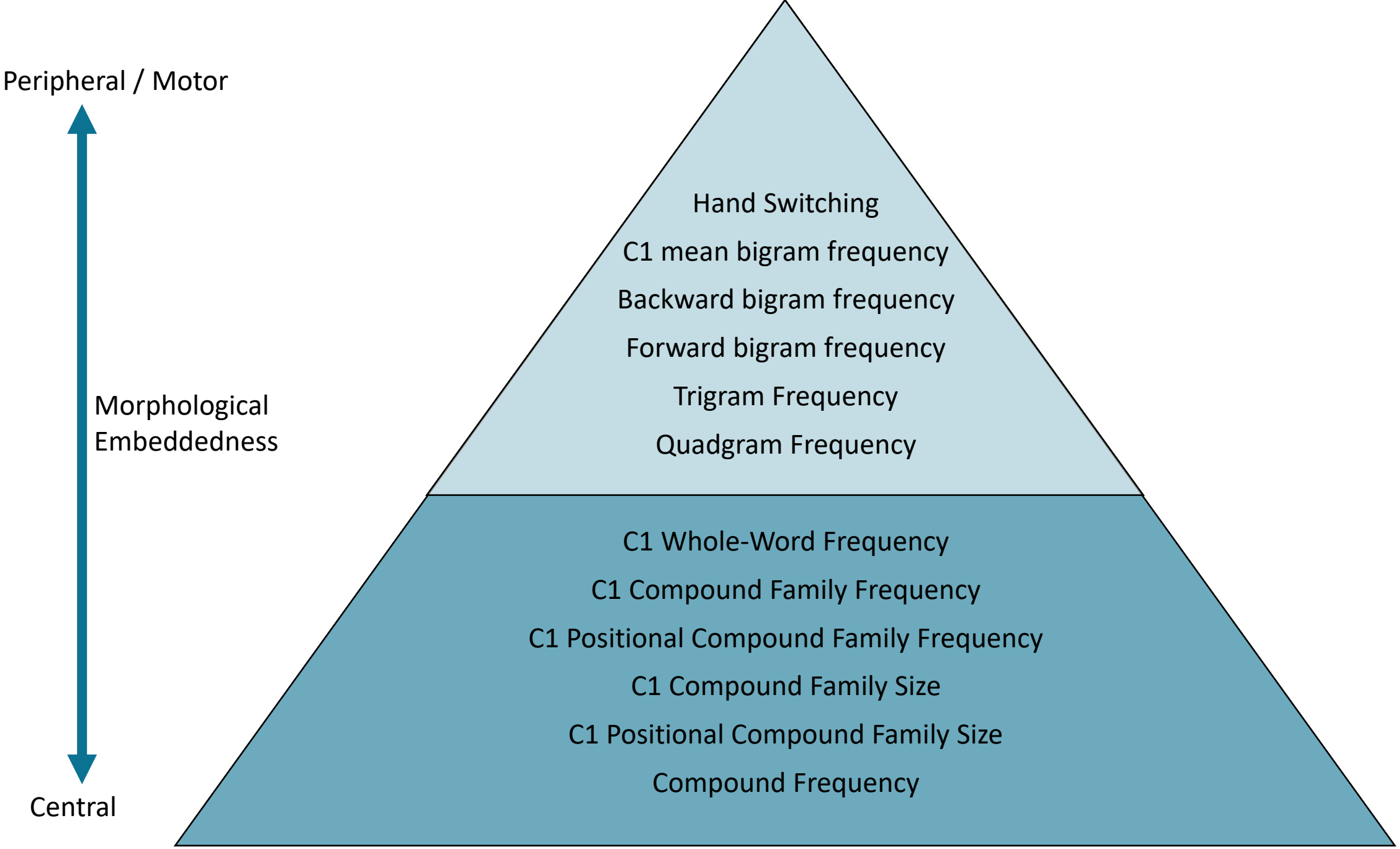
Modifier Consistency measures taken from Gunther & Marelli (2021)

Compound Stimuli

REAL COMPOUNDS (REAL)	NOVEL COMPOUNDS (NOVEL)

COMPOUNDS WITH A NON-WORD MODIFIER (NONMOD)	COMPOUNDS WITH A NON-WORD HEAD (NONHEAD)




Peripheral / Motor
Morphological Embeddedness
Central
Hand Switching
C1 mean bigram frequency
Backward bigram frequency
Forward bigram frequency
Trigram Frequency
Quadgram Frequency
C1 Whole-Word Frequency
C1 Compound Family Frequency
C1 Positional Compound Family Frequency
C1 Compound Family Size
C1 Positional Compound Family Size
Compound Frequency

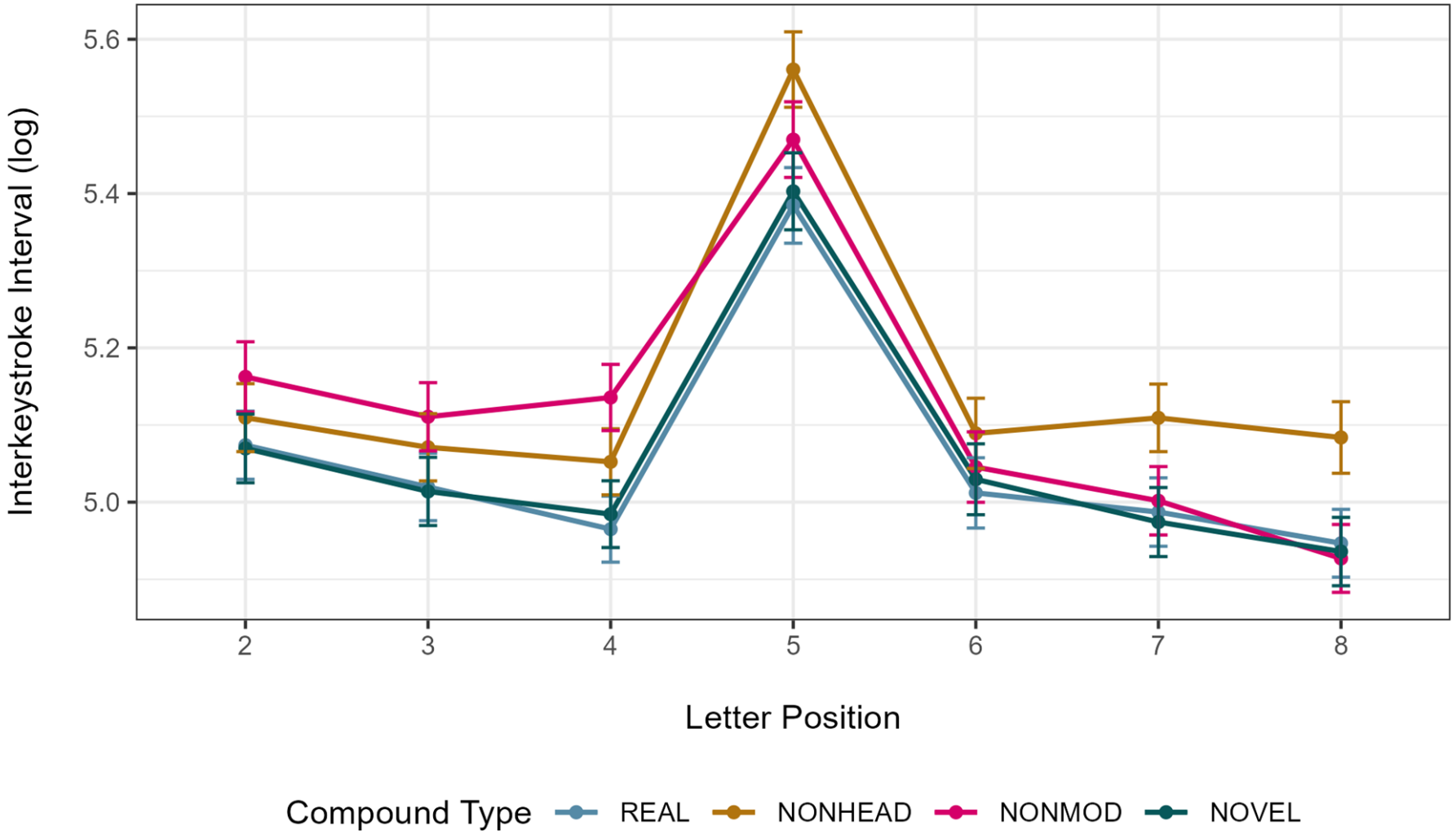
Interactions with typing ability[2]

Variable	Significantly Improved Model Performance	P Values[1]
Hand Switching	✓	<0.001
C1 mean bigram frequency	✓	0.04
Backward bigram frequency	✓	0.01
Forward bigram frequency	✓	0.02
Trigram Frequency		0.53
Quadgram Frequency		0.99
C1 Whole-Word Frequency		0.69
C1 Compound Family Frequency		0.28
C1 Positional Compound Family Frequency		0.42
C1 Compound Family Size		0.23
C1 Positional Compound Family Size		0.26
Compound Frequency		0.95

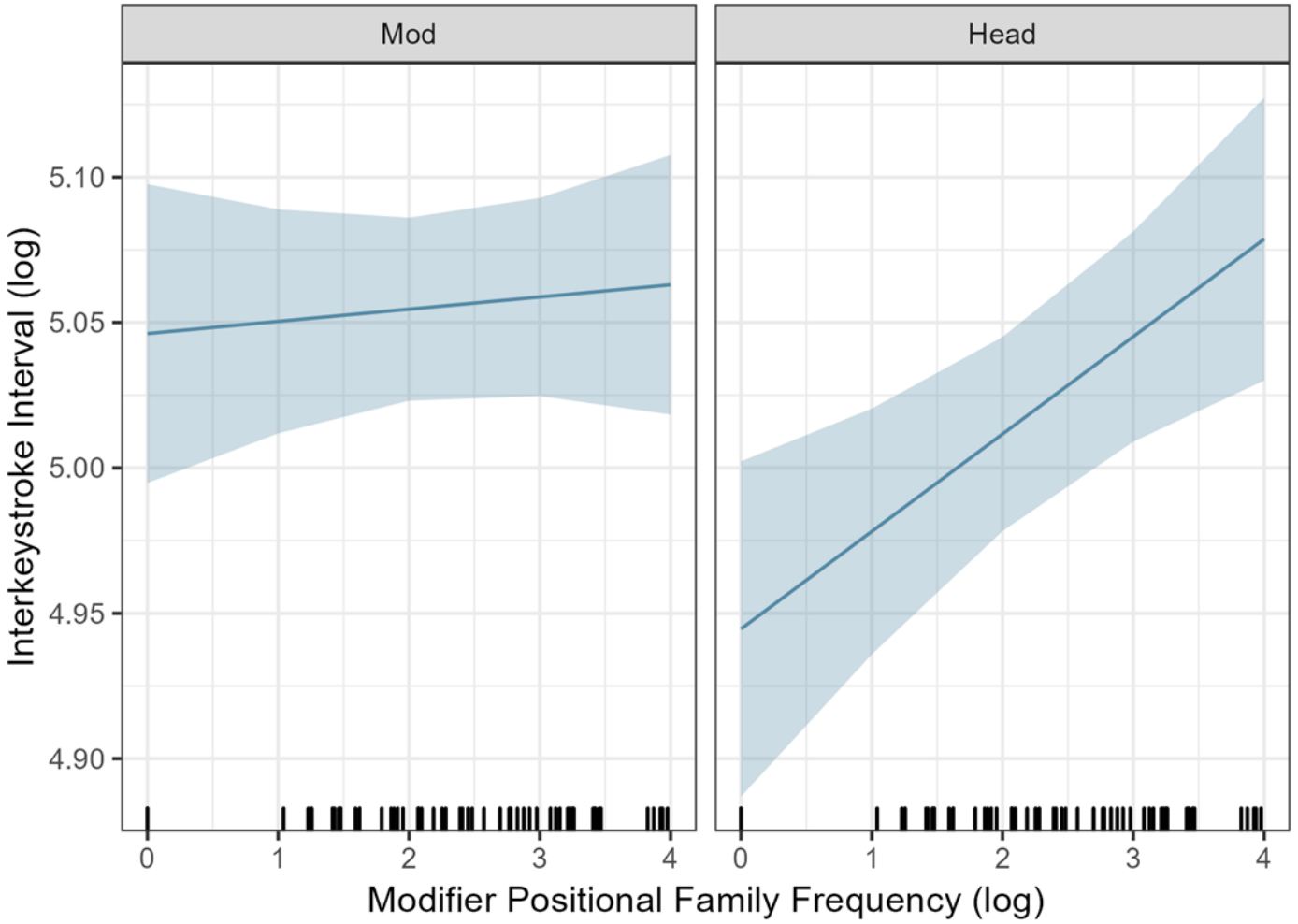
[1] P-values from an ANOVA comparing the performance of a base model (containing both typing ability and the variable in question) with a model containing an interaction between those two variables

[2] Typing ability was operationalized by individual participant mean IKIs in a paragraph task, which was administered prior to the experiment

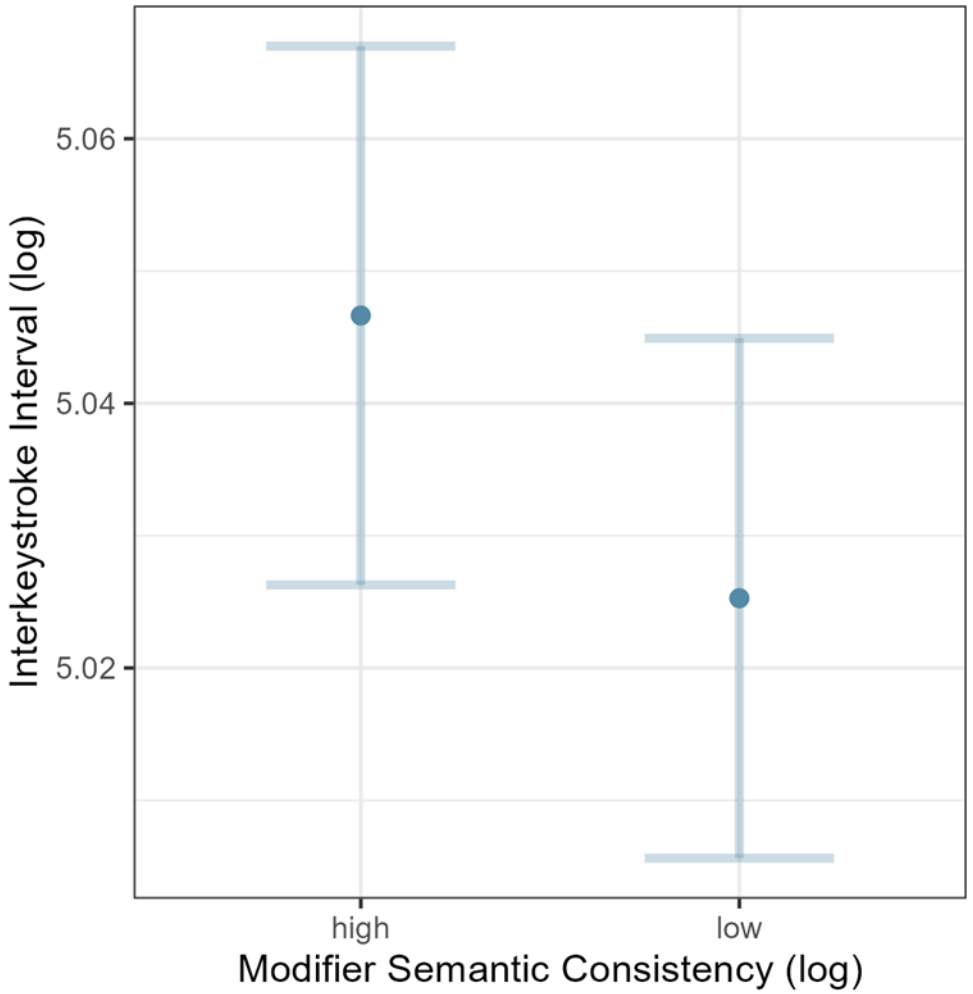
Compound and Constituent Lexicality



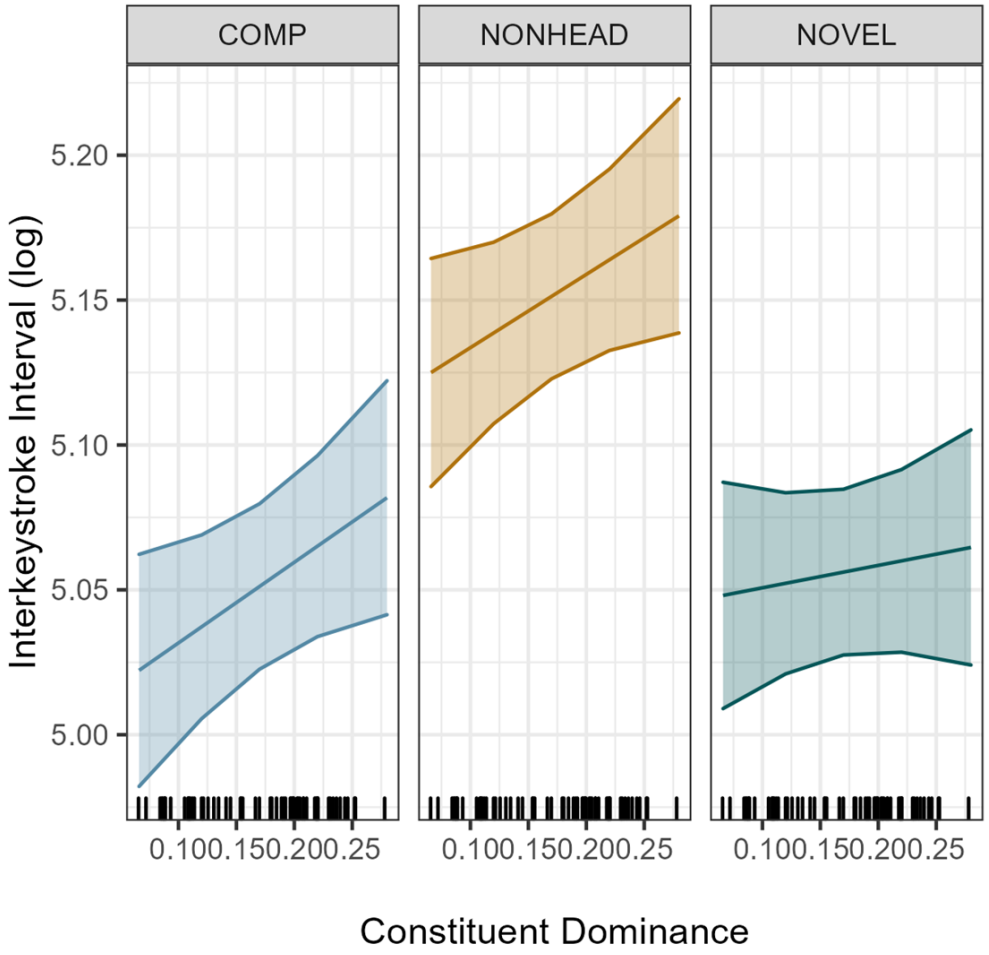
C1 Positional Family Frequency

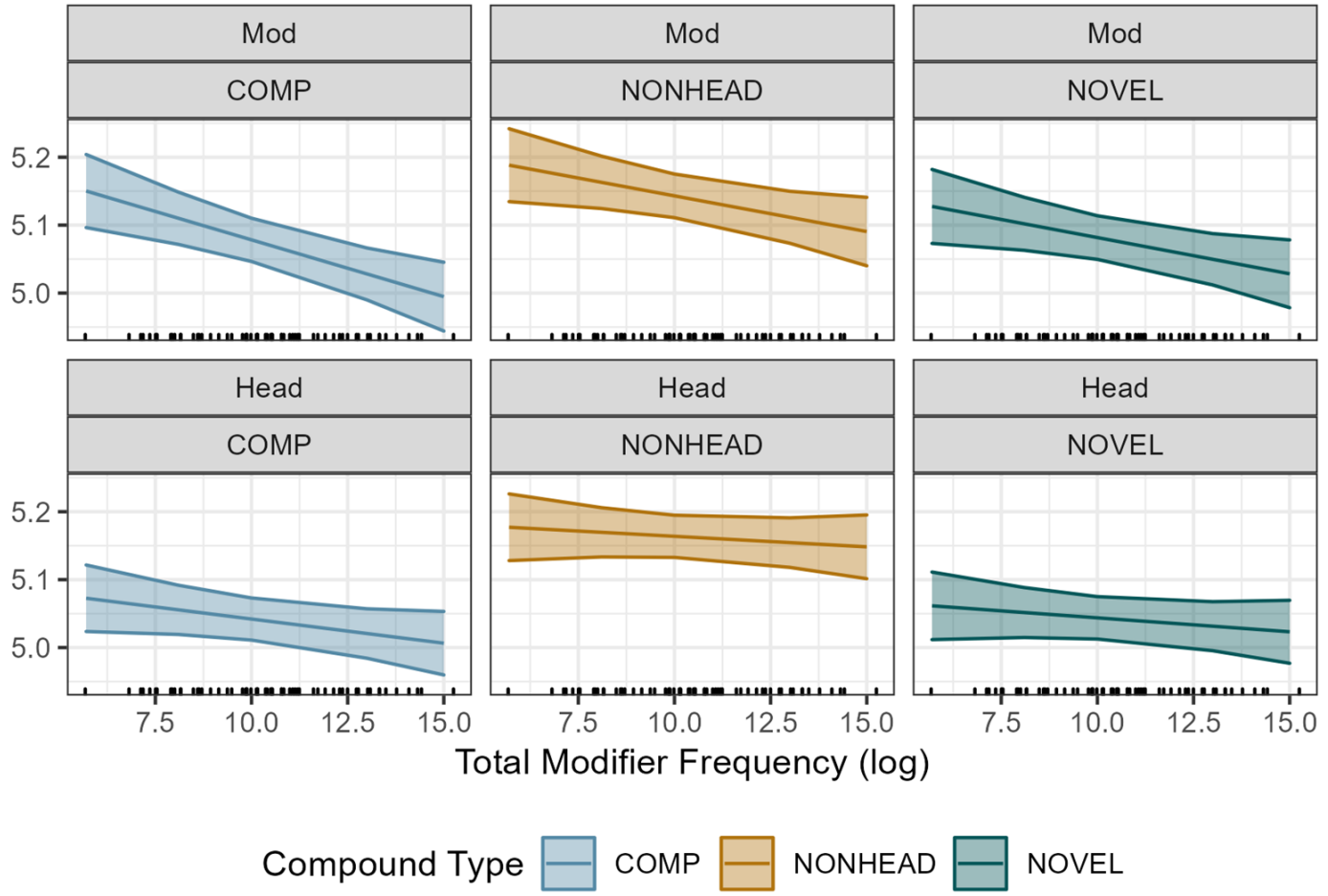


C1 Semantic Consistency



Constituent-ness





Results

- Constituent lexicality (e.g., fast vs. yest) influenced IKIs but compound lexicality (e.g., fastware vs. software) did not.
  - Compound production processes are driven by constituent
- IKIs by position show anticipatory and carry-over effects across constituents.
  - Planning and execution are neither purely local nor serial.
- Family-wide properties of modifier constituents (i.e., semantic consistency and family-frequency) influenced IKIs
  - Compound production activates the broader morphological system such that semantic and distributional properties of constituents can play a role

Conclusions

- Typed production tasks can provide unique insights into compound processing
- Morphological effects are not restricted to the constituent boundary positions
- Production does not treat constituents independently
- Family-wide properties permeate the production of individual words

Future Directions

- Track L2 morphological development via typing
- Explore links between literacy and patterns of typed production (e.g., using eye-tracking measures)
- Investigate the involvement of morphological family properties in languages where compound productivity is greater than English (e.g., Japanese and Chinese)

Thank you very much!

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References

- Feldman, L. B., Dale, R., & van Rij, J. (2019). Lexical and frequency effects on keystroke timing: challenges to a lexical search account from a type-to-copy task. *Front. Commun. 4:17*.
- Gallant, J., (2023). Typed transcription as an implicit measure of foreign-accent comprehensibility: an online replication study. *Research Methods in Applied Linguistics*, *2*(2).
- Günther, F. & Marelli, M. (2021). CAOSS and transcendence: Modeling role-dependent constituent meanings in compounds. *Morphology*, 1–24.
- Libben, G., Gallant, J., & Dressler, W. (2021). Textual Effects in Compound Processing. *Frontiers in Communication,* 6:646454.
- Libben, G., & Weber, S. (2014). Semantic transparency, compounding, and the nature of independent variables. *Morphology and Meaning*. Amsterdam/Philadelphia: John Benjamins.
- Will, U., Nottbusch, G., & Weingarten, R. (2006). Linguistic units in word typing: Effects of word presentation modes and typing delay. *Written Language & Literacy*, 9(1), 153-176.