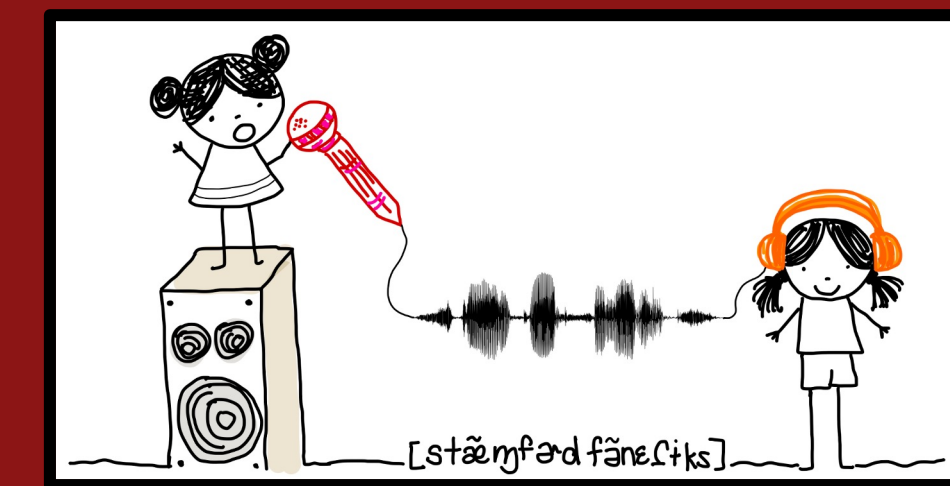# Sublexical ARTifacts: Bottom-Up Interference in a Lexical Category Search

William Clapp, Nora Dee, & Meghan Sumner

How do we understand a talker we've never heard before?

Background

Adaptive Resonance Theory (ART):

- **Unified theory of cognition**:

  Conscious perception occurs when bottom-up (BU) input pattern matches top-down (TD) categories tuned through experience (Grossberg, 2013; Grossberg, 2021).

- **No basic "unit" for speech perception**:

  Category-level nodes span many levels of representation (Goldinger & Azuma, 2003; Samuel, 2020).

- **Larger levels mask smaller levels**; e.g., sentence > word > phoneme > acoustic feature (Goldinger & Azuma, 2003; Kazerounian & Grossberg, 2014).

How do we understand a talker or accent we've never encountered before?

If no resonance forms immediately between BU and TD → category search finds or creates a suitable match.
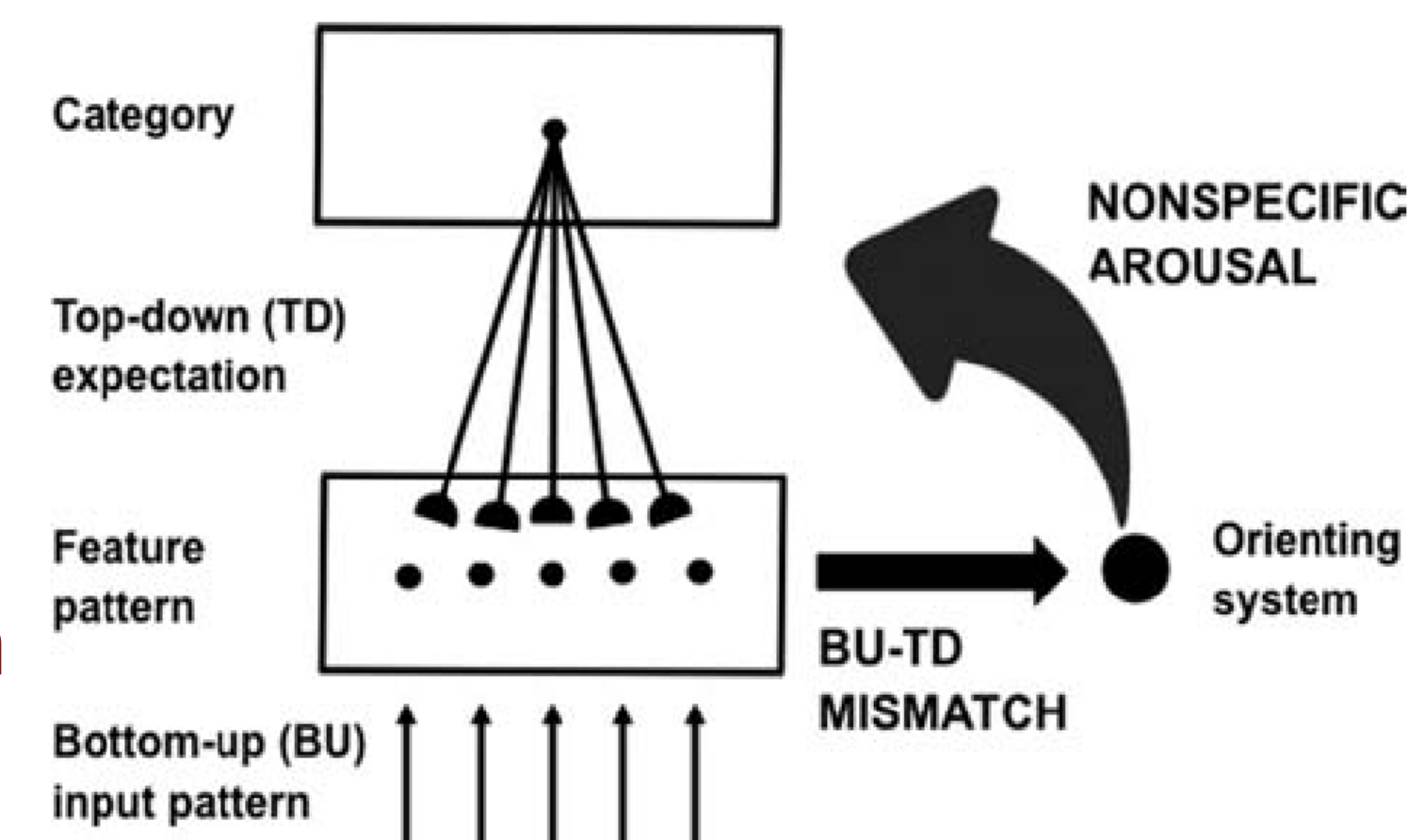
ART predicts masking effects are weaker during a category search.

Question:

When a listener's stored expectations are violated in the context of a spoken sentence, is the **masking effect dampened**, leading to increased **interference from bottom-up patterns**?

Study:

- Induce category search to resolve perception.
- Measure sub-lexical (BU) interference (visual world paradigm).

Methods

Eye tracking / visual world paradigm:

- *96 participants* recruited on Prolific. Eye-tracking via WebGazer in jsPsych (de Leeuw, 2015).

- **Stimuli:** unpredictable sentences ending in imageable di- or trisyllabic noun, where penultimate syllable forms a different word, e.g. [ARCH]er; bi[KEY]ni

- **Critical trials:** **Anchor talker** produces sentence through penultimate word; **Intrusive talker** spliced in for last word.

- **Control trials**: **Anchor talker** produces entire sentence.

- **Talkers**: 1 Anchor talker (female native GA speaker); 4 Intrusive talkers (2 female, 2 male GA).

- 8 critical, 8 control, 84 filler trials

- **Analysis**: Looks to target via generalized additive mixed model (GAMM). *Accuracy and RT not reported here.*

- **Hypothesis**: Competitor draws looks from target more for Intrusive talker than for Anchor talker.
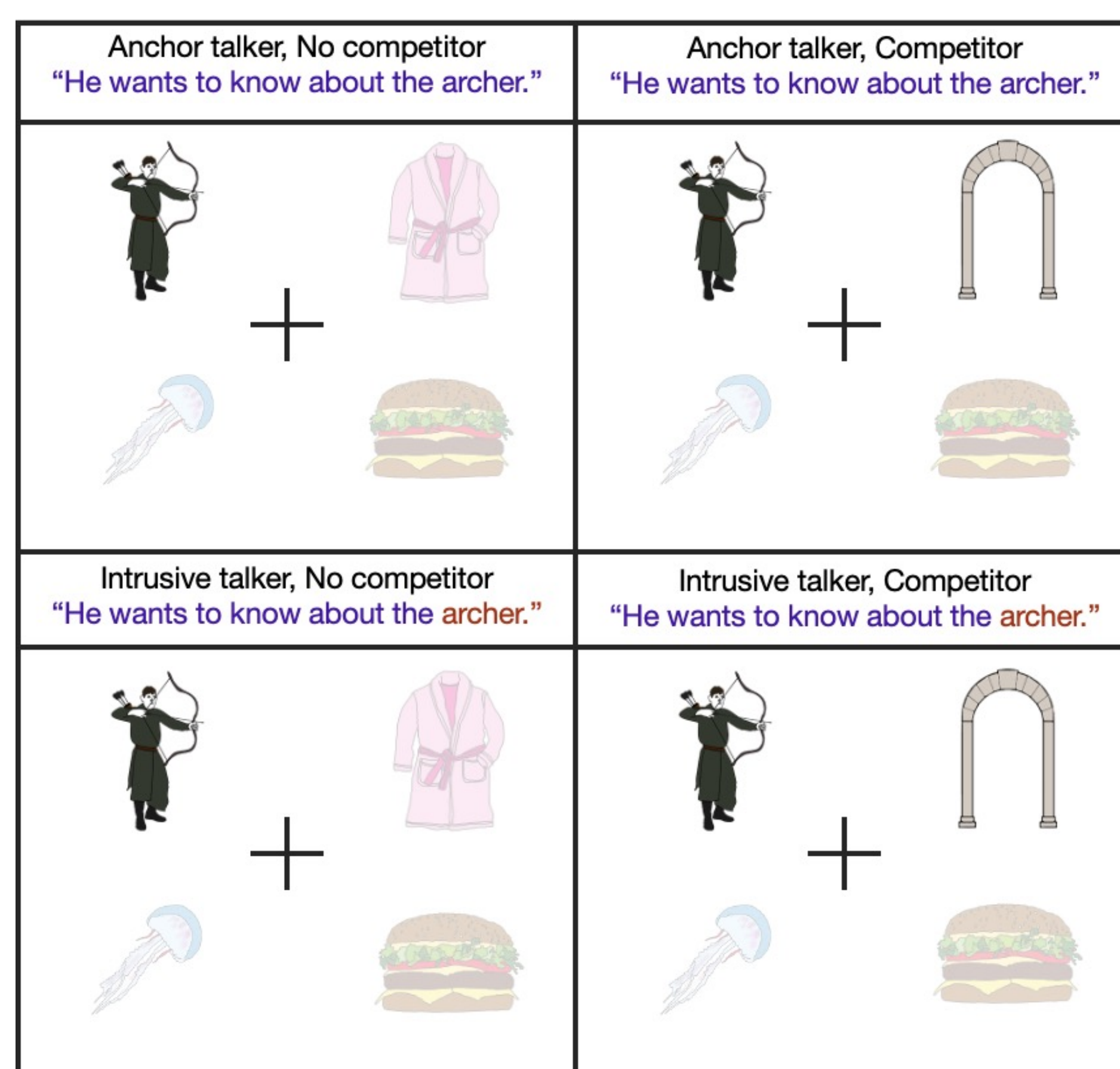
Results

Model predictions: Looks to target in Empirical Logits.

Difference between smooths. Significant between dotted lines.
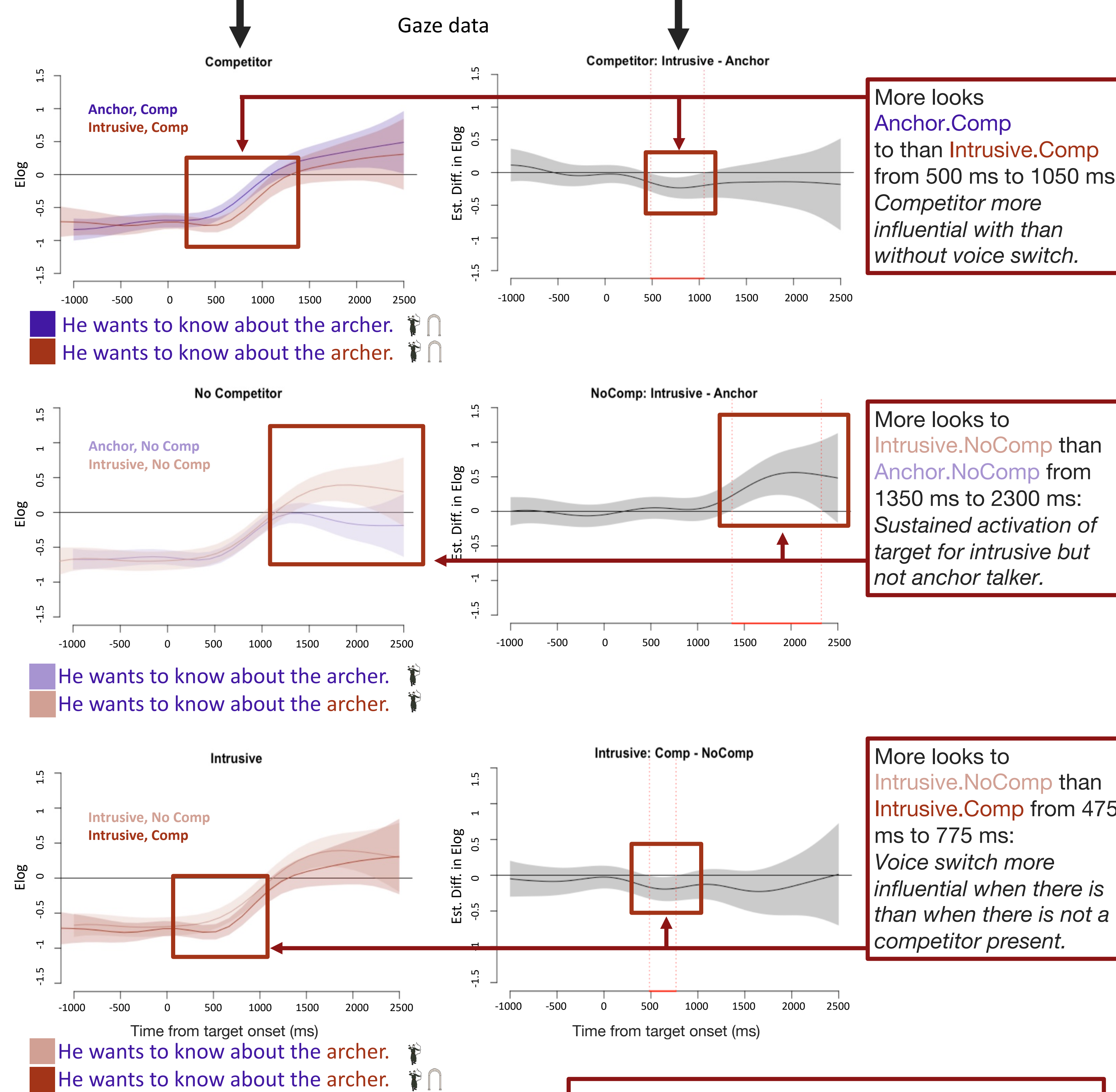
More looks Anchor.Comp to than Intrusive.Comp from 500 ms to 1050 ms: *Competitor more influential with than without voice switch.*

More looks to Intrusive.NoComp than Anchor.NoComp from 1350 ms to 2300 ms: *Sustained activation of target for intrusive but not anchor talker.*

More looks to Intrusive.NoComp than Intrusive.Comp from 475 ms to 775 ms: *Voice switch more influential when there is than when there is not a competitor present.*

Relative to reference level Anchor.NoComp, parametric coefficient (i.e. *overall looks to target*) only significant for Intrusive.Comp. (β = -0.79, t = -2.21, p < 0.05)

All four smooth terms significant:
Anchor.NoComp (edf = 7.20, F = 9.07, p < 0.001)
Intrusive.NoComp (edf = 6.20, F = 6.11, p < 0.001)
Anchor.Comp (edf = 6.59, F = 9.28, p < 0.001)
Intrusive.Comp (edf = 7.22, F = 11.60, p < 0.001)

Discussion

- *Main hypotheses supported*: Competitor drew looks from target more for Intrusive talker than for Anchor talker.

  - With competitor present, 500 ms after voice switch, more looks to target on Anchor talker trials than on Intrusive talker trials.

  - On Intrusive talker trials, 500 ms after voice switch, more looks to target with *No Competitor* than with *Competitor*.

- With *No Competitor* present, looks to target sustain for Intrusive talker trials, but not Anchor talker trials: Retracing auditory signal in working memory?

- Listeners shift attention to finer-grained (i.e. sub-lexical) information to process an anomalous input. This may shed light on how listeners map new talkers' speech to linguistic meanings.

References

de Leeuw, J. R. (2015). jsPsych: A JavaScript library for creating behavioral experiments in a web browser. Behavior Research Methods, 47(1), 1–12. doi: 10.3758/s13428-014-0458-y

Goldinger, S. & Azuma, T. (2003). Puzzle-solving science: the quixotic quest for units in speech perception. Journal of Phonetics, 31, 305–320. doi:10.1016/S0095-4470(03)00030-5

Grossberg, S. (2013). Adaptive Resonance Theory: How a brain learns to consciously attend, learn, and recognize a changing world. Neural Networks, 37, 1–47. doi: 10.1016/j.neunet.2012.09.017

Grossberg, S. (2021). Conscious Mind, Resonant Brain: How Each Brain Makes a Mind. Oxford University Press.

Kazerounian, S., & Grossberg, S. (2014). Real-time learning of predictive recognition categories that chunk sequences of items stored in working memory. Frontiers in Psychology, 5, Article 1053. doi:10.3389/fpsyg.2014.01053

Samuel, A. G. (2020). Psycholinguists should resist the allure of linguistic units as perceptual units. Journal of Memory and Language, 111, Article 104070. doi: 10.1016/j.jml.2019.104070

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