



A Dynamic Neural Field Model for Production Mode and Phonological Neighborhood Density Effects

Symposium: Dynamic Field Theory for unifying discrete and continuous aspects of linguistic representations

Xiaomeng (Miranda) Zhu - Yale University
2025 LSA Annual Meeting
January 10, 2025

Background

Phonological neighborhood density (PND)

- Number of phonologically similar words in the lexicon; two words are neighbors if they differ by deletion, insertion, or substitution of one segment
 - E.g. glee /gli/ vs. glue /glu/
- Affects production and recognition differently (Dell & Gordon 2003)
 - Intelligibility-based account:  PND, exaggeration/hyperarticulation
 - Production-based account:  PND, reduction (shortening & centralization) / hypoarticulation

Previous Work

Dichotomy

- Intelligibility-based account:



- Intuition: Speakers want to ensure intelligibility for words that are otherwise hard to understand
- 📶 vowel dispersion, 📶 intelligibility
- **Prediction:** 📶 PND, exaggeration/hyperarticulation
- Supported by Wright (2004): examination of a database of words that were spoken in isolation; word-list reading task where individual words were shown on a computer screen; significant main effect of PND: vowels from words with denser neighborhoods are more dispersed than those from sparser neighborhoods

- Production-based account:



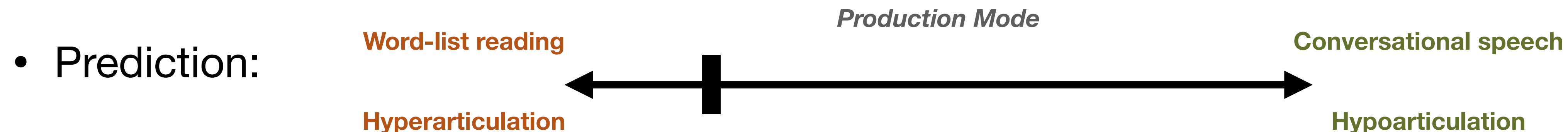
- Intuition: variation happens due to production-internal mechanisms, such as speed of lexical access and retrieval
- 📶 PND, production is facilitated (Vitevitch & Sommers, 2003)
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- Supported by Gahl et al. (2012): examination of Buckeye corpus of conversational speech (Pitt et al., 2007) and found that high neighborhood density is associated with reduced vowel dispersion

What causes this distinction?

Proposal by Gahl et al. (2012)

Differences in methodology -> *production mode*

- Production speed:
 - Faster and more variable in conversational speech; even pace in word-list reading
 - Speakers are temporally restricted against the articulation of more extreme targets
- Attentional demands:
 - Conversational speech planning and production is more complex than word-list reading
 - More freedom to realize extreme articulatory targets in word-list reading 🙌
hyperarticulation



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Research Question

Dynamic Field Theory

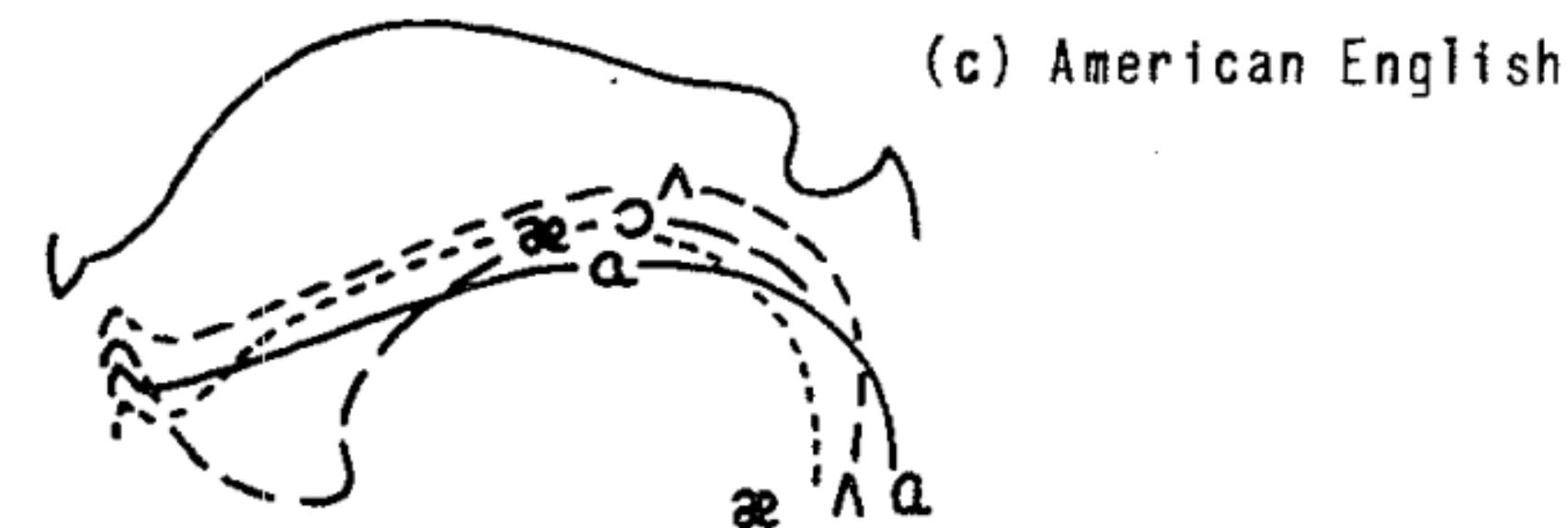
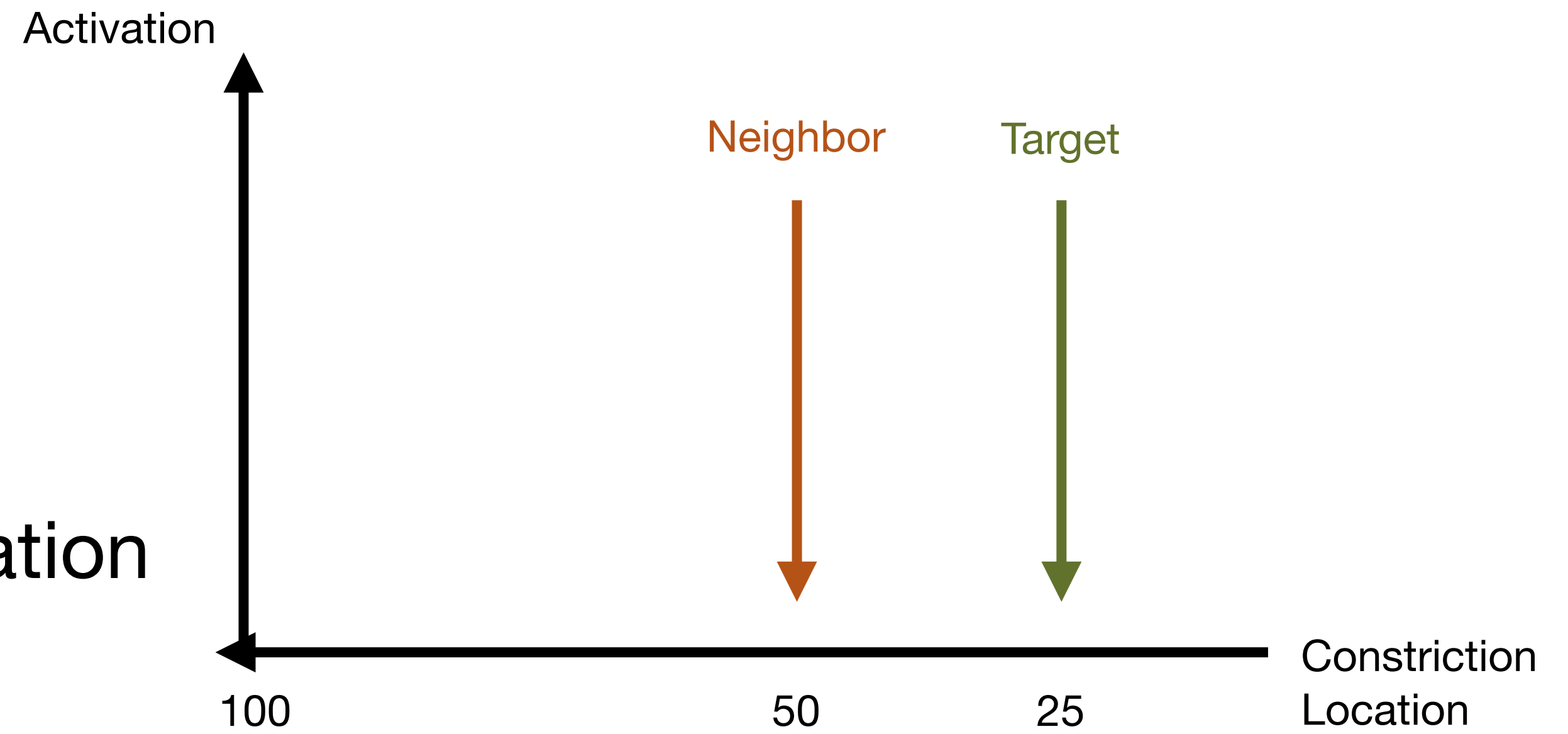


- Can we account for both sides within the same DFT model?
 - Resting level h of the production field
 - Lower h for word-list reading; higher h for conversational speech
 - Width w of the target input
 - smaller w for word-list reading; larger w for conversational speech

Model Setup

Dynamic Field Theory

- Simplified model:
 - Field dimension: constriction location
 - Field Size: 100
 - Two inputs (by default excitatory):
 - Target s_i : working example of [u] $p_n = 25$
 - Neighbors s_n : located at center of the field
 - $p_n = 50$

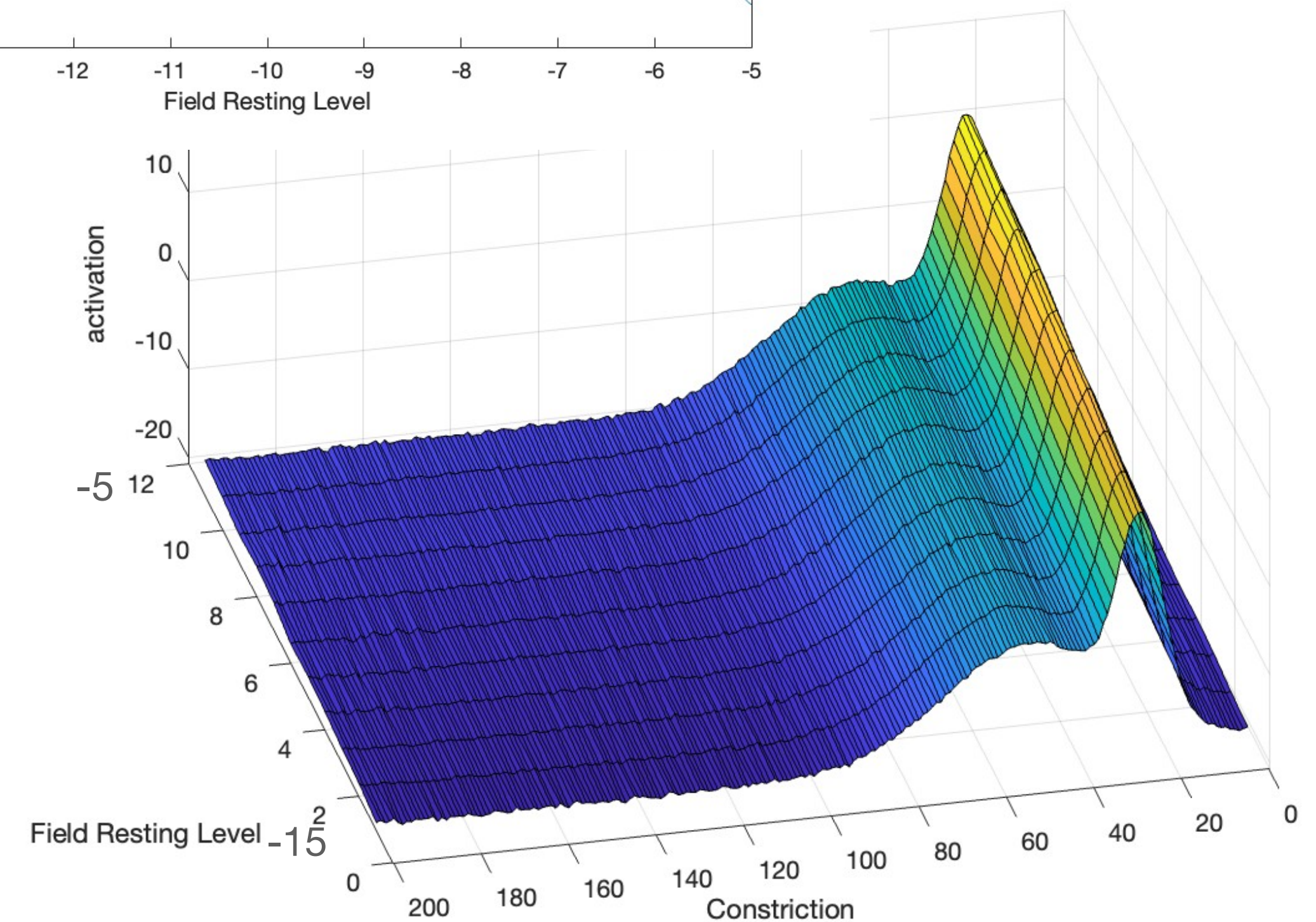
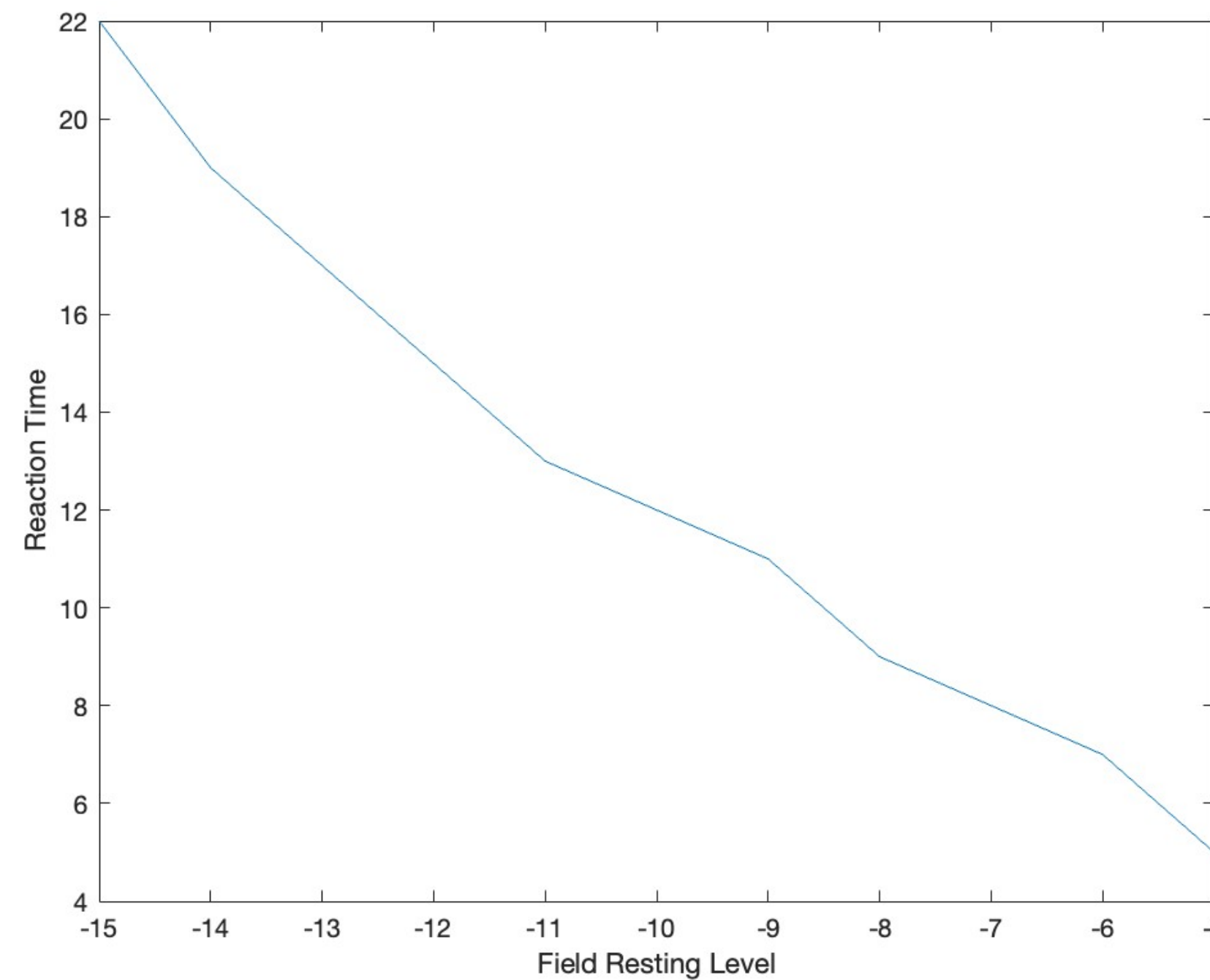


(Wood, 1975)

Results

Part 1. Varying h

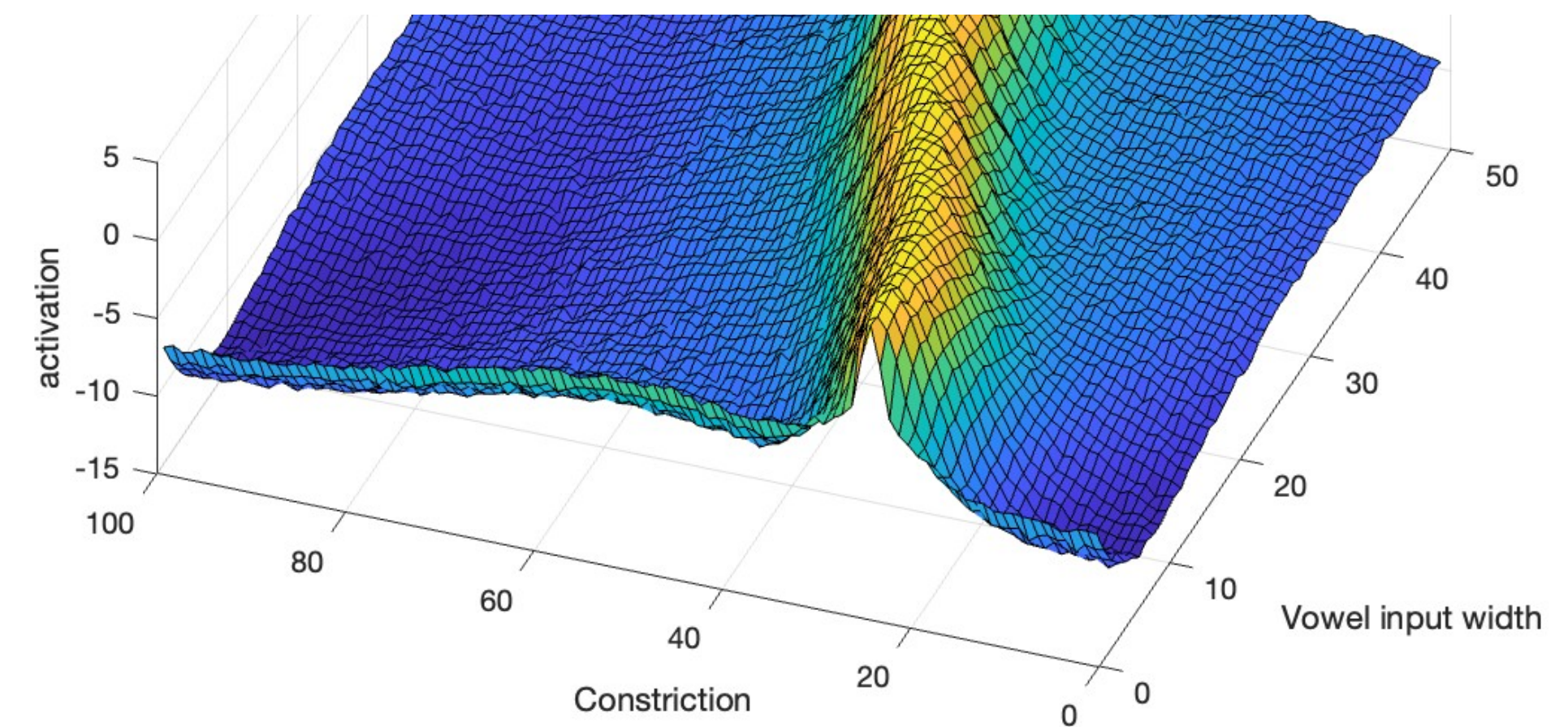
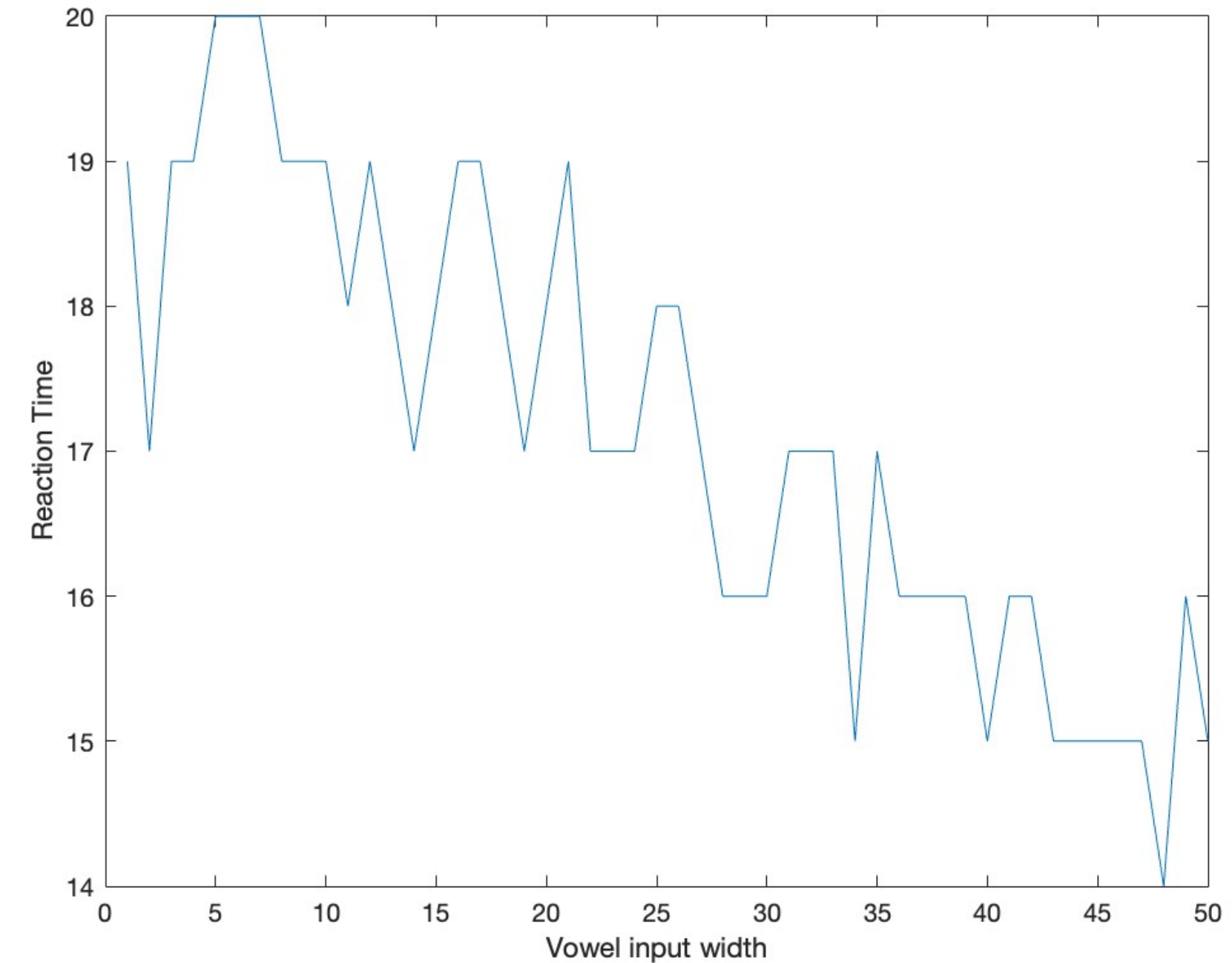
- Resting level 0 through 10 represents -15 to -5
- As the resting level increases, the time the field takes to cross threshold decreases, but the location where a stable peak remains the same across different resting levels



Results

Part 2. Varying w_T

- The field stabilizes at $p_T \approx 25$ for all $w_T < 15$, producing the target vowel.
- As the width of the target input increases, the location of the peak moves towards the center of the production field.
- For $w_T > 40$, the peak stabilizes near the center of the field at around 50.



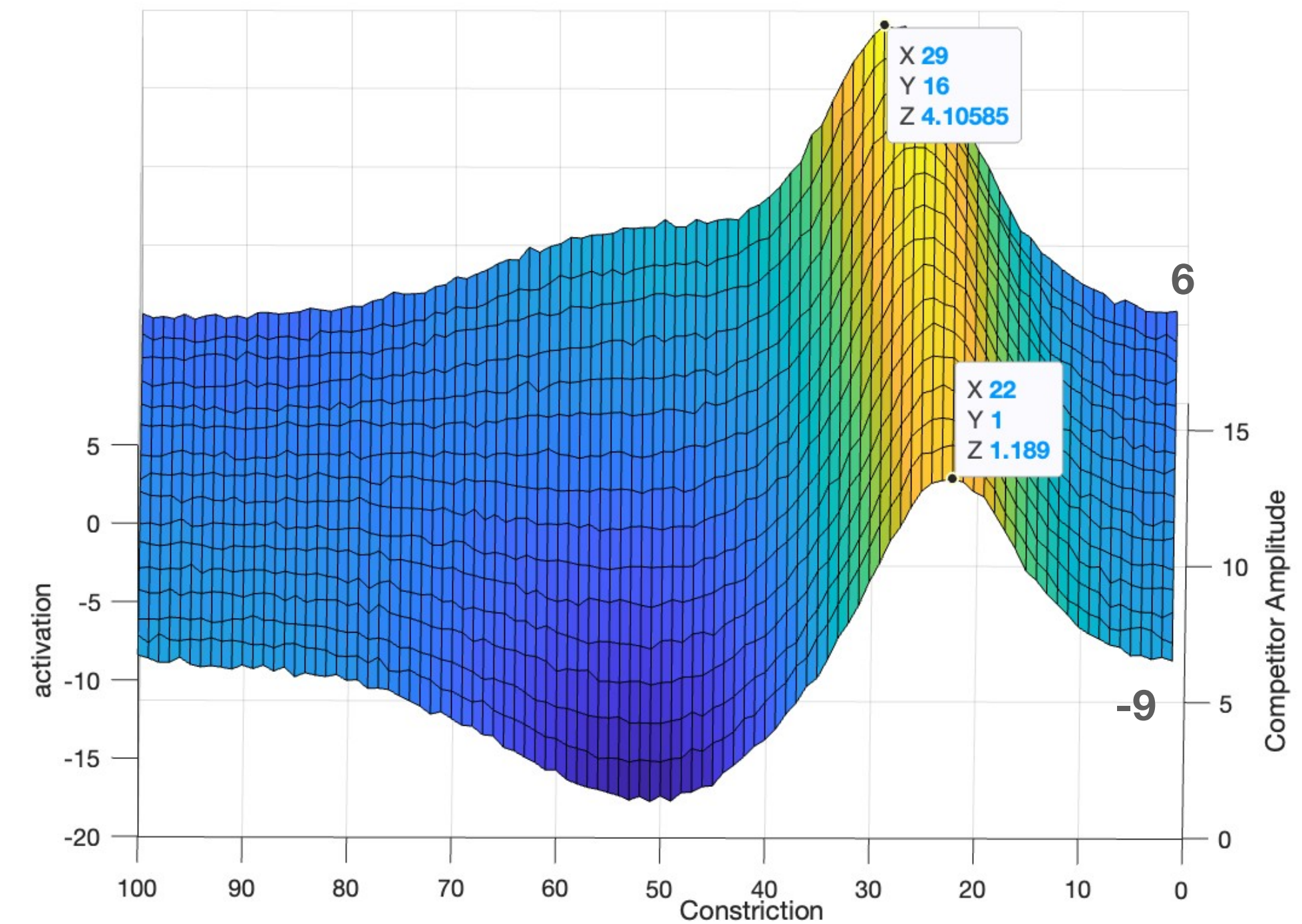
Interim Summary

- The simulation results so far is only consistent with half of the empirical data: with a higher w_T , the vowel gets increasingly hypo articulated but never hyper articulated
- Further question: what are the factors that might drive hyperarticulation in a DNF?

Results

Part 3. Varying a_N

- Amplitude of 10 on the figure represents $a_N = 0$
- Dispersion when $a_N < 0$, centralization when $a_N > 0$



Summary

Production Mode and PND

- What is the best way to model production mode in a DNF?
 - Intuitively, as in part 3, a_N
 - However, phonological neighbors should only be facilitative (Dell & Gordon 2003)
 - Proposal:
 - w_T is the best way to model production mode
 - hypoarticulation is the default effect of high PND if the production is not subject to external inhibitory inputs
 - However, an explicit inhibitory input that prevents vowel centralization can override the default effect, which results in hyperarticulation

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Not a theoretical dichotomy! Hypoarticulation is “default” but can be overridden

Future Directions

- Prediction: for a production mode that is in between word list reading and conversational speech, we will see a smaller override effect of inhibitory inputs
- Reaction time: the DNF in Part 2 predicts  RT for hypoarticulation, which could be tested in empirical work

Thank you!

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Code: [TODO]