Dynamic Field Theory for unifying discrete and continuous aspects of linguistic representations
(two-part organized session)

Part I (1:45-3:15)

- ***Dynamic Field Theory: An introduction,*** Michael C. Stern (1:50-2:15)

Case Studies

- ***Speech Errors in Vowels: trace effects,*** Manasvi Chaturvedi (2:15-2:35)
- ***Asymmetric Interference Effects in Code-Switching***, Alessandra Pintado-Urbanc (2:35-2:55)

Discussant: Khalil Iskarous (2:55-3:05)

General discussion (3:05-3:15)

Part II (3:30-5:00)

More case Studies

- ***A Dynamic Neural Field Model for Production Mode and Phonological Neighborhood Density Effects***, Xiaomeng (Miranda) Zhu (3:30-3:50)
- ***Deriving sibilant-vowel phonotactics from a soft bias in perception,*** Ayla Karakaş (3:50-4:10)
- ***Error-driven Learning in DFT: A case study of structural priming***, Zhenghao (Herbert) Zhou (4:10-4:30)

Discussant: Khalil Iskarous (4:30-4:40)

General discussion (4:40-5:00)

Thanks also to **Teresa Borneo**.

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. glue /glu/ vs. glee /gli/
- 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
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  - **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
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What causes this distinction?

Proposal by Gahl et al. (2012)

Differences in methodology -> *production mode*
word-list reading in Wright (2004) vs. conversational speech in Gahl et al. (2012)

- 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
- Prediction:

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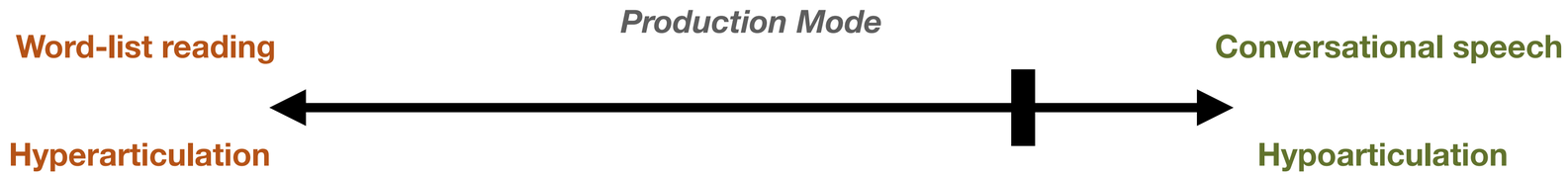
Research Question

Dynamic Field Theory

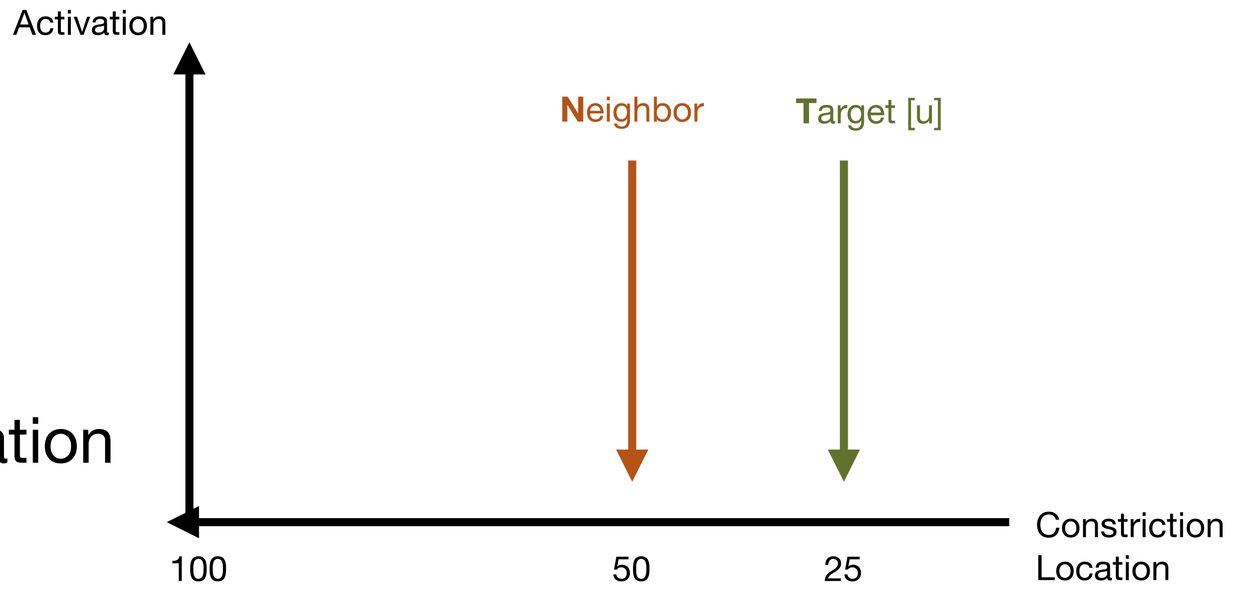


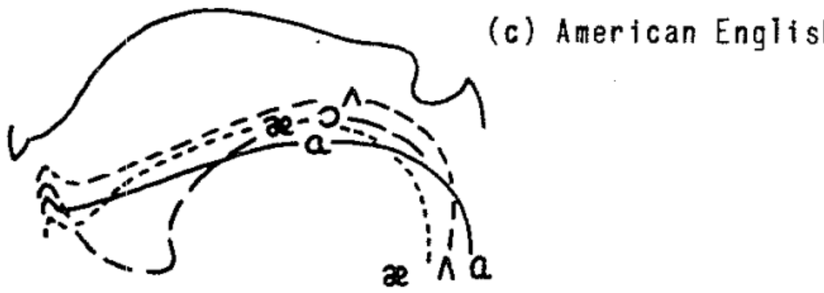
- Can we account for both sides within the same DFT model?
  - Resting level h of the production field
    - Lower h for word-list reading; higher h for conversational speech
  - Width w of the target input
    - smaller w for word-list reading; larger w for conversational speech

Model Setup

Dynamic Field Theory

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



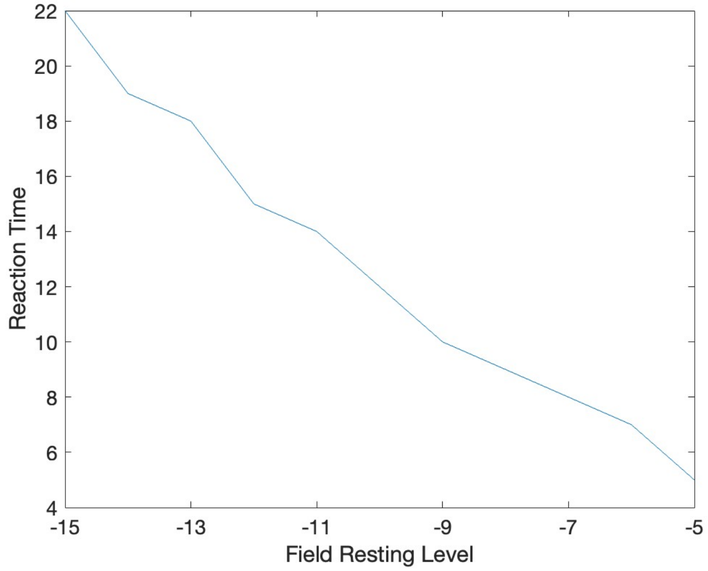


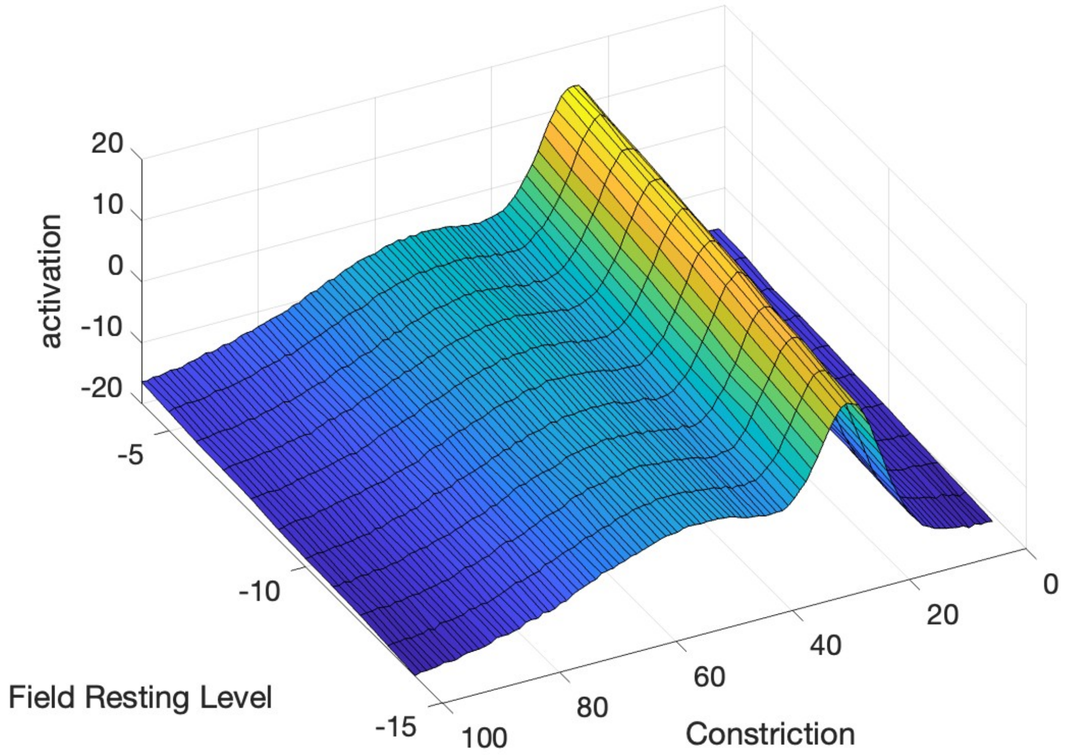
(Wood, 1975)

Results

Part 1. Varying h

- Resting level ranges from -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

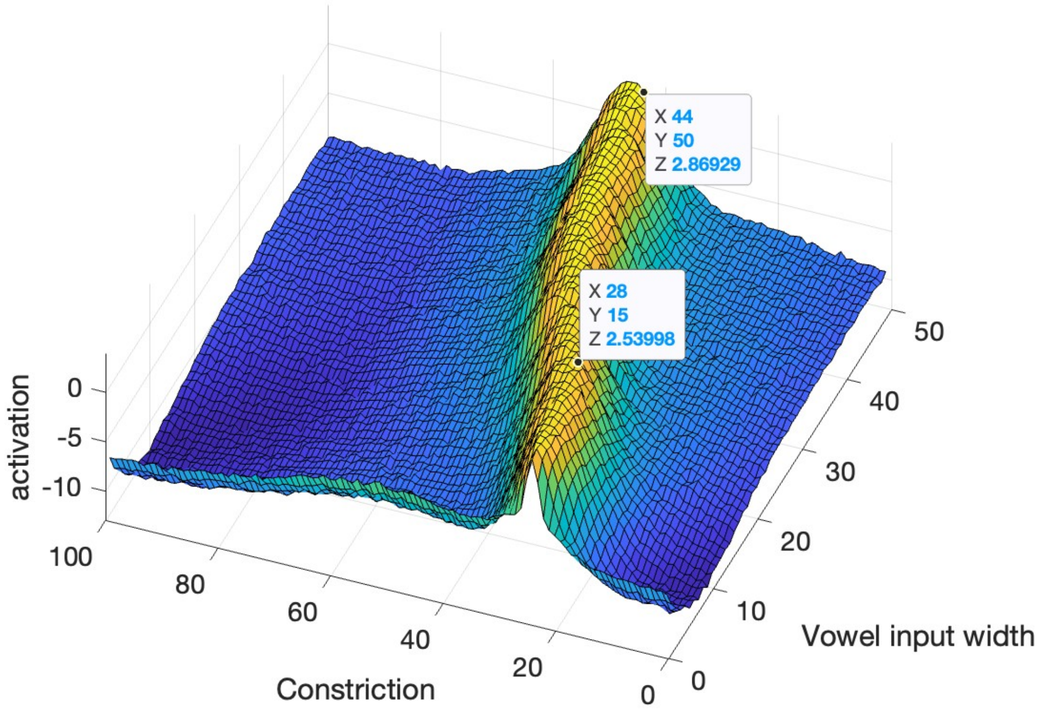


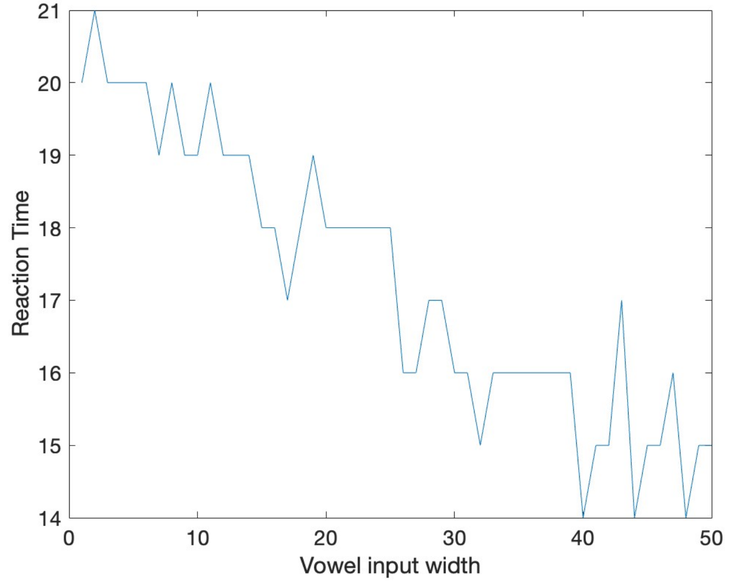


Results

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.





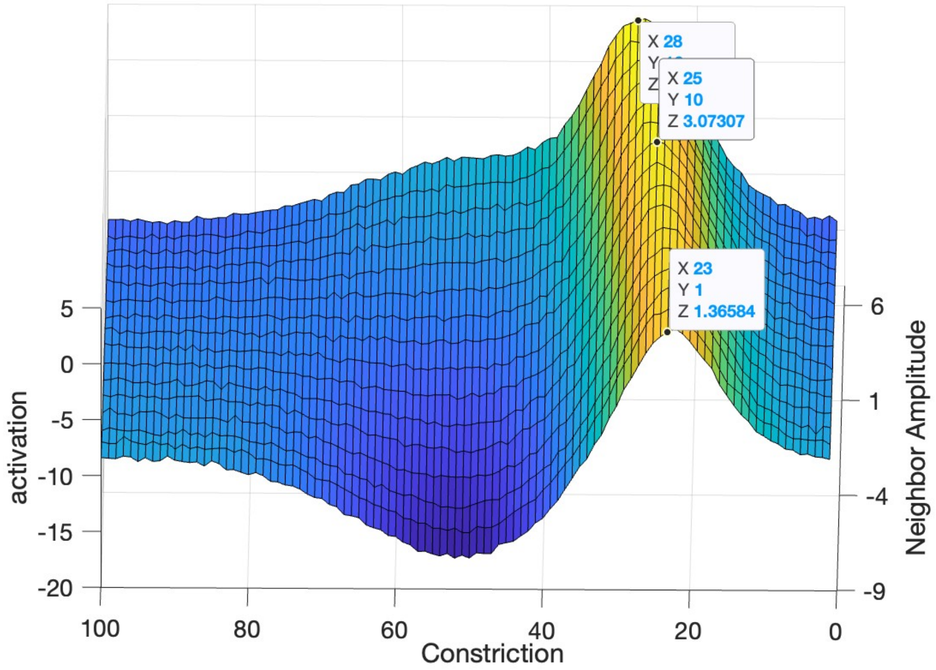
Interim Summary

- 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

- Neighbor amplitude ranges from -9 to 6
- 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

References

Dell, G. S., & Gordon, J. K. (2003). Neighbors in the lexicon: Friends or foes. *Phonetics and phonology in language comprehension and production: Differences and similarities*, 6, 9-37.

Gahl, S., Yao, Y., & Johnson, K. (2012). Why reduce? Phonological neighborhood density and phonetic reduction in spontaneous speech. *Journal of memory and language*, 66(4), 789-806.

Vitevitch, M. S., & Sommers, M. S. (2003). The facilitative influence of phonological similarity and neighborhood frequency in speech production in younger and older adults. *Memory & cognition*, *31*(4), 491-504.

Wright, R., Local, J., Ogden, R., & Temple, R. (2004). Factors of lexical competition in vowel articulation. *Papers in laboratory phonology VI*, 75-87.

Thank you!

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Slides and code: https://github.com/YaleDYNAMICS/LSA2025Dynamics/

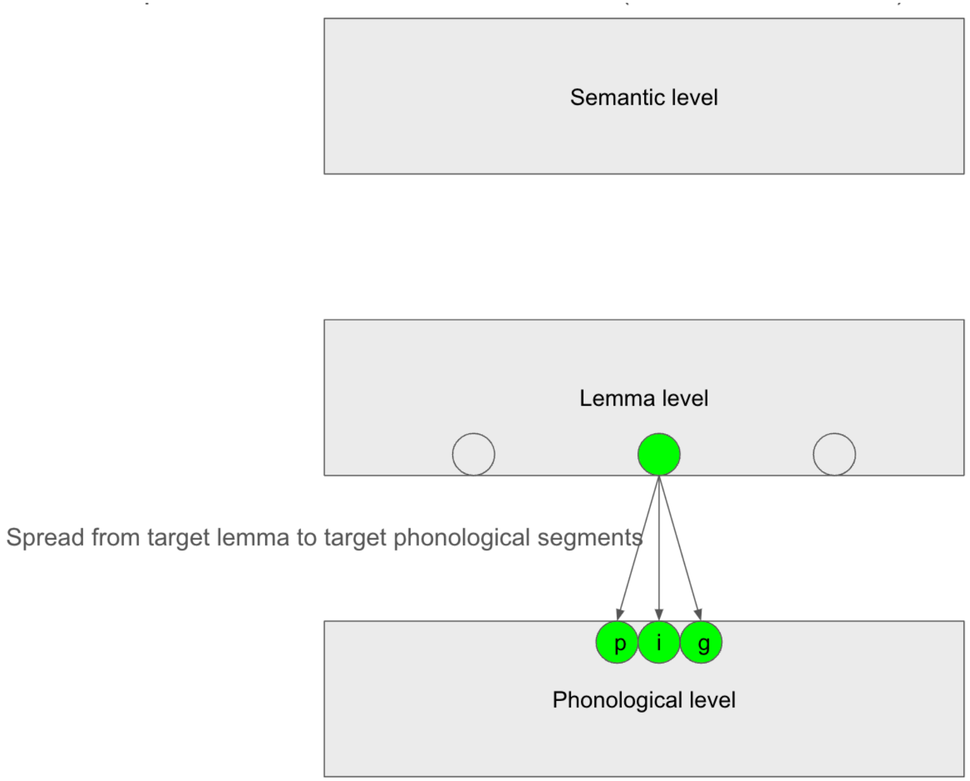
Appendix A: Terminologies

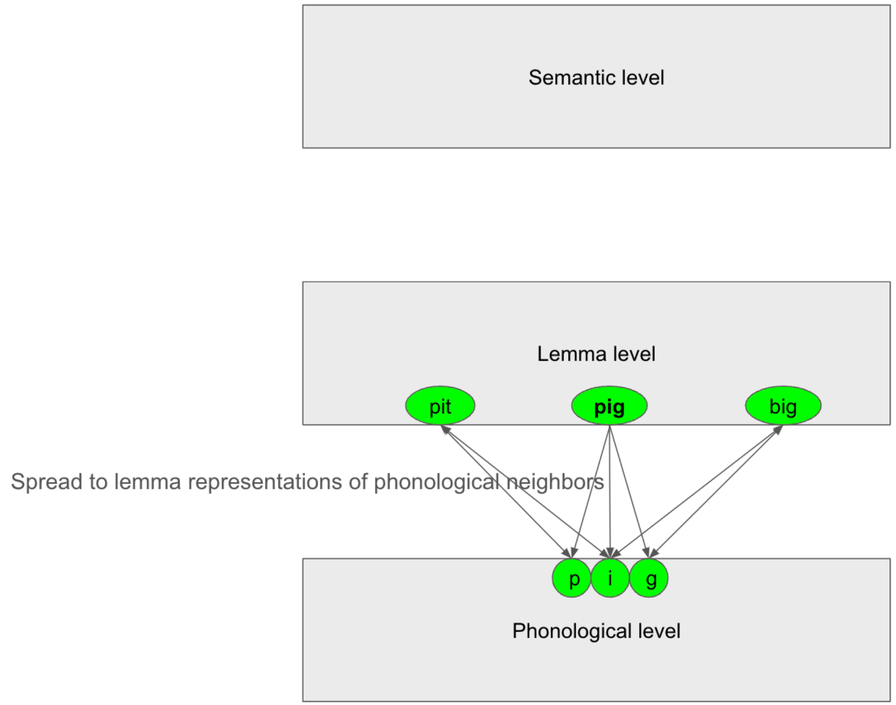
Vowels

- Dispersion
  - Away from the center of the vowel space
  - =exaggeration / **hyper**articulation
- Centralization
  - Towards the center of the vowel space
  - =reduction / **hypo**articulation

Appendix B: Dell & Gordon (2003)

Two-step interactive model of lexical access





Appendix B: Dell & Gordon (2003)

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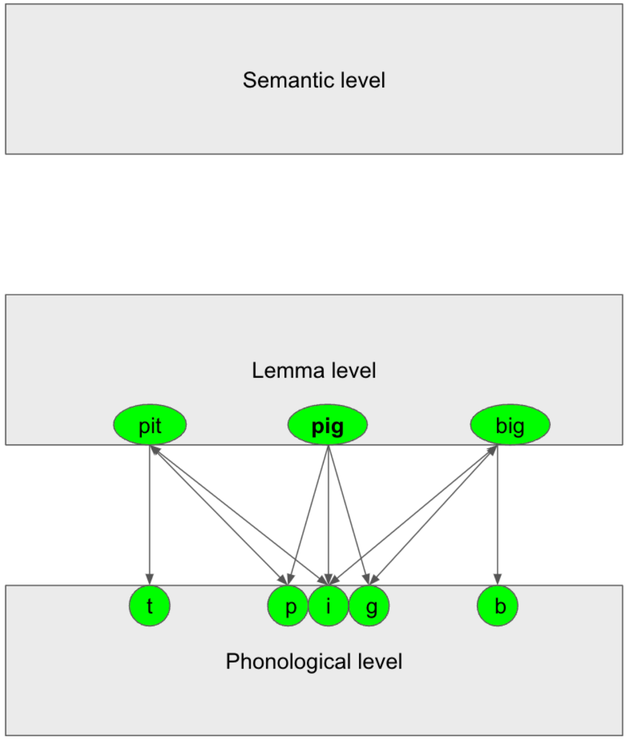
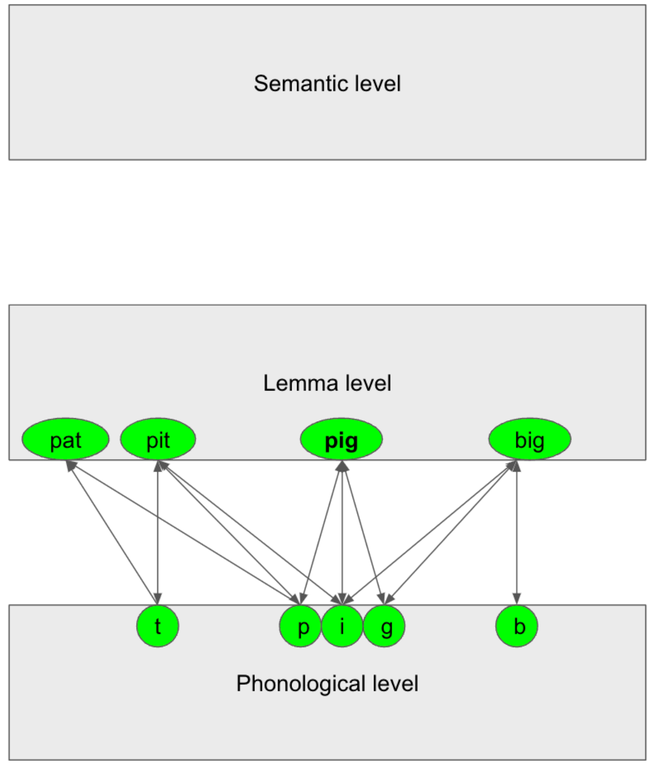


Spread from lemmas of phonological neighbors to phonological segments of phonological neighbors



Activated segments send activation back to lemmas linked to them