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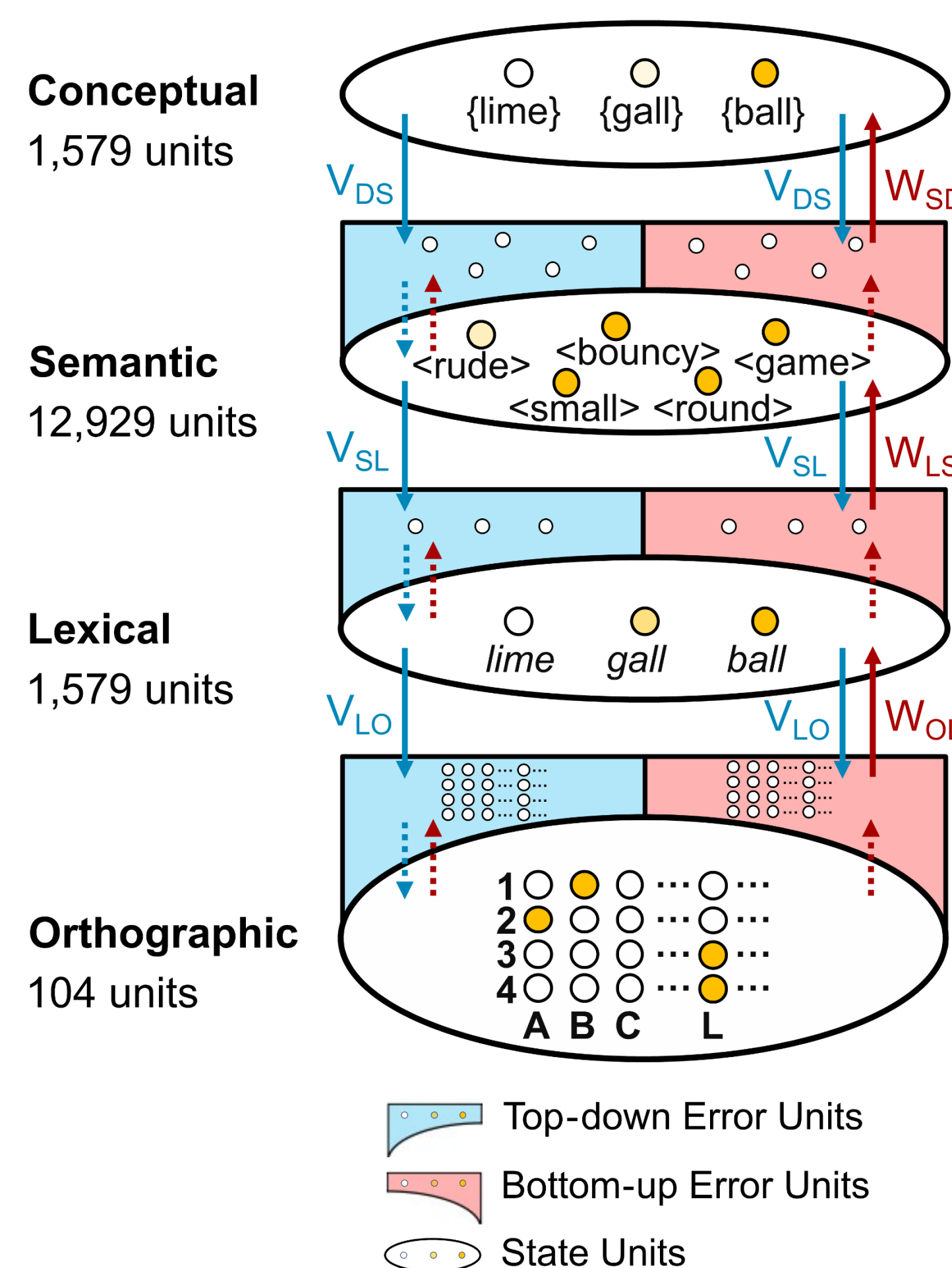
## Introduction

- A wealth of behavioral and neural experimental data shows that contextual information facilitates the mapping of form to meaning.
- When processing predicted words, both sentence contexts and single-word contexts lead to:
  - Faster behavioral responses (many studies!)
  - Reduced neural activity 300-500 ms (N400) [1]
- Challenges for explaining these effects in connectionist models:
  - Faster behavioral responses require *more* activity in the model
  - Reduced neural activity requires *less* activity in the model
- Predictive coding:
  - Overarching theoretical framework in neuroscience [2]
  - Naturally accounts for both behavioral and neural contextual effects with its dual-unit architecture [3]
  - Dynamics of algorithm serve to minimize prediction error (encoded within error units) via convergence on correct states (encoded in state units)

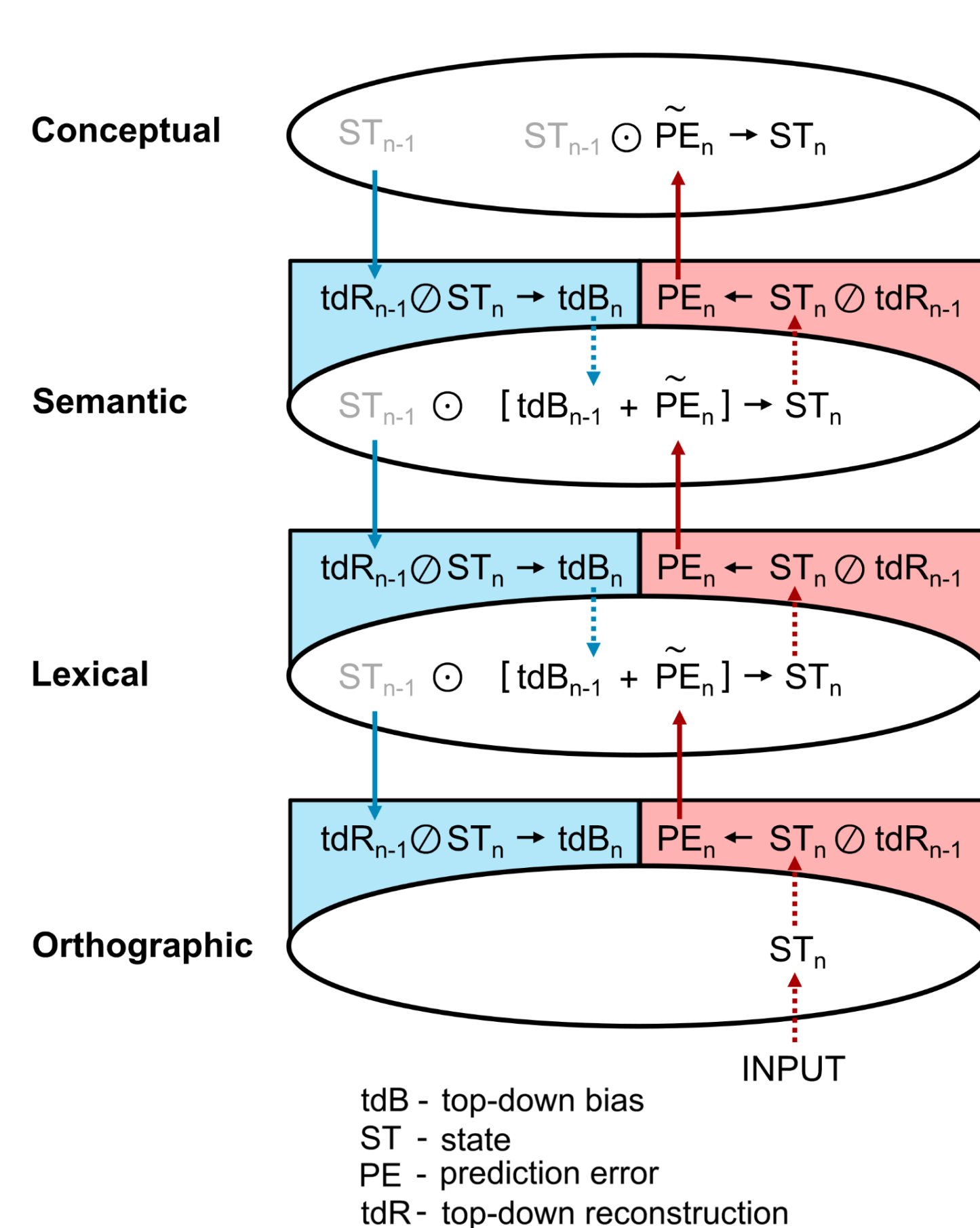
## Methods: Architecture & Algorithm

- Each level: two populations of units:
  - *State* units: encode the internal representations being inferred by the model
  - *Error* units: encode the difference in information encoded in state units at that level and predictions generated by the level above.
- Semantically related units (e.g. *sour*, *lime*) shared 8 semantic features; unrelated units (*ball*, *lime*) shared no semantic features
- At each iteration  $n$ , (1) state units updated; (2) prediction error computed; (3) top-down predictions generated

Predictive coding model architecture. [4,5]

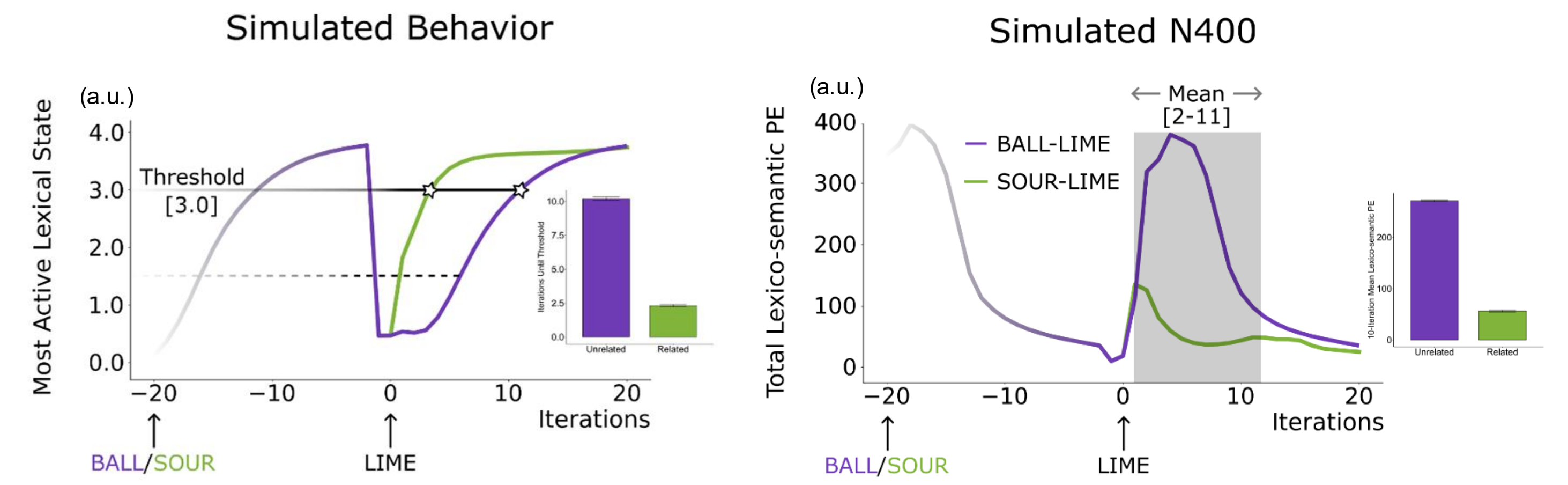


Predictive coding algorithm.

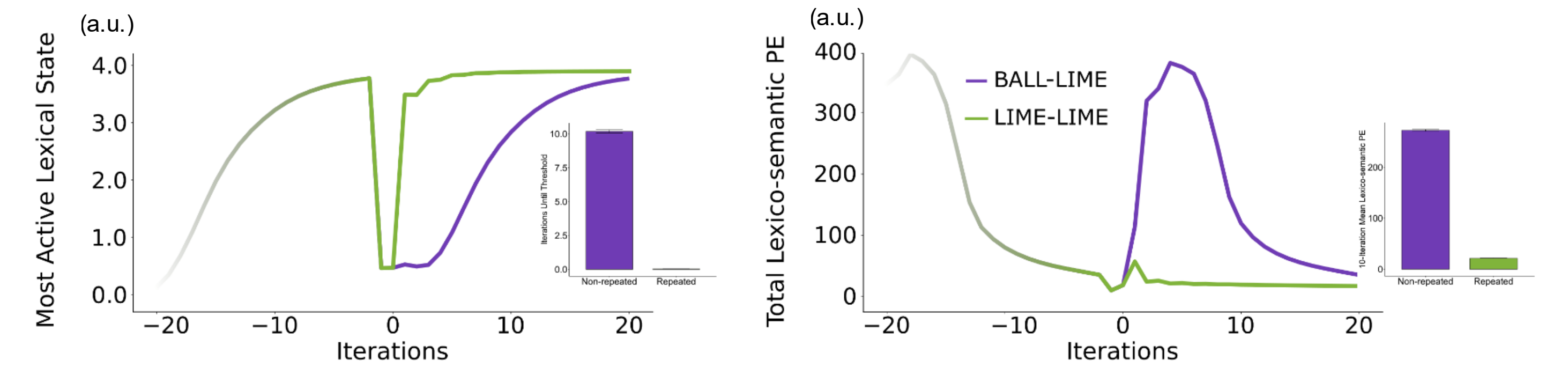


## Simulated Effects

Semantic priming (SOUR → LIME)

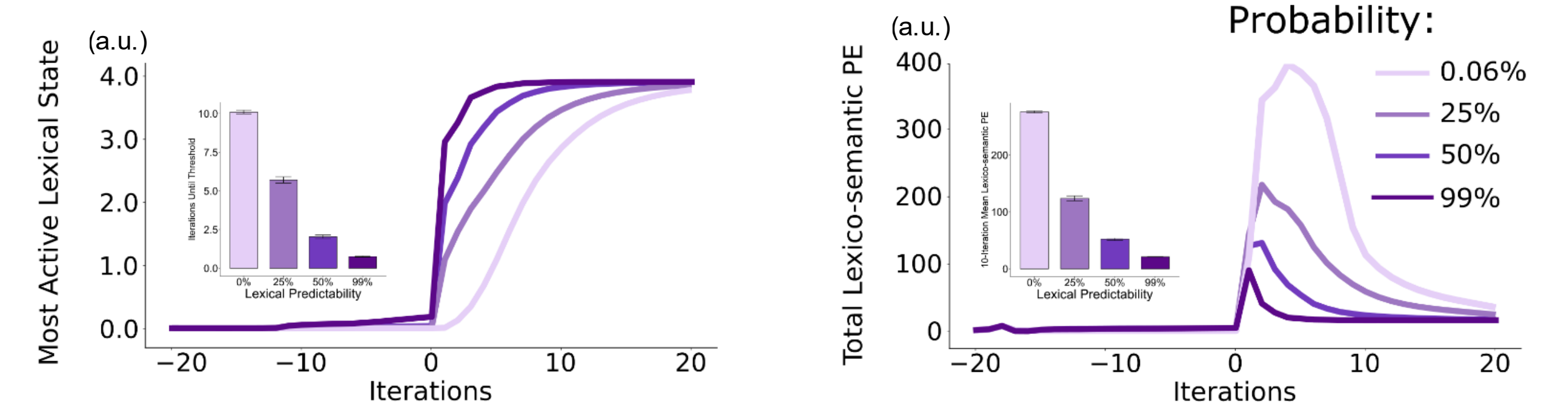


Repetition priming (LIME → LIME)



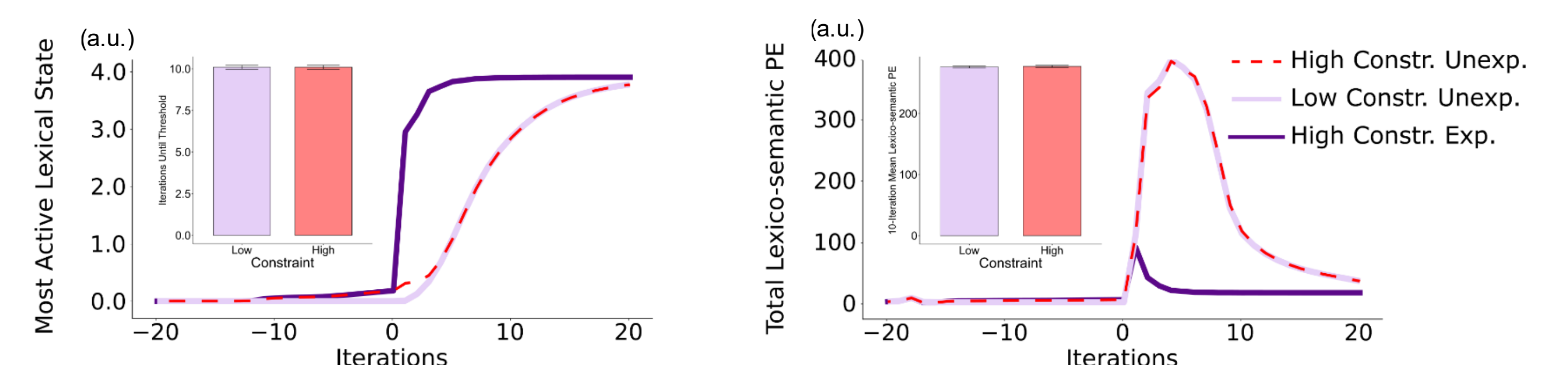
Contextual predictability effect.

99% probability: I like my coffee with cream and sugar;  
0.06% probability: I now realized we were out of sugar



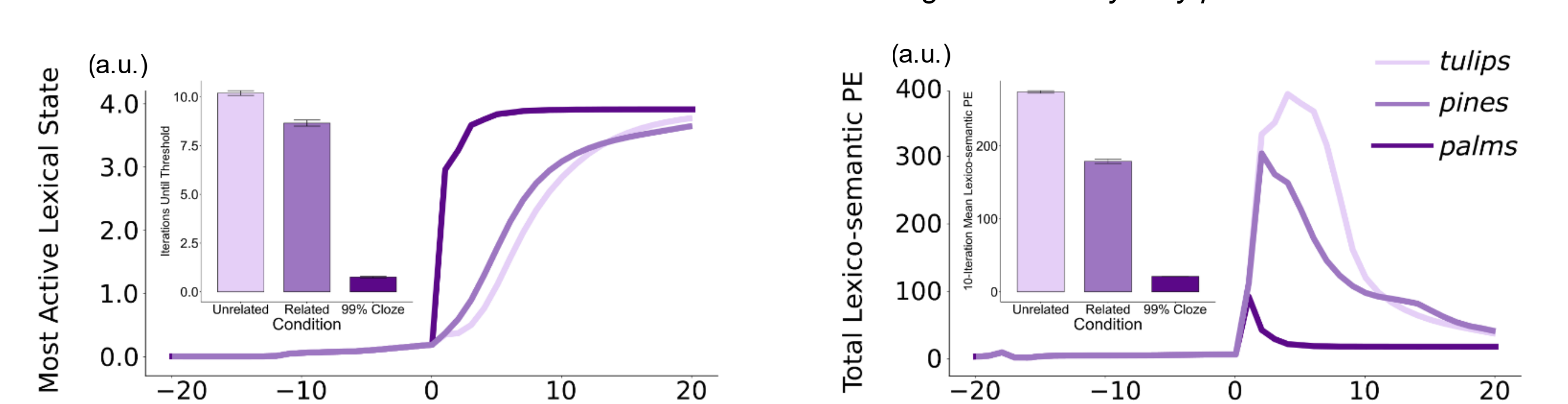
Null effect of contextual constraint for unexpected inputs.

High Constr. Exp.: I like my coffee with cream and sugar  
High Constr. Unexp.: I like my coffee with cream and ice  
Low Constr. Unexp.: Hiking was difficult because of the ice



Anticipatory semantic overlap effect.

They wanted to make the hotel look more like a tropical resort. So along the driveway they planted rows of...



## Discussion

- Predictive coding shows that when suitable contextual information is available, encoding units quickly accumulate enough activity to cross a decision threshold (leading to faster RTs) against a background of reduced total activity (leading to attenuation of N400).
- Unlike other models:
  - Prediction error plays an integral role in inference [4]
  - Cognitively plausible (faster decisions despite reduced total activity)
  - Neurally plausible (clear linking function between model activity and evoked N400 response)
- Future directions:
  - Model predicts that certain manipulations may dissociate the N400 amplitude from response times (e.g. form priming)

## Methods: Simulations

- Priming simulations:
  - Prime: Bottom-up input for 20 iterations
  - Blank input for 2 iterations
  - Target: Bottom-up input for 20 iterations
- Contextual simulations:
  - Top-down pre-activation of conceptual layer for 20 iterations
  - Target: Bottom-up input for 20 iterations

## REFERENCES

[1] Kutas M. & Federmeier K. (2011); [2] Friston (2005) [3] Rao, R. P., & Ballard, D. H. (1999); [4] Nour Eddine, S., Brothers, T., & Kuperberg, G. (2022); [5] Nour Eddine, S., Brothers, T., Wang, L., Spratling, M., & Kuperberg, G. (bioRxiv)

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## CONTACT

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