Symbolic vs. Gradient Phonemes

Chao Han[1], Ryan Rhodes[2], William Idsardi[3], Arild Hestvik[1]

[1]Department of Linguistics and Cognitive Science, University of Delaware; [2]Center for Cognitive Science, Rutgers University; [3]Department of Linguistics, University of Maryland
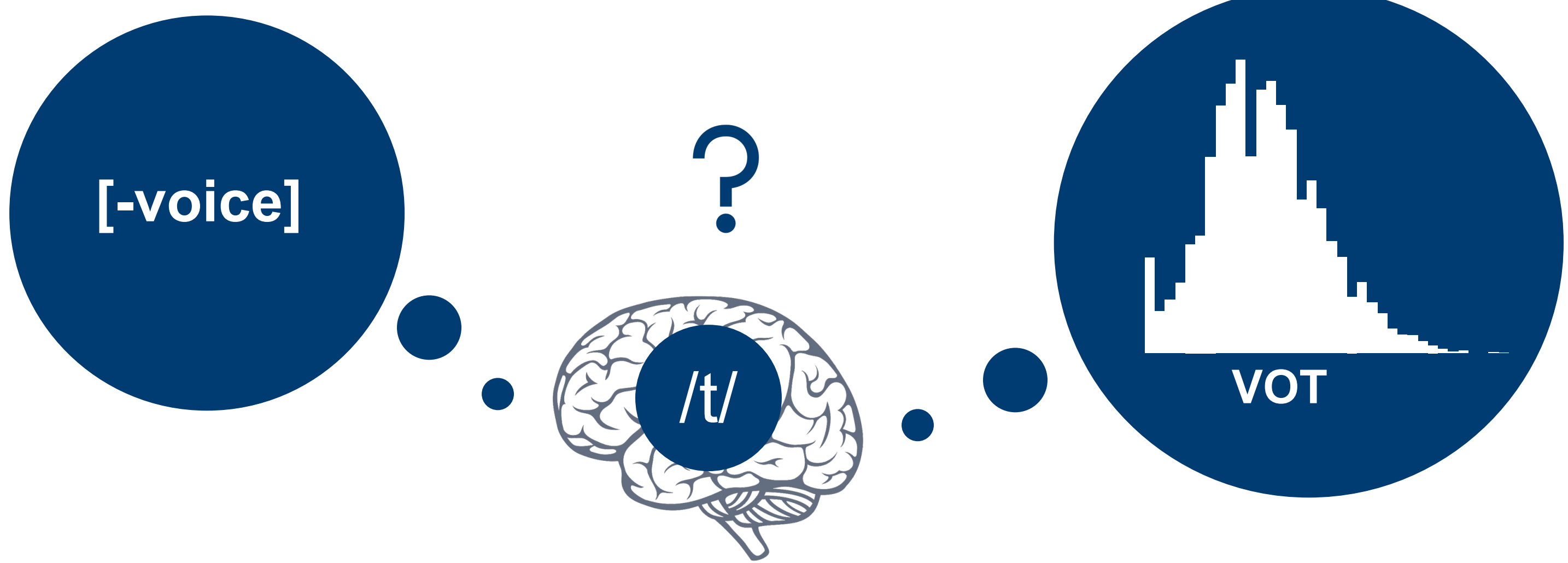
Summary

Question: Does a phoneme representation contain phonetic information?
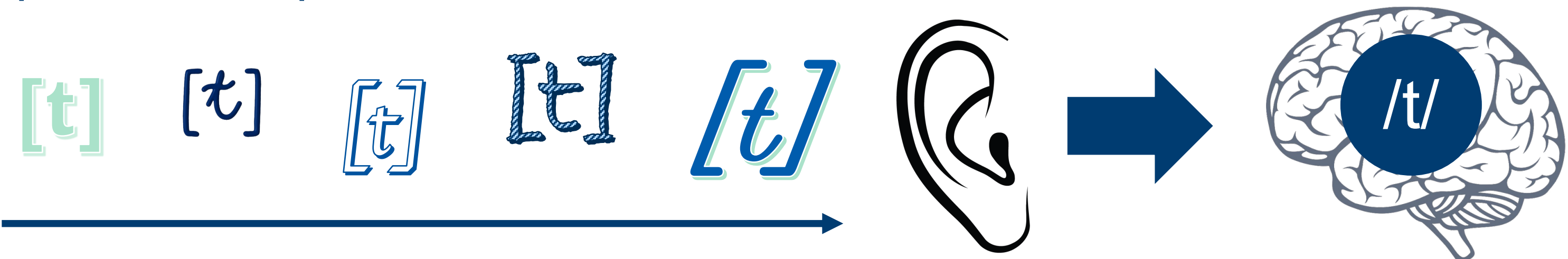### Main Finding: Yes.

Background: Competing views

Phoneme is symbolic.
(e.g., Substance-free Phonology [1])
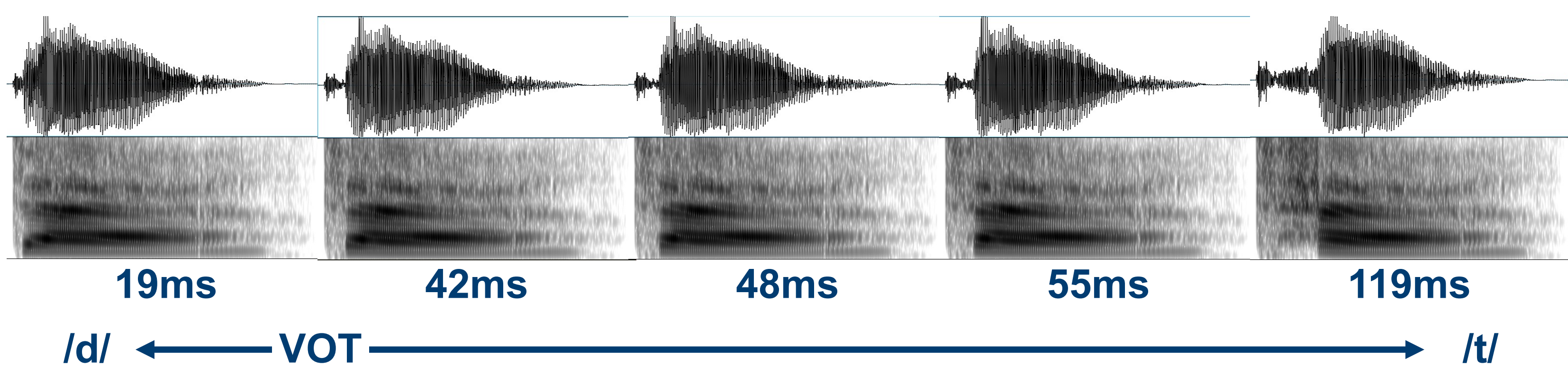
Phoneme is gradient.
(e.g., Stochastic phonology [2])

[-voice]   ?   /t/   VOT

How to test them?

- The "various-standard" assumption: Varying standards enforces a phoneme representation [3].

[t] [t] [t] [t] [t] → /t/

Stimuli: /d-t/ continuum [4]

| 19ms | 42ms | 48ms | 55ms | 119ms |

/d/ ← VOT → /t/

Experiment design and analysis strategy

Single-standard block	48	48	48	48	48	**119**	48
						MMN?	
Roving-standard block (control)	19	**119**	119	119	119	119	**19**
						MMN?	
Various-standard block	42	55	48	42	48	**119**	55

Single-standard Group (N = 30)

Various-standard Group (N = 32)

Amplitude = Group + Stimulus + Group×Stimulus

Single-standard Group — 119ms VOT as standard
Various-standard Group — 119ms VOT as deviants

Predictions

48 + 119 → MMN

Gradient phoneme: + 119 → MMN

Symbolic phoneme: [-voice] + 119 → no MMN
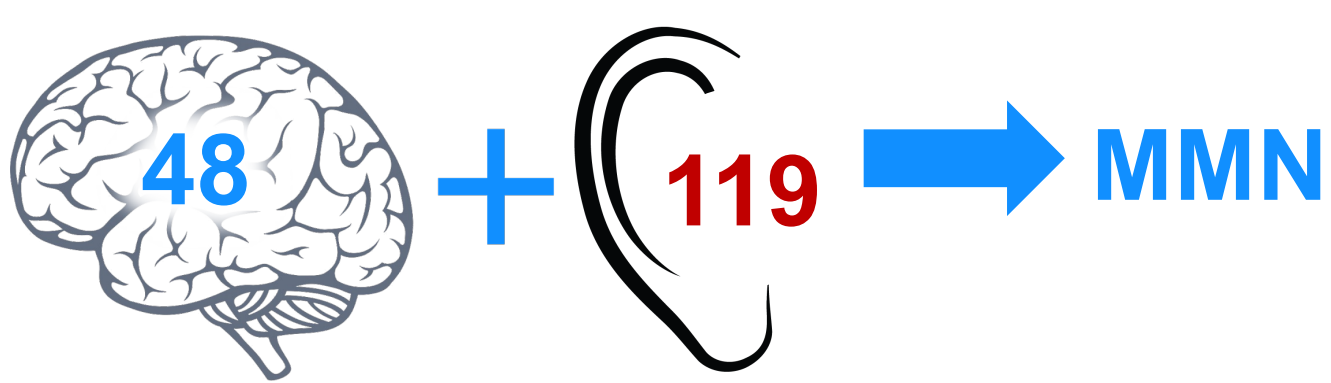
Results

- Measure MMN as ERP average over 176-248ms, and 7 frontocentral channels (delimited by PCA [5]).

Single-standard Group (N = 30)
119ms VOT as standards
119ms VOT as deviants
difference

Various-standard Group (N = 32)
119ms VOT as standards
119ms VOT as deviants
difference

176ms   216ms   248ms

Single-standard Group	Various-standard Group

119ms as standards
119ms as deviants
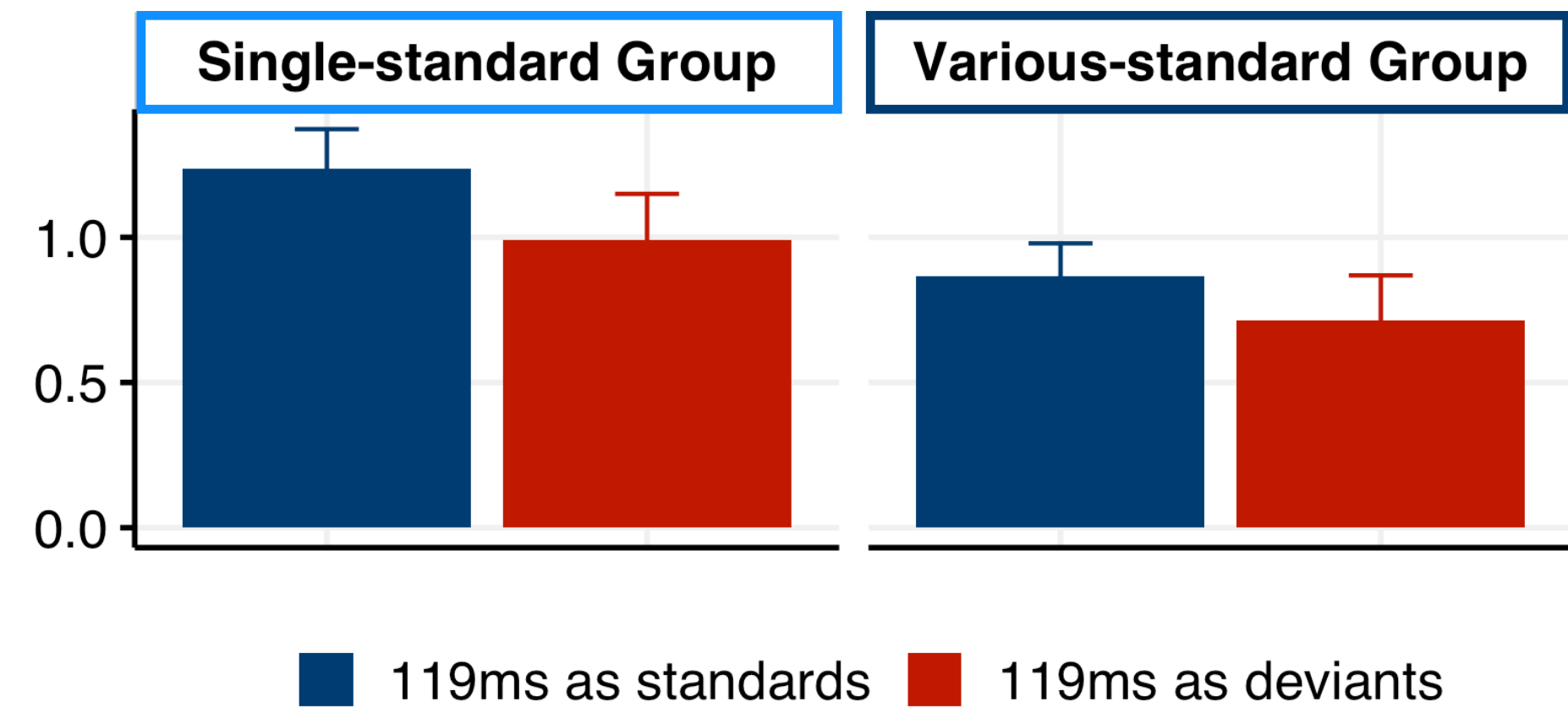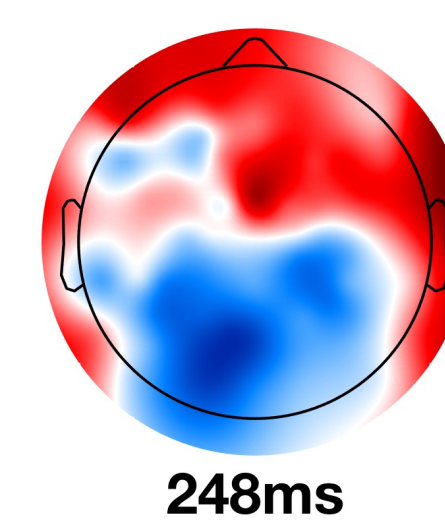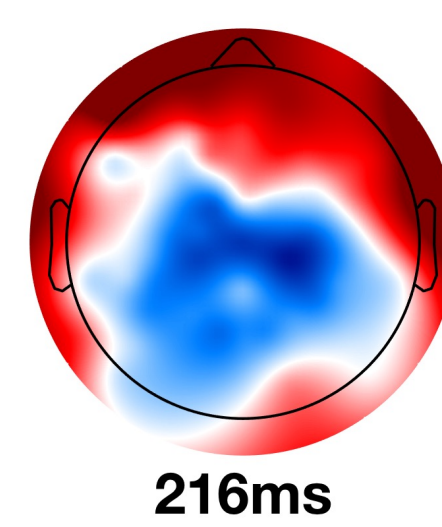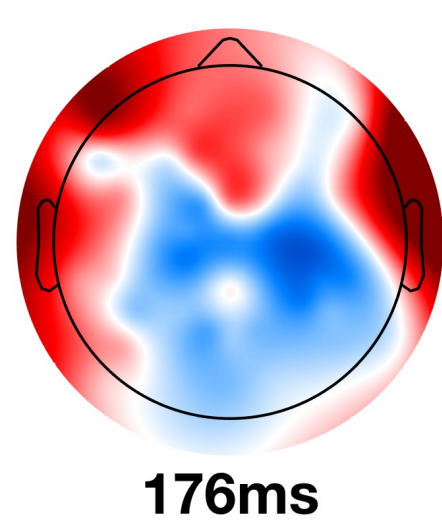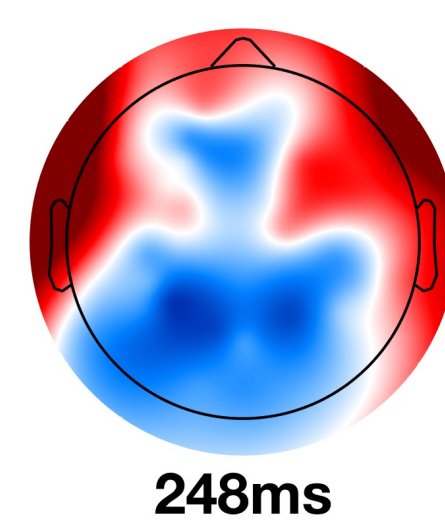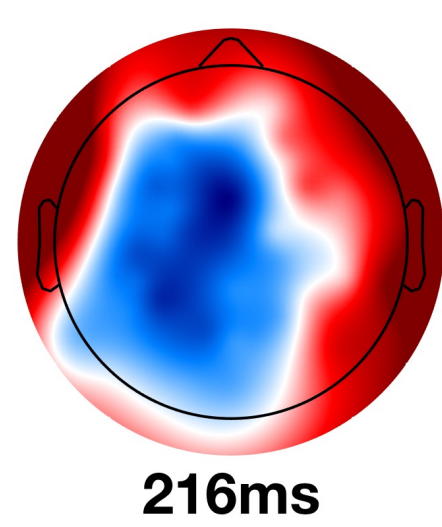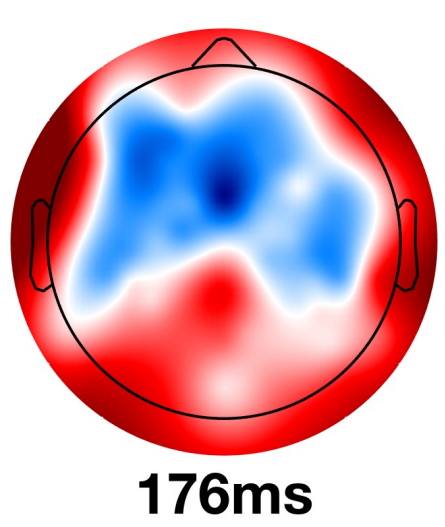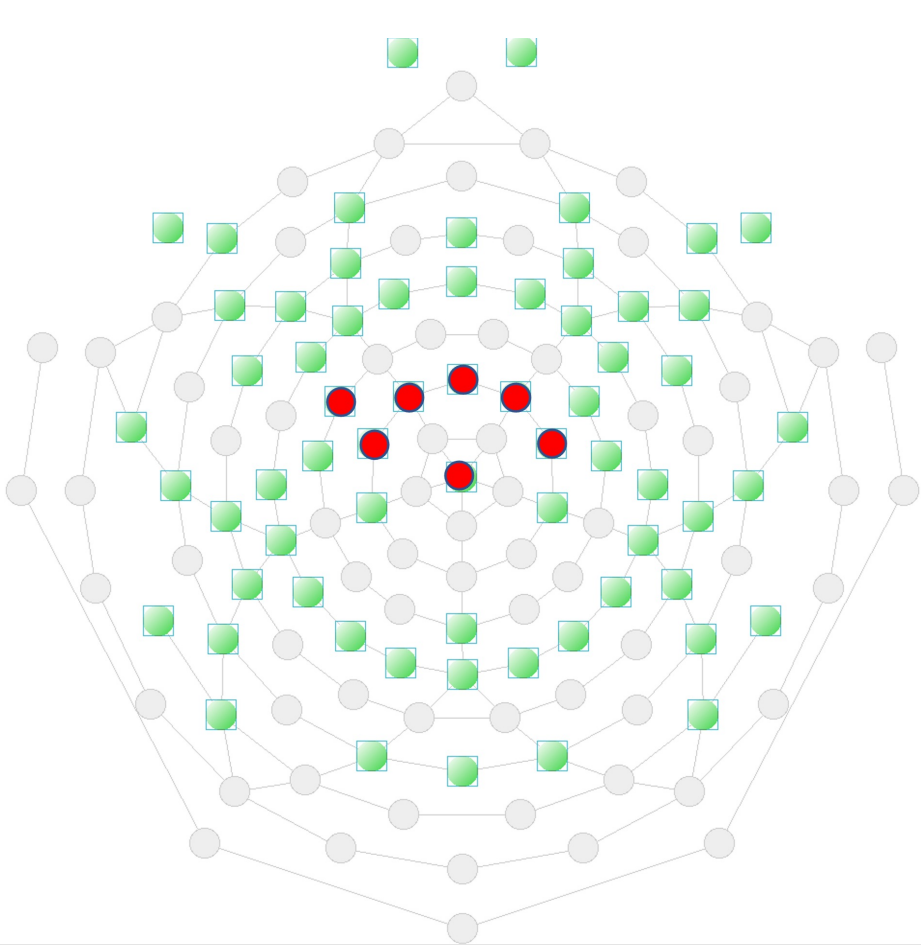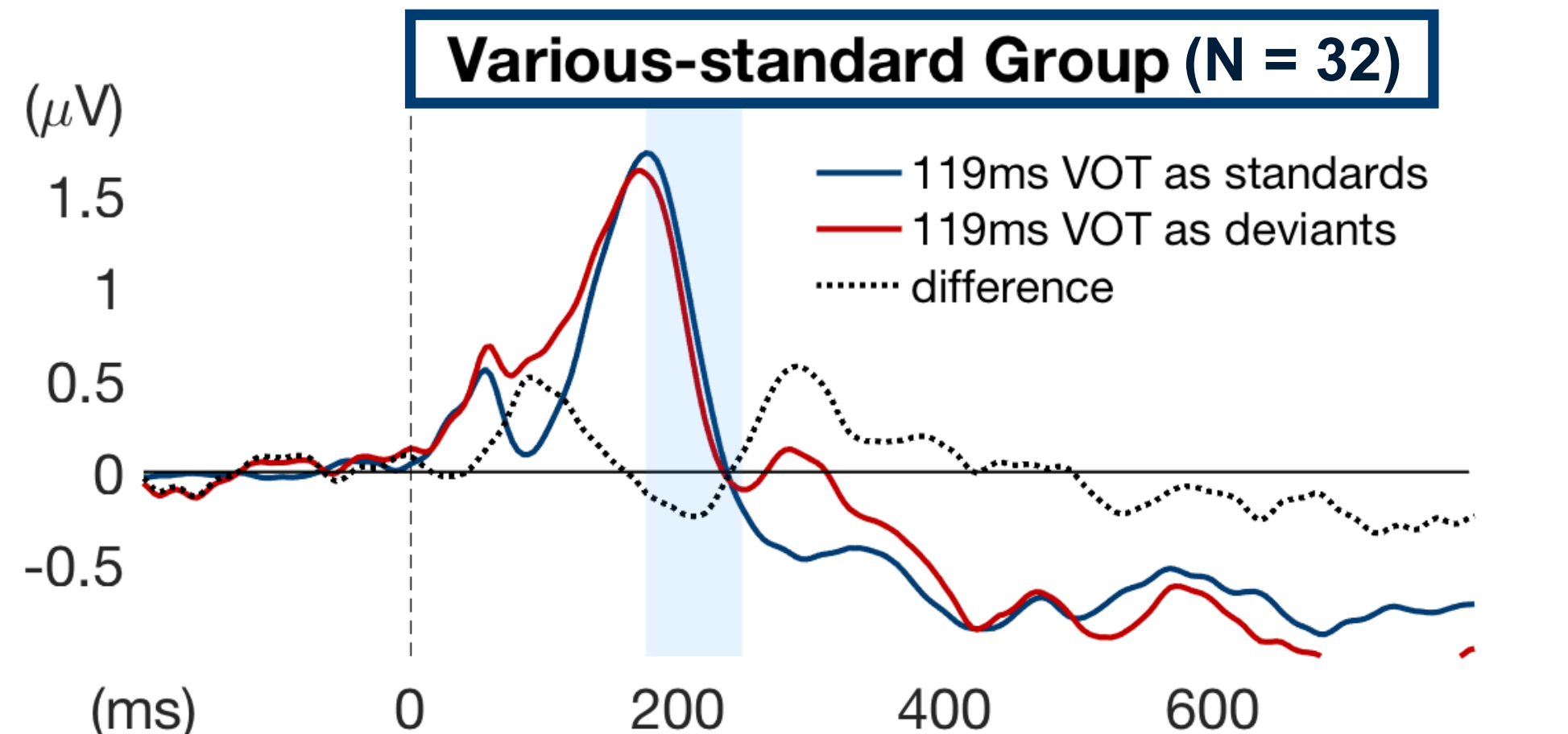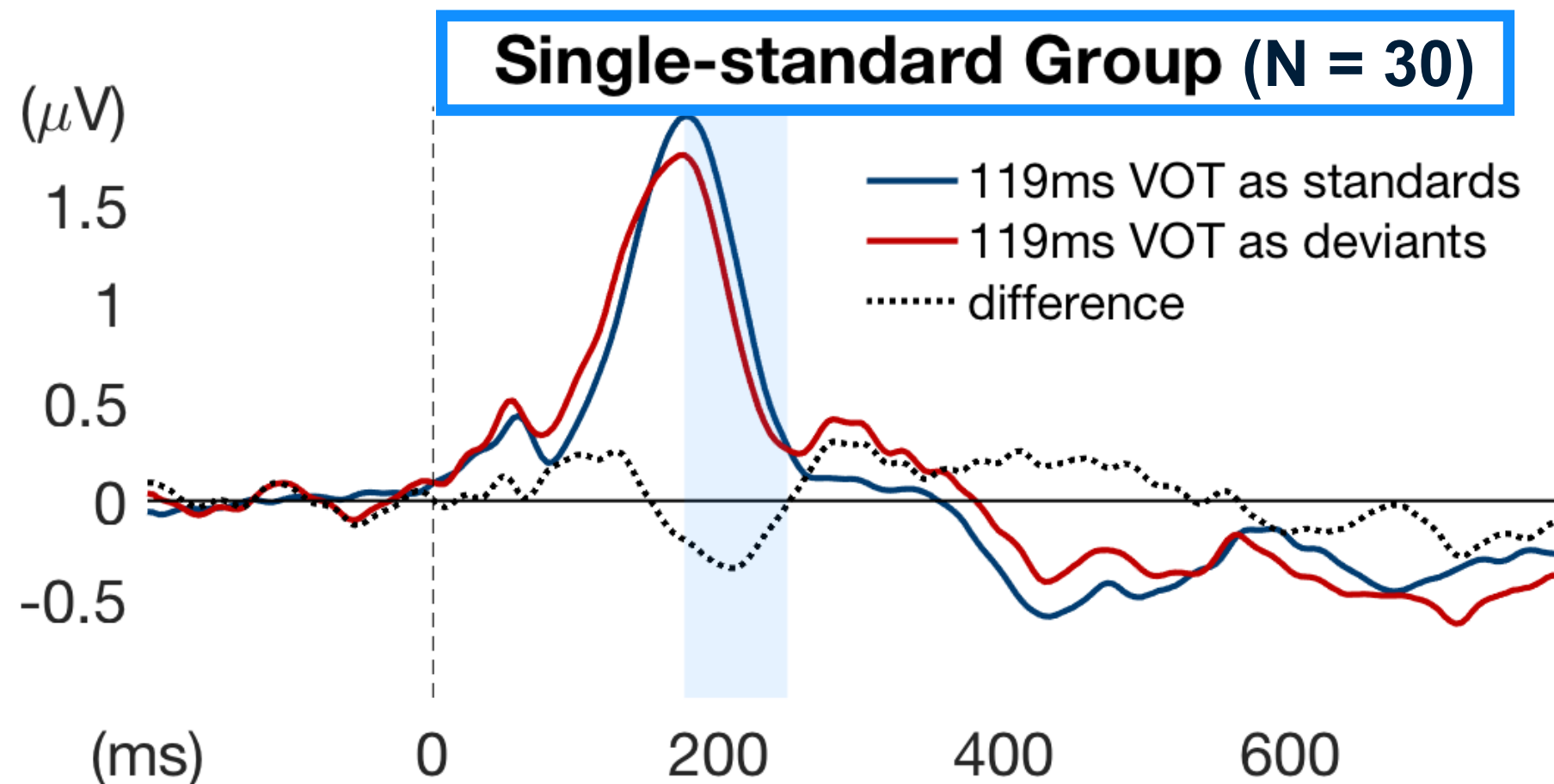
- **Interpretation:** MMN in both groups ⇒ sensitivity to phonetic details when a phoneme representation is enforced ⇒ The phoneme representation must contain phonetic information.
- **Alternative:** The various-standard MMN is due to detecting an outlier in the statistical summary of presented VOTs.
- **Follow-up:** Will there still be MMN if standards are atypical VOTs and deviants are typical VOT?

[1] Reiss, C. (2017). *The Routledge Handbook of Phonological Theory*. (S. J. Hannahs & A. R. K. Bosch, Eds.), *The Routledge Handbook of Phonological Theory*. Routledge.

[2] Pierrehumbert, J. (2001). Stochastic phonology. In *Glot international* (Vol. 36, pp. 195–207).

[3] Phillips, C., Pellathy, T., Marantz, A., Yellin, E., Wexler, K., Poeppel, D., … Roberts, T. (2000). Auditory cortex accesses phonological categories: an MEG mismatch study. *Journal of Cognitive Neuroscience*, 12(6), 1038–1055.

[4] Winn, M. B. (2020). Manipulation of voice onset time in speech stimuli: A tutorial and flexible Praat script. *The Journal of the Acoustical Society of America*, 147(2), 852–866.

[5] Dien, J. (2012). Applying principal components analysis to event-related potentials: A tutorial. *Developmental Neuropsychology*, 37(6), 497–517.