# THINK IT LOUD!

## How the Volume of Inner Speech Affects Neural Processing

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## Background and Methods

- Corollary discharges are neural signals used to predict the sensory consequences of overt speech, and can suppress the neural responses to speech sounds consistent with that prediction (1).
- Recent evidence suggests that inner speech – the silent production of words in one's mind – also produces corollary discharge, which can attenuate activity in the auditory cortex as measured by the N1 component of the event-related potential (ERP) (2).
- While corollary discharge for inner speech has been found to be associated with the content and timing of inner speech (3,4), it is unknown whether it contains information about auditory qualities, such as volume, of inner speech.
- **Our study examined whether the volume of inner speech was associated with corollary discharge mechanisms.**

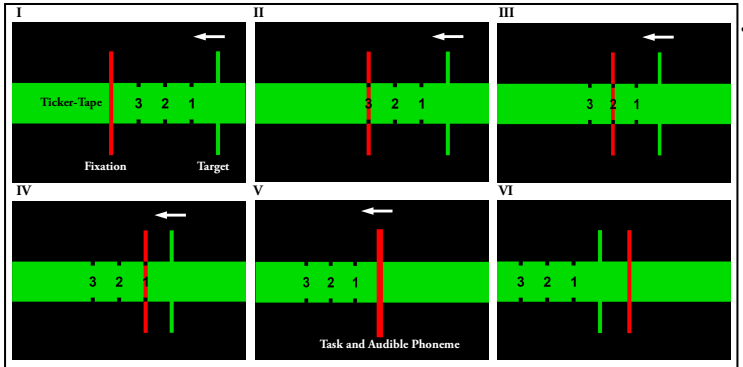


*Figure 1:* Experimental stimuli. The production of inner speech and the audible phoneme occurred as the red and green vertical lines overlapped.

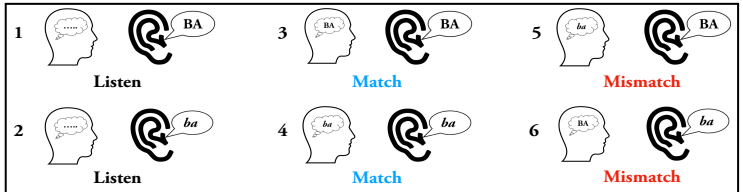


*Figure 2:* Experimental conditions. **BA** denotes loud phonemes, and *ba* soft phonemes

- EEG data was collected on participants (*N*=60) who viewed a ticker-tape style cue (*Figure 1*), and were asked to either passively listen or actively produce loud or soft inner speech at the precise moment a loud or soft audible phoneme was simultaneously delivered. Conditions therefore were defined as Listen, Match, or Mismatch (*Figure 2*).

## Results and Discussion

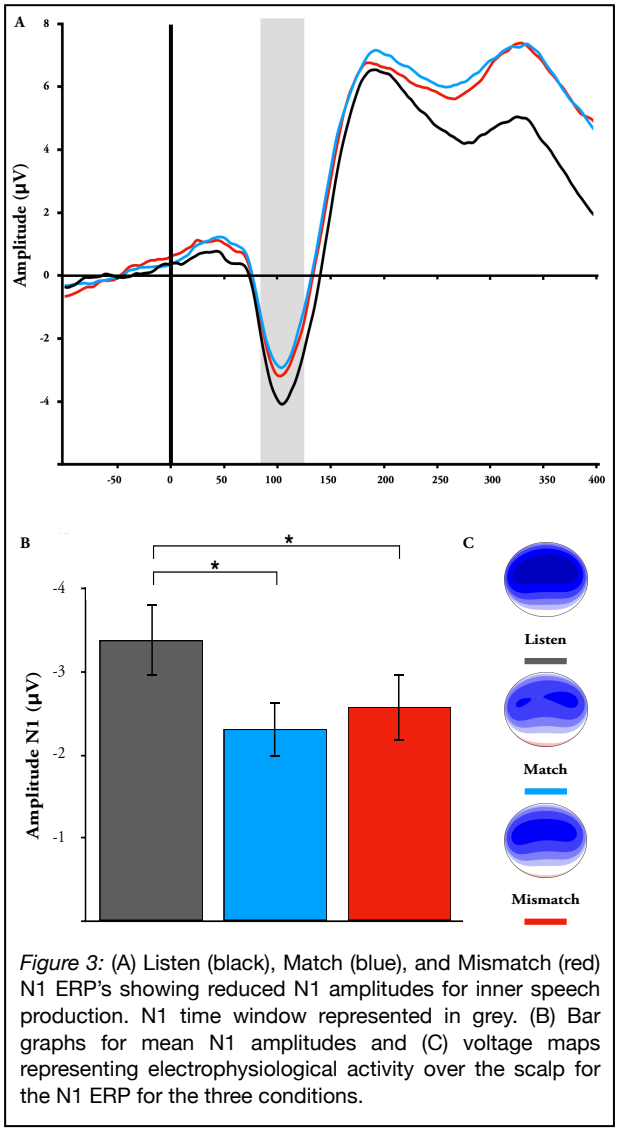


*Figure 3:* (A) Listen (black), Match (blue), and Mismatch (red) N1 ERP's showing reduced N1 amplitudes for inner speech production. N1 time window represented in grey. (B) Bar graphs for mean N1 amplitudes and (C) voltage maps representing electrophysiological activity over the scalp for the N1 ERP for the three conditions.

- While the mere production of inner speech attenuated the N1 (*Figure 3*), *there were no differences in N1 amplitudes between inner phonemes that either matched or mismatched the audible phoneme on volume*.
- **These results indicate that corollary discharge signals of inner speech do not convey information on its volume.**
- Importantly, these findings provide a greater understanding of the neurobiology of thought by suggesting there is a functional dissimilarity between how the brain processes volume for inner and overt speech.
- This study may assist in understanding the misattributed sense of agency in auditory-verbal hallucinations from schizophrenia.

## References

(1) Crapse, T. B., & Sommer, M. A. (2008). *Nature Reviews Neuroscience, 9*(8), 587-600. (2) Whitford, T. J. (2019). *Biological Psychiatry: Cognitive Neuroscience and Neuroimaging, 4*(9), 791–804. (3) Whitford, T. J. et al., (2017). *eLife, 6*, 1-23. (4) Jack, B. N. et al., (2019). *NeuroImage, 198*, 170–180.