

Asymmetries in the Mismatch Negativity: not just phonology

Stephen Politzer-Ahles¹

¹University of Kansas

Background: The Mismatch Negativity. The brain rapidly sorts incoming stimuli into categories. Evidence for this comes from the Mismatch Negativity (MMN), a brain response that occurs when a stimulus falls into a different category than most of the other stimuli that have recently been perceived (e.g., Näätänen et al., 2007). For example, if a person hears a sequence in which 85% of the sounds are voiced, then voiceless sounds occasionally interspersed in this sequence elicit an MMN.

The MMN is sensitive to how categories are represented in memory. When the frequently-presented stimuli in a sequence (the *standards*) are phonologically underspecified in some feature, the infrequently-presented stimuli (the *deviants*) elicit a smaller MMN, compared to when the standards are fully specified (e.g., Eulitz & Lahiri, 2004). For instance, *da da da da* (with the standard /d/ underspecified for place of articulation) yields a smaller MMN than *ba ba da da* – not because of intrinsic differences between *ba* and *da* (which are accounted for in the calculation of the MMN), but because of differences in the direction of the contrast. These findings, referred to as *MMN asymmetries*, show that the MMN does not merely reflect the detection of changes; it reflects how incoming stimuli are encoded into memory representations.

Furthermore, the MMN is not only elicited by physical contrasts like *ba-da*. Abstract linguistic contrasts without a reliable physical correlate also elicit MMN. Monahan and colleagues (2022) found an MMN for a phonological voicing contrast, where the "voiced" sounds included both truly voiced fricatives and voiceless unaspirated stops. Politzer-Ahles & Jap (2024) replicated this, and found an MMN for a contrast between English irregular past-tense and present-tense verbs, with no systematic physical difference between them.

Does the MMN show similar sorts of asymmetries for these sorts of highly abstract contrasts as it does for the simpler acoustic contrasts which have been the focus of most MMN research? There is currently only a small amount of evidence. Monahan and colleagues (2022) did find such an asymmetry (voiced deviants amidst voiceless standards yielded a larger MMN than voiceless deviants amidst voiced standards). Jap & Politzer-Ahles (2025) found a trend towards an asymmetrical MMN in a word-pseudoword contrast, but it was not statistically significant.

In the present study, I re-analyze data from Politzer-Ahles & Jap (2024) to test for asymmetries in both the phonological contrast, and the past-present contrast. Evidence from morphosyntax and processing suggests that past-tense may be marked and present-tense not; in which case the MMN should also be asymmetrical for this contrast, with a larger MMN when the standards are past and the deviants are present.

Results. The dataset includes data from 60 English-speaking participants, processed using the same parameters as Politzer-Ahles & Jap (2024) used. Asymmetries were tested using cluster-based permutation statistics (Maris & Oostenveld, 2007). As shown in Figure 1, all contrasts yielded asymmetrical MMNs. A basic acoustic contrast yielded a strong asymmetry (the contrast between unaspirated deviants and aspirated standards yielded a larger [more negative] MMN than that between aspirated deviants and unaspirated standards; $p=.001$), but this could be driven just by the processing of basic acoustics. The more phonological voicing contrast was also asymmetrical ($p=.003$), replicating Monahan et al. (2021). Finally, the tense contrast was asymmetrical ($p=.037$): the contrast between present-tense deviants and past-tense standards elicited a larger [more negative] MMN than that between past-tense deviants and present-tense standards.

These findings extend our understanding of how the MMN interacts with underspecification in memory representations. Specifically, it is not only *phonological* underspecification that affects the generators of the MMN; the MMN is sensitive to other types of underspecification as well.

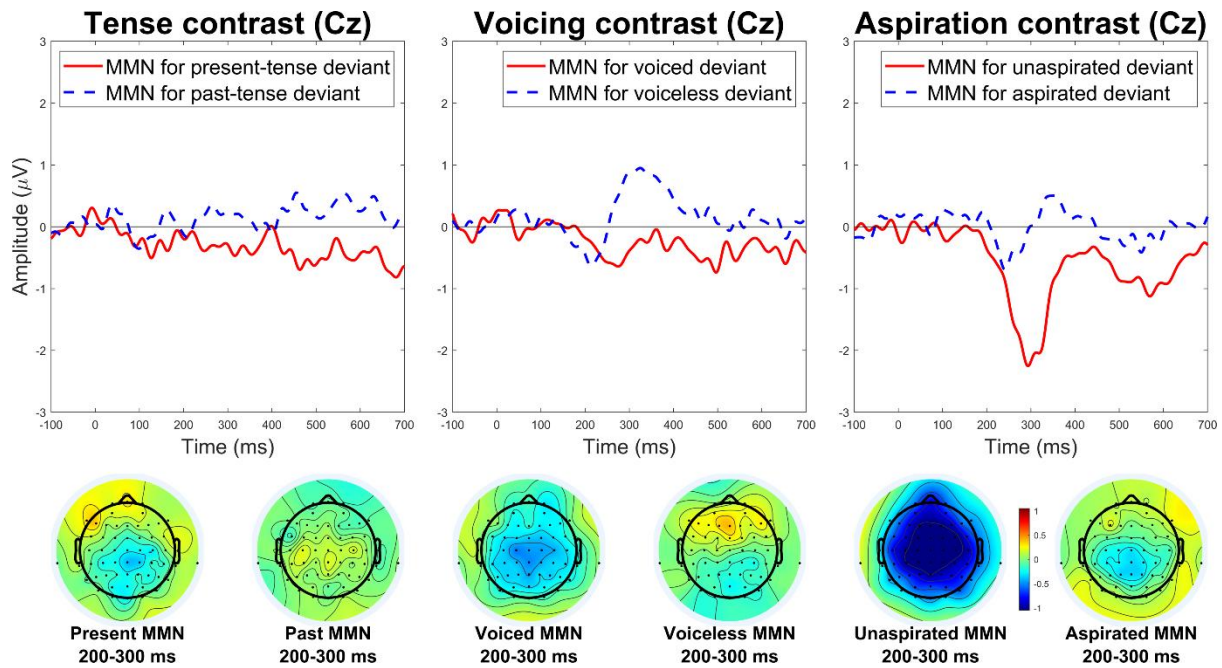


Figure 1. ERP waveforms and topographic plots for identity MMNs (stimulus as deviant minus same stimulus as standard). Red solid lines indicate the conditions predicted to yield larger (more negative) MMN.

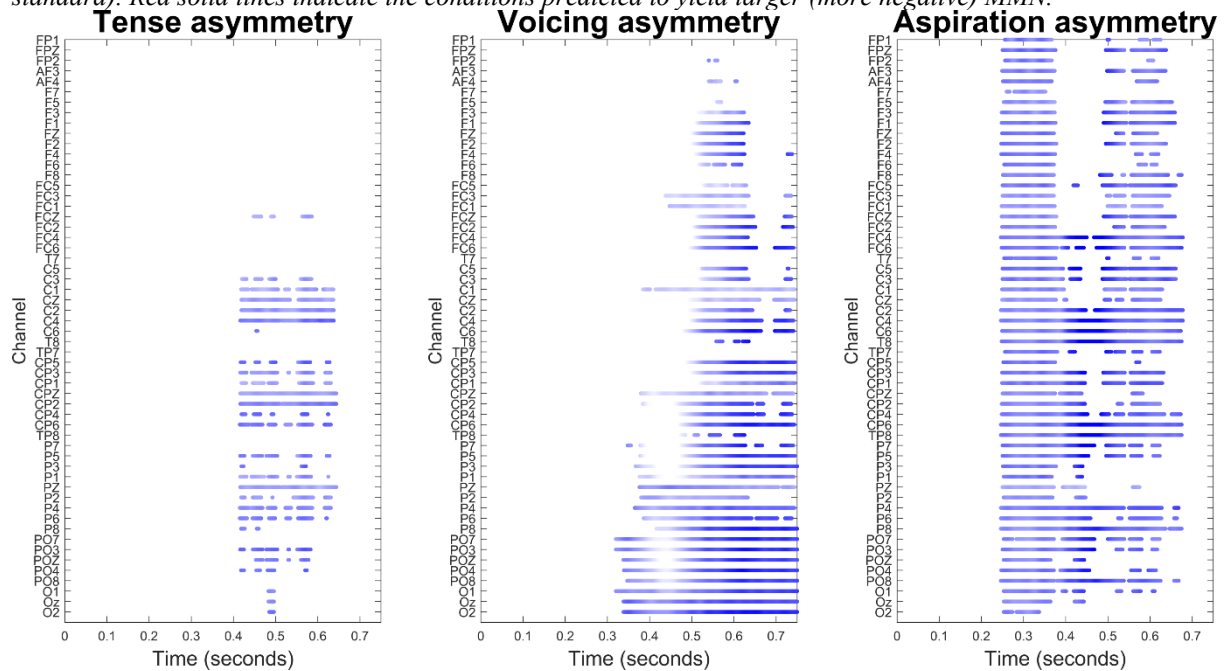


Figure 2. Raster plots showing spatiotemporal distribution of clusters from the statistical test. Darker blue indicates greater difference between MMNs.

References

- Eulitz, C., & Lahiri, A. (2004). Neurobiological evidence for abstract phonological representations in the mental lexicon during speech recognition. *Journal of Cognitive Neuroscience*, 16, 577-583.
- Maris, E., & Oostenveld, R. (2007). Nonparametric statistical testing of EEG- and MEG-data. *Journal of Neuroscience Methods*, 164, 177-190.
- Monahan, P., Schertz, J., Fu, Z., & Pérez, A. (2022). Unified coding of spectral and temporal phonetic cues: electrophysiological evidence for abstract phonological features. *Journal of Cognitive Neuroscience*, 34, 618-638.
- Näätänen, R., Paavilainen, P., Rinne, T., & Alho, K. (2007). The Mismatch Negativity (MMN) in basic research of central auditory processing: a review. *Clinical Neurophysiology*, 118, 2544-2590.
- Politzer-Ahles, S., & Jap, B. (2024). Can the mismatch negativity really be elicited by abstract linguistic contrasts? *Neurobiology of Language*, 5, 818-843.