Department of Communication
Sciences and Disorders

University of Texas at Austin

Auditory Sensory Gating: Effects of Noise

Fan-Yin Cheng, M.A., Julia Campbell, Ph.D., Au.D., and Chang Liu, Ph.D.
Central Sensory Processes Laboratory, University of Texas at Austin

Central Sensory Processes Laboratory

INTRODUCTION

Several factors influence the cortical encoding of acoustic speech information in the presence of background noise. One factor includes the spectrotemporal properties of both the target signal and background masker. Masking features can interact with the target signal, affecting the neural representation of speech. For example, Maamor & Billings (2017) found that multi-talker babble noise, comprised of both informational and energetic masking, interfered with cortical signal encoding via CAEPs, as compared to modulated noise, which consists of only energetic masking.

Another factor that may be important to the neural encoding of speech signals in competing background noise is central inhibition. Central inhibition may aid this process by suppressing irrelevant auditory information (e.g., background noise), allowing the listener to focus on the target speech signal (Janse, 2012). Inhibition can be measured through auditory gating using cortical auditory evoked potentials (CAEPs) in response to identical pairs of acoustic stimuli (Javitt & Freedman, 2015). Typical gating results in a significant decrease in the amplitude of the CAEP response to the second stimulus in the pair (S2) versus the first (S1), as the stimulus is deemed non-novel (Javitt & Freedman, 2015).

To our knowledge, the interaction between intrinsic inhibitory function and extrinsic properties of speech-in-noise input is unknown. With this in mind, we measured gating function via CAEPs in response to speech stimuli in three background conditions: quiet, temporally-modulated multi-talker babble, and multi-talker babble, to assess inhibitory function in various masker conditions.

AIM

To observe the effects of energetic (temporally-modulated babble) and combined energetic and informational masking (four-talker babble) on cortical inhibition using an auditory gating paradigm with speech stimuli.

METHODS

- 15 normal-hearing adults without tinnitus (18-35 years) (*M*=23.46 years, *SD*=3.54 years) participated.

- Conventional audiometry was conducted bilaterally across the frequency range of 250-8,000 Hz.

- CAEPs were recorded via EEG in response to 50 ms male-voiced vowel /I/ pairs (S1, S2). Stimuli were presented at 80 dB SPL, in all conditions, via soundfield at +/-45° azimuth while participants watched a muted movie with subtitles. 300 trials were presented for S1 and S2 (a total of 600 trials).

- The speech signal was presented in quiet and at 5 dB SNR in two noise conditions: temporally modulated four-talker babble and four-talker babble. Babble was generated using two male and two female voices reading a history selection from the Coordinate Response Measure (CRM) corpus (Bolia et al., 2000). Talker-modulated babble was temporally-modulated such that the temporal envelope of the babble was maintained and provided only energetic masking.

- Individual frontal ROIs were created from an average of thirteen electrodes (3, 4, 5, 9 or Fp2, 10, 11 or Fz, 12, 15, 16, 18, 19, 22 or Fp1, 23). Amplitude (baseline to peak) and latency of CARP peaks in response to S1 and S2 were measured at the frontal region of interest (ROI) and marked at the highest peak point or mid-peak for a broad peak. Approximate timeframes for peak components were as follows: P50 50-90 ms, N1 90-130 ms, and P2 140-190 ms.

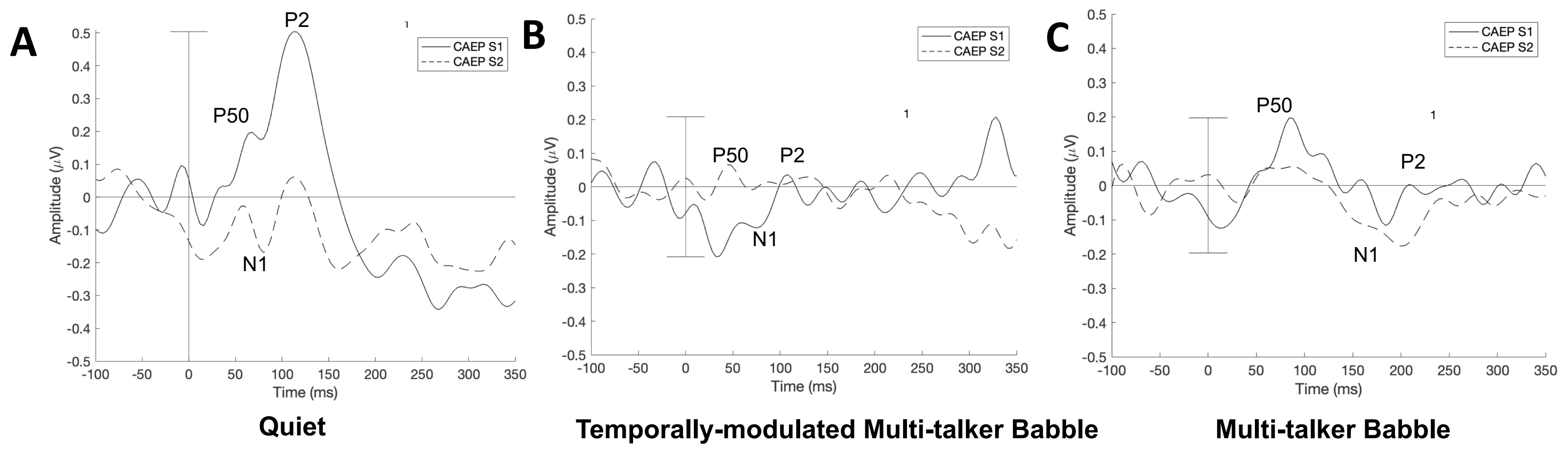
- Raw electrophysiological data were offline band-pass filtered (10-45 Hz) for P50 across noise conditions, and the figures in this poster were offline low-pass filtered (30 Hz).

- Amplitude ratio and differences calculations (e.g., P50 amplitude S2/ P50 amplitude S1, P50 amplitude S1- P50 amplitude S2) were performed for each participant at each peak component. Between-group comparisons with repeated measure were conducted using the Friedman test for non-parametric one-way ANOVA. Post hoc analysis with Wilcoxon signed-rank tests was conducted with a Bonferroni correction applied.

- P50 amplitude gating difference scalp maps were plotted to observe cortical regions involved in gating during the three conditions.

PRELIMINARY RESULTS

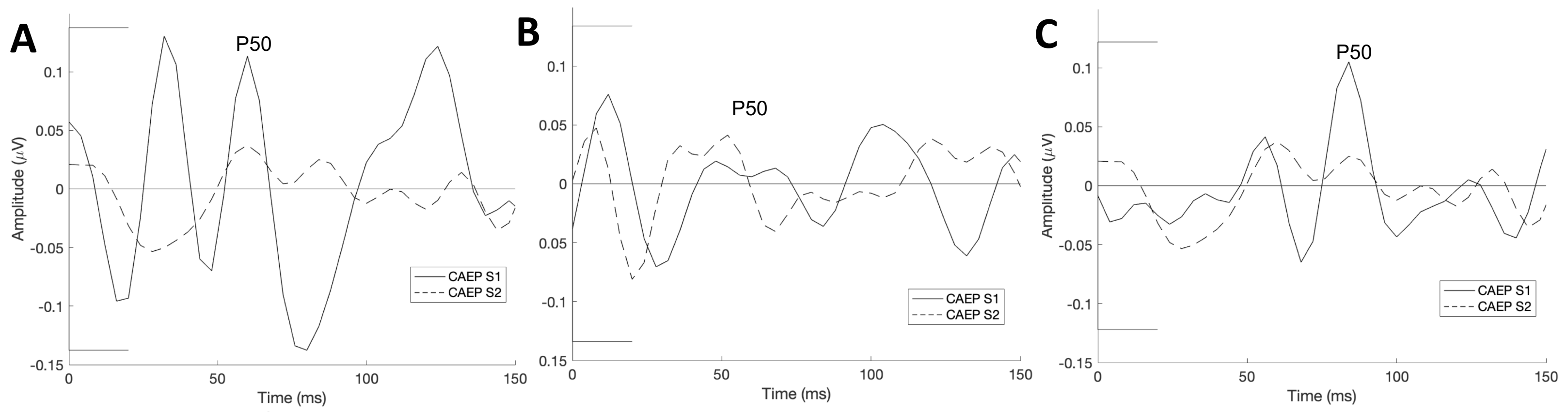
CAEP Gating



Quiet | Temporally-modulated Multi-talker Babble | Multi-talker Babble

Figure 1. CAEP gating responses in different noise conditions. Black line indicates CAEP response to S1 and dashed line indicates CAEP response to S2. A) CAEP in quiet. B) CAEP in temporally-modulated multi-talker babble. C) CAEP in multi-talker babble.

Filtered P50 Gating



Quiet | Temporally-modulated Talker Babble | Multi-talker Babble

Figure 2. Filtered P50 CAEP gating responses in different noise conditions. Black line indicates CAEP response to S1 and dashed line indicates CAEP response to S2. A) CAEP in quiet. CAEP in temporally-modulated multi-talker babble. C) CAEP in multi-talker babble.

Significant P50 gating was observed only in the quiet condition. No other components were found to demonstrate significant gating in all conditions.

Statistics

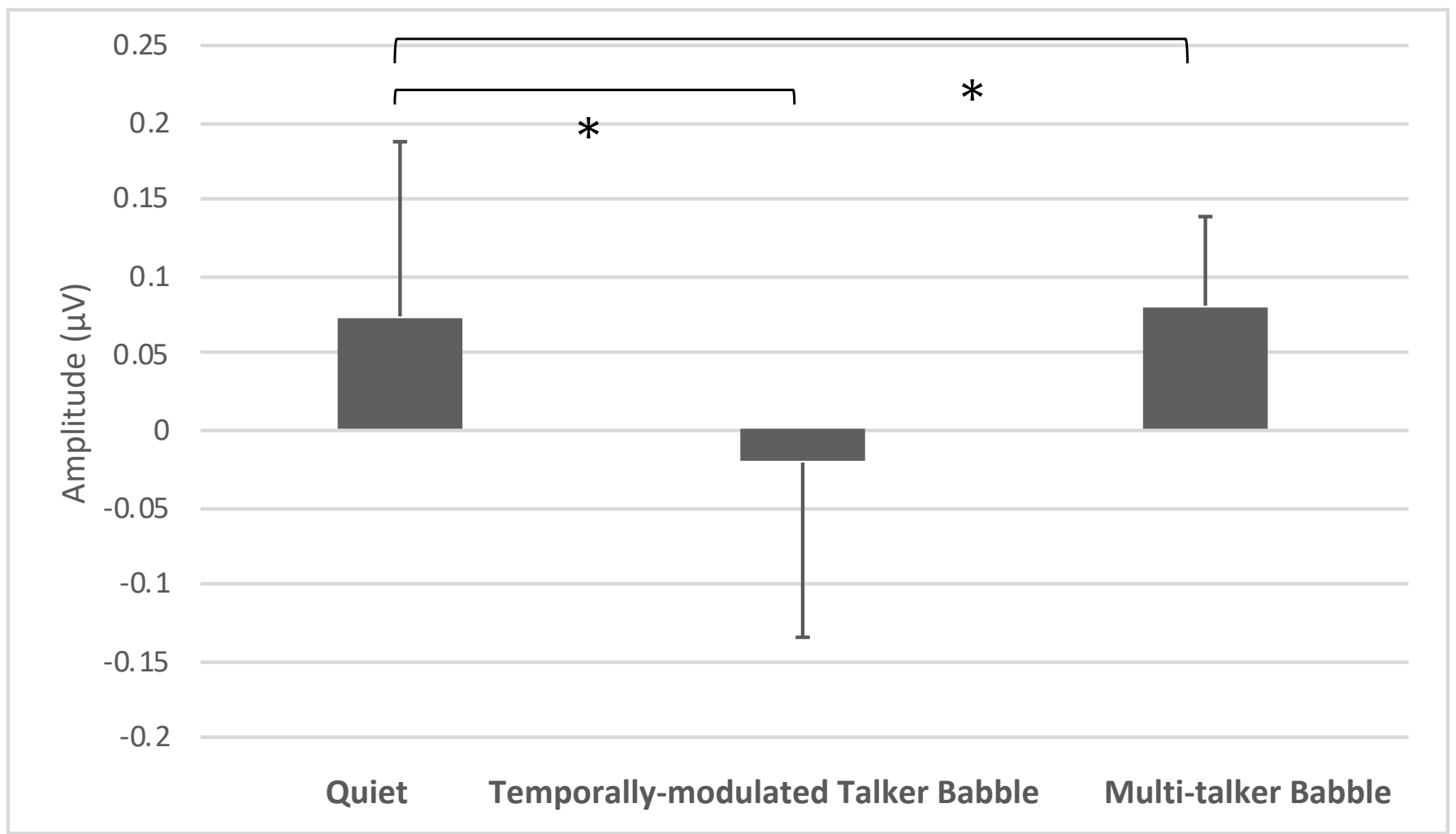
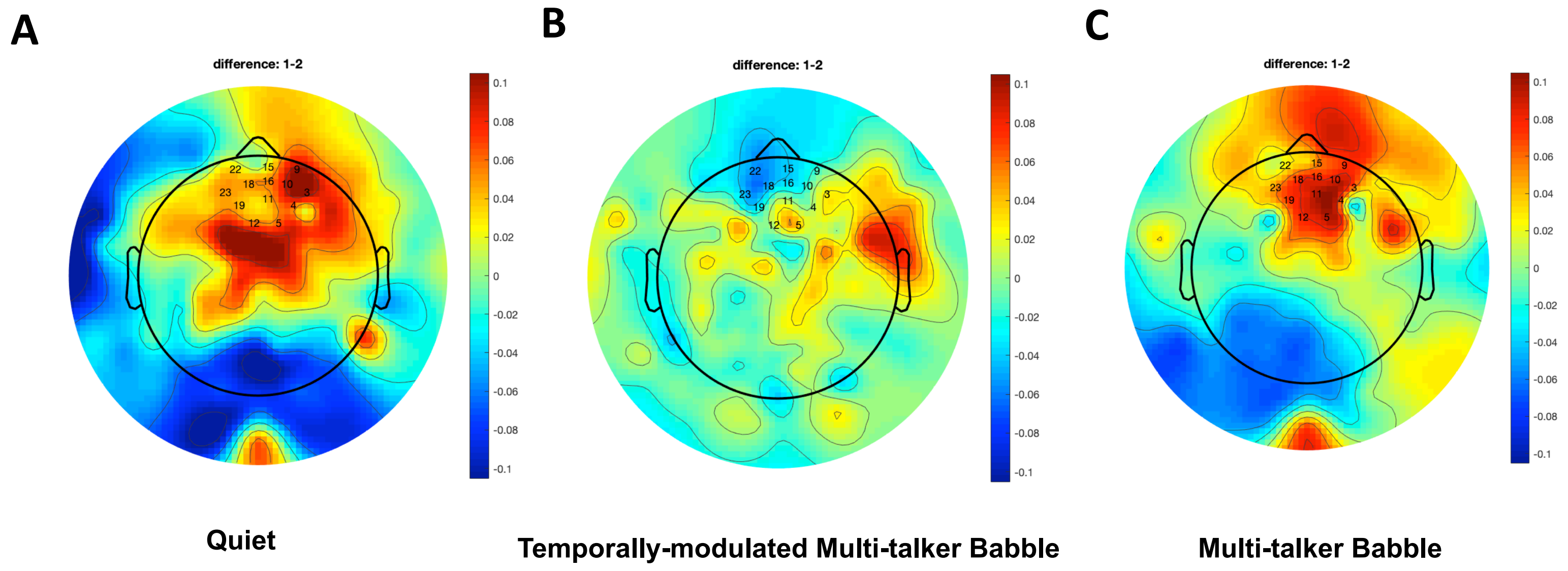


Figure 3. Mean filtered P50 amplitude gating differences for different noise conditions. Error bars indicate + one standard error of the mean. Asterisks indicate p < 0.017.

There was a statistically significant difference in P50 amplitude gating difference dependent on noise condition (χ2[2] = 12.154, p = 0.002). Post-hoc analyses using Wilcoxon signed-rank tests were conducted with a Bonferroni correction applied, resulting in a significance level set at p < 0.017 (0.05/3). No significant gating effects were observed between temporally-modulated babble and four-talker babble conditions (Z = -1.274, p = 0.203), but P50 gating in quiet was much greater when compared to temporally-modulated babble (Z = -2.668, p = 0.008) and four-talker babble conditions (Z = -2.402, p = 0.016). While there was not a significant difference between P50 gating in temporally-modulated talker babble and multi-talker babble, there is a trend for greater gating in the multi-talker babble condition.

There were no statistically significant differences in N1 (χ2(2) = 1.4, p = 0.497) and P2 (χ2(2) = 0.974, p = 0.614) amplitude gating differences between conditions. Moreover, there was no statistically significant difference in P50 (χ2(2) = 3.128, p = 0.209), N1 (χ2(2) = 0.6, p = 0.741), and P2 (χ2(2) = 0.2, p = 0.905) amplitude gating ratios for all conditions.

P50 Gating Scalp Maps



Quiet | Temporally-modulated Multi-talker Babble | Multi-talker Babble

Figure 4. Scalp maps of P50 amplitude differences in different noise conditions. Frontal region of interest is plotted with channel labels.

P50 gating is indicated in frontal cortical networks for quiet and multi-talker babble conditions (Figure 4), consistent with previous studies (Knott et al., 2009). However, the frontal cortical networks of temporally-modulated multi-talker babble show reduced responses than other conditions, and cortical activation is focused in the right temporal (auditory) region.

SUMMARY AND CONCLUSION

This study examined the effects of energetic masking and combined energetic and informational masking on inhibitory gating processes using a vowel stimulus.

There were two main findings in this study:

1. P50 amplitude gating was observed in quiet, and P50 gating in quiet was significantly increased in comparison to temporally-modulated babble and four-talker babble.

2. Scalp maps of the P50 amplitude difference indicate that different cortical networks are active in the presence of specific masking types. Interestingly, gating networks are most similar in quiet and combined energetic/informational masking.

Overall, masker type appears to affect inhibitory processes related to speech processing, although this was a trend rather than statistically significant.

Results in this study indicate that central inhibition was strongly reduced when there was energetic masking, and that gating networks in typical frontal regions were inactive. However, when the informational masking was added, the inhibitory response re-emerged, along with expected frontal gating networks. One possible explanation for this finding is that the multi-talker babble in this study was in listeners' native language and familiar in content, which provided the listeners with cognitive cues to differentiate signals from babble. For example, in a study by Mattys, Brooks, and Cooke (2009), listeners performed better in an informational masking task versus energetic masking task. The authors hypothesized that the additional of informational masking could have directed listeners' attention to the lexical-semantic content of the target phrases and away from sublexical detail. In other words, inhibitory networks may become engaged when additional information is present which is helpful in distinguishing the speech signal. Future studies should examine this hypothesis, as well as the effect of different dB SNR on CAEP gating function.

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