Intelligibility Modulates Early Attentional Filtering of Competing Speech

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Center for the CNBC Neural Basis of Cognition

Overview

- Intelligible speech masks target speech more than unintelligible speech [1,2,3], but manipulations of intelligibility vary in the literature: time reversal, N-talker babble, vocoding, filtering, etc. [4,5,6,7].
- Here, we controlled for acoustic differences between intelligible and unintelligible maskers, and measured neural responses.
- Intelligible speech, which more readily masked target speech, modulated the P1-N1 response but not the P300 response, suggesting an early attentional filtering mechanism.

Stimuli & Color Word Detection Task

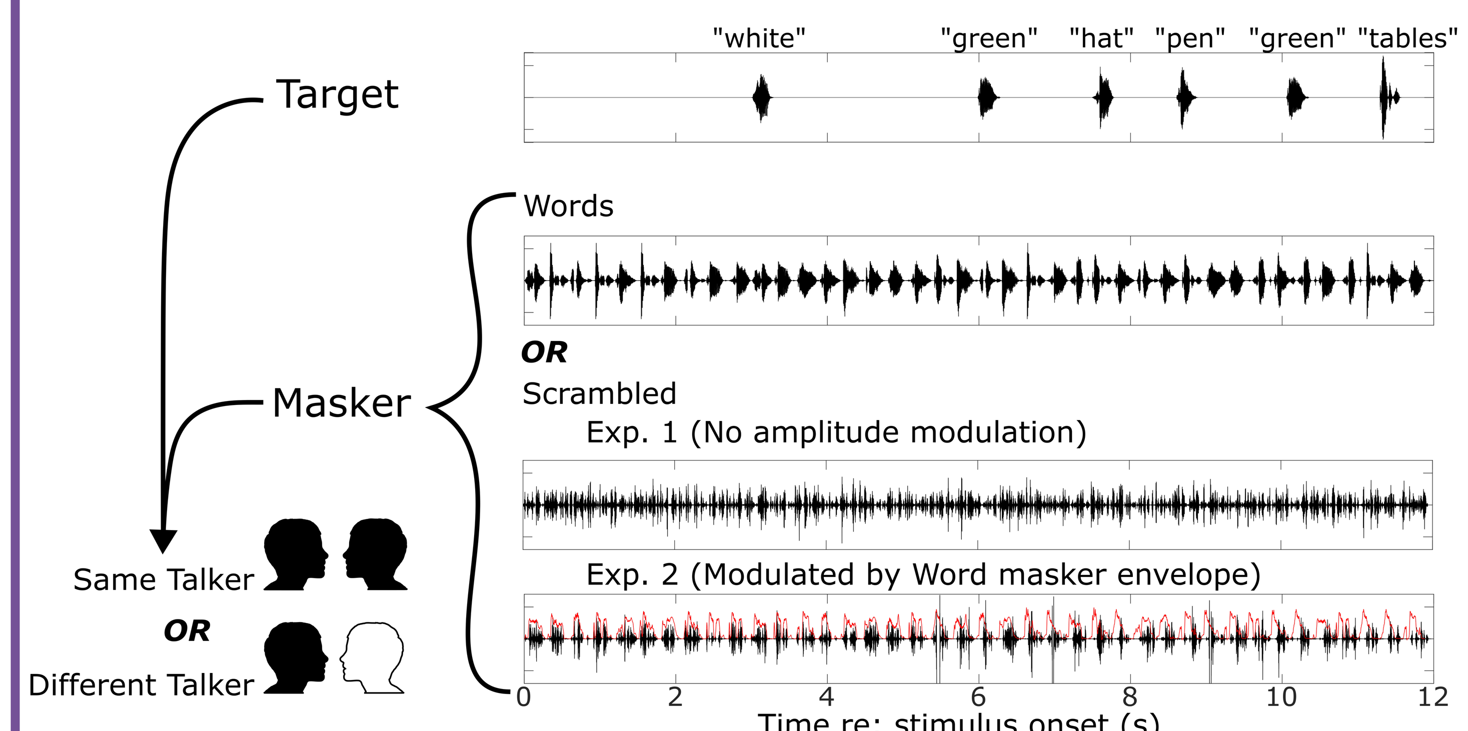


Fig. 1. Schematic of a single task block. Listeners attended to the sporadic target stream (top row), and ignored a simultaneous, isochronous Masker that depended on condition (bottom rows).

- N = 20 normal hearing listeners in each of two experiments.
- Listeners responded to color words in the target stream (Fig. 1).
- Listeners ignored an isochronous masker: either words from the same set ("Words"), or scrambled speech ("Scrambled").
- Target and masker were spoken by the same or different talkers.
- In Exp. 2, masker was amplitude modulated with a Word envelope
- Target and masker were filtered into non-overlapping bands (Fig. 2A).
- Scrambling (Fig. 2B) preserved local spectrotemporal density.

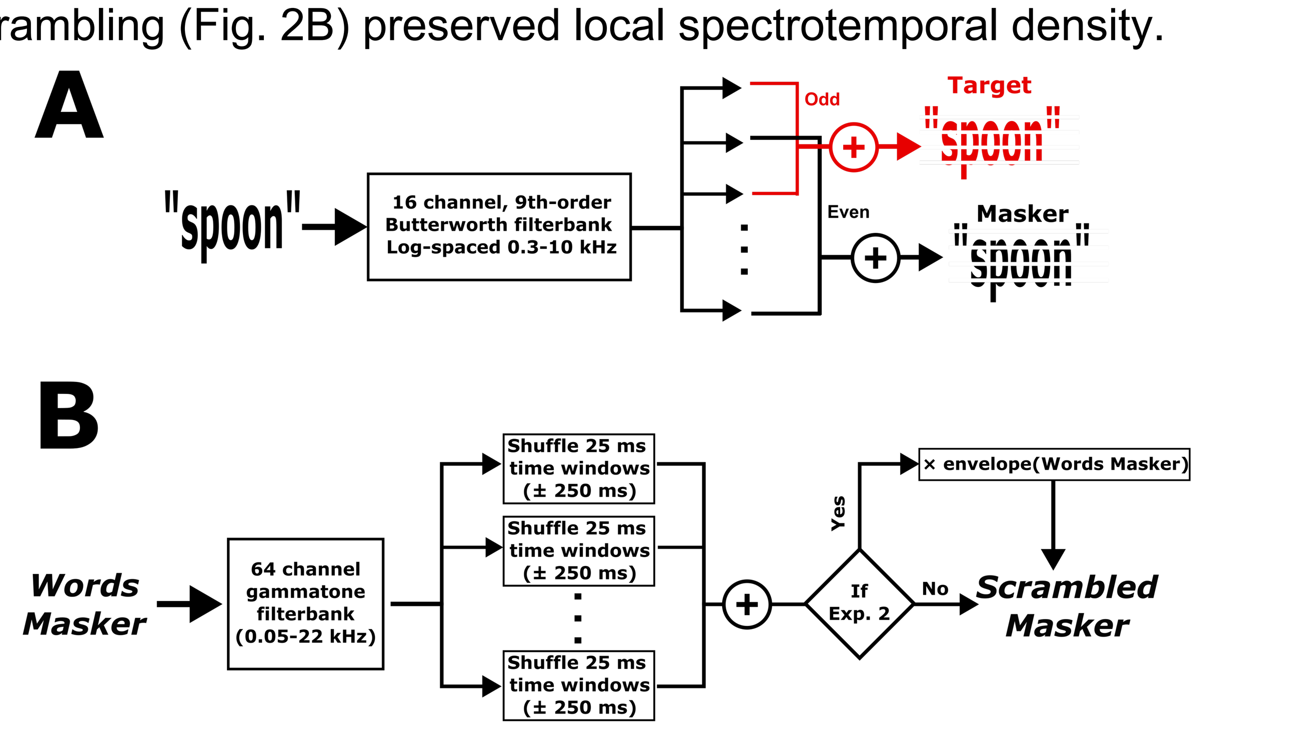
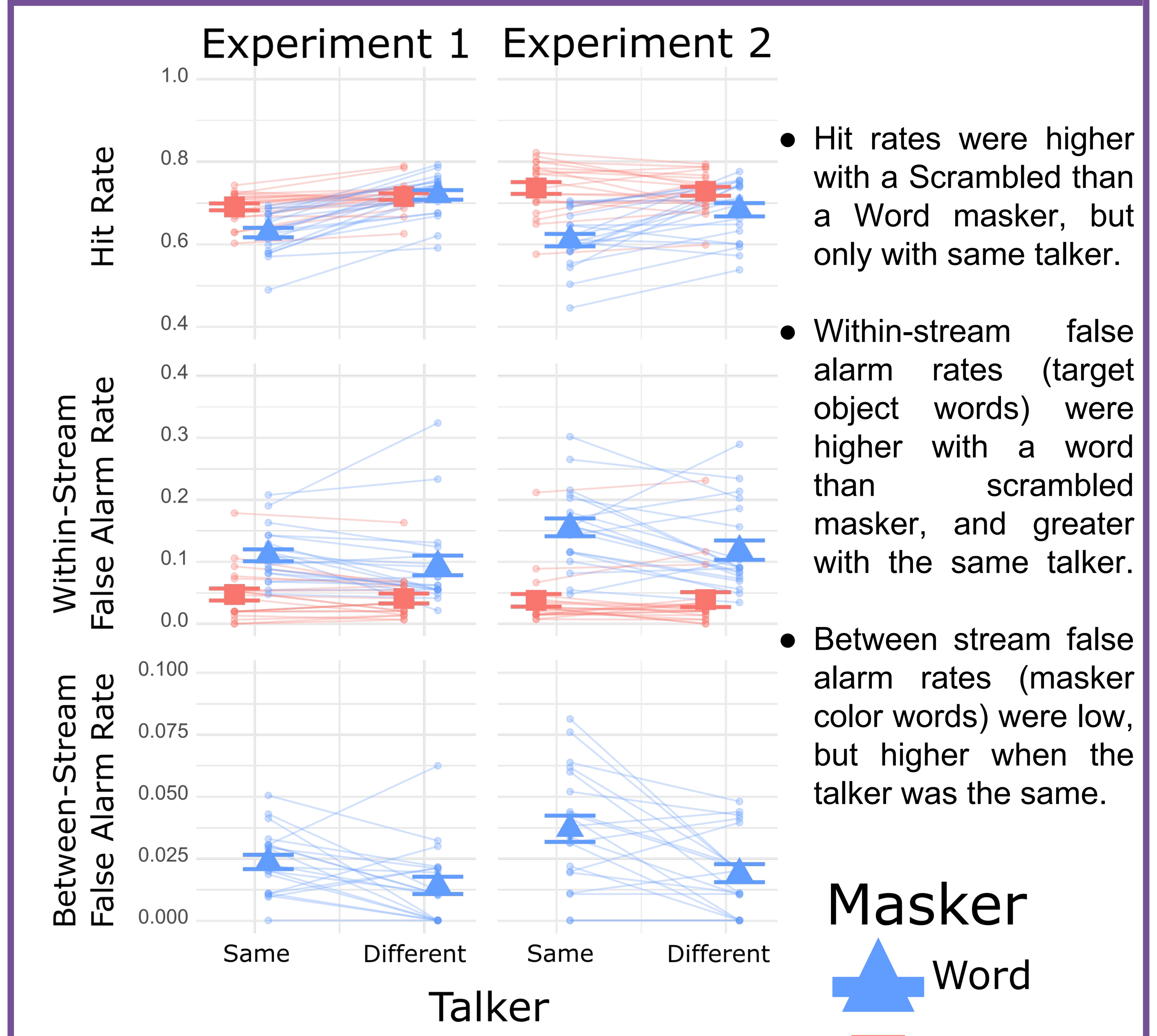


Fig. 2. Controls for energetic masking and spectrotemporal properties. (A) Target and masker were filtered into non-overlapping frequency bands. (B) The scrambling process resulted in similar spectrotemporal density between Word and Scrambled maskers

EEG Methods and ERP Analysis

- We measured 32-channel EEG throughout the task.
- Preprocessing included manual artifact rejection, eye blink/saccade rejection using ICA, and rejection of ERPs with magnitude ± 100 V.
- We measured event-related potentials (ERPs), and calculated…
  - P1-N1 sensory onset responses in frontocentral electrodes
  - P300 color word recognition responses in parietooccipital electrodes

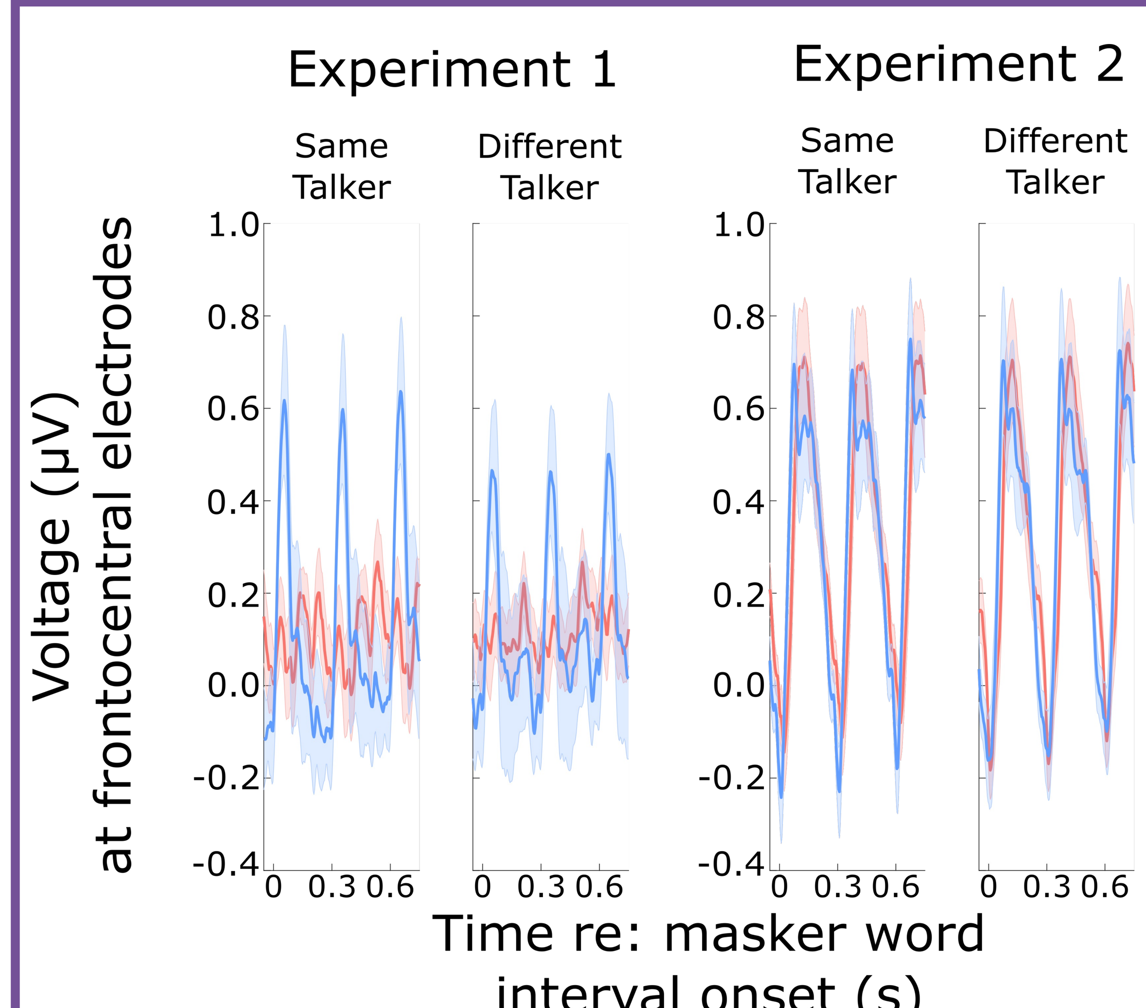
Behavior Results



- Hit rates were higher with a Scrambled than a Word masker, but only with same talker.
- Within-stream false alarm rates (target object words) were higher with a word than scrambled masker, and greater with the same talker.
- Between stream false alarm rates (masker color words) were low, but higher when the talker was the same.

Fig. 3. Individual behavioral data (small symbols connected by thin lines) and across-subject average and standard error (large symbols with error bars).

ERPs to the masker stream



- In Exp. 1, ERPs followed the Words masker envelope but did not show rhythmic structure for a Scrambled masker.
- In Exp. 2, we addressed this confound by amplitude modulating the Scrambled masker.

Fig. 4. ERPs evoked by masker streams over frontocentral electrodes, time locked to word onsets in the Word masker.

References

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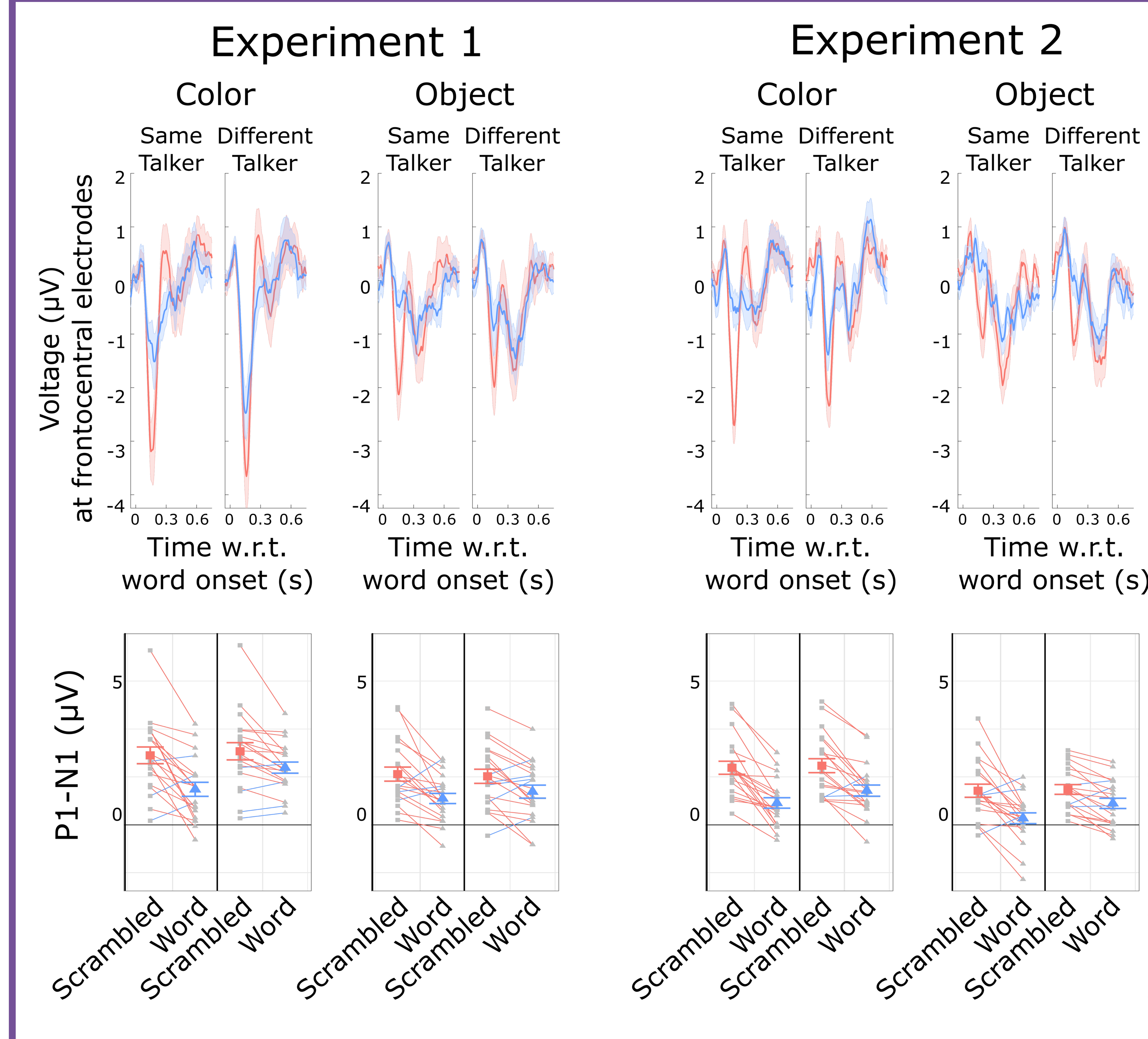
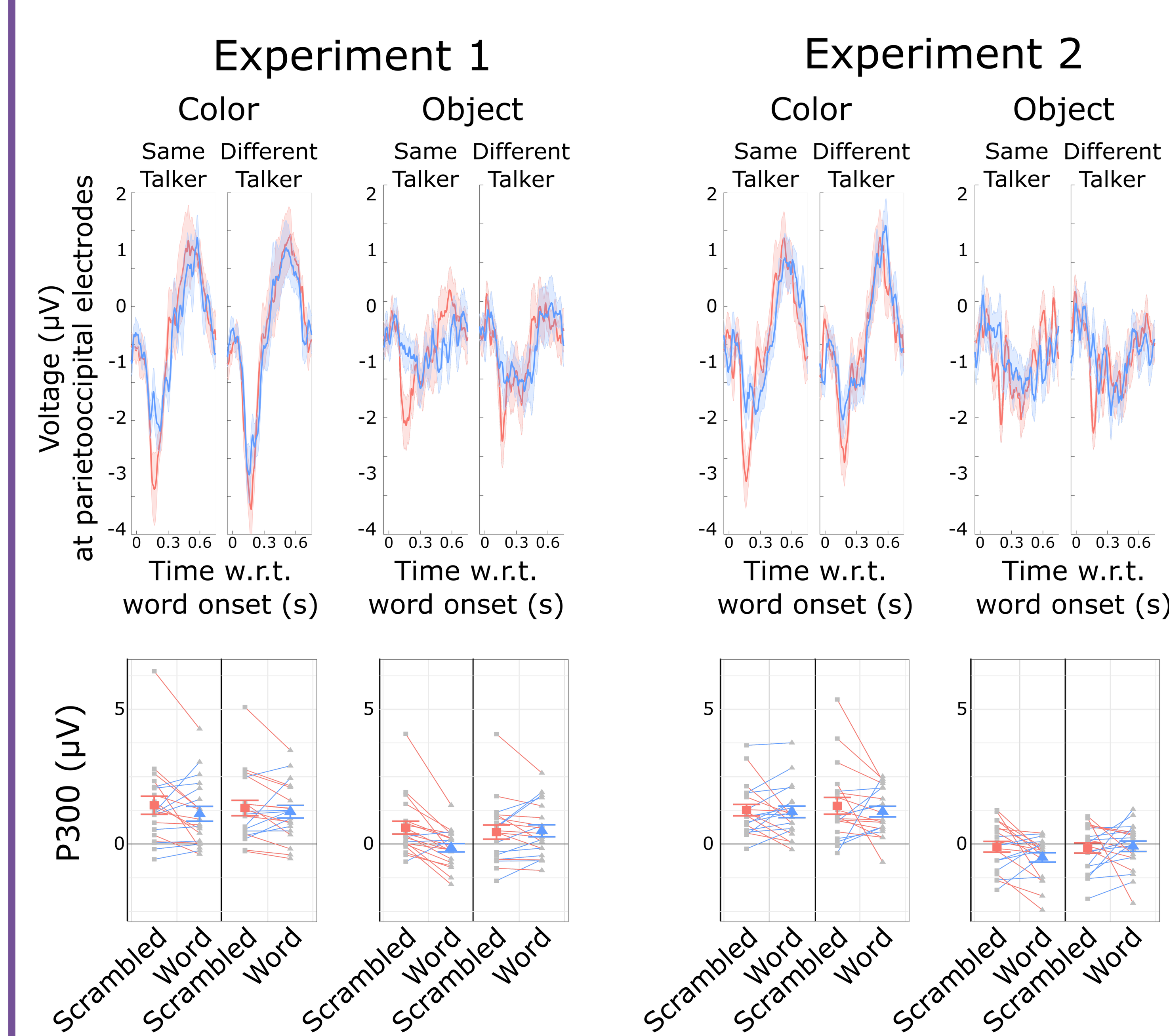
Sensory (P1-N1) responses to target words



- P1-N1 to target color words was larger than to object words in the target stream
- P1-N1 to the target stream was significantly larger with a Scrambled masker than with a Word masker, especially when the talker was the same.

Fig. 5. ERPs over frontocentral electrodes. **Top row:** Time traces averaged over participants, with bands showing the across-participant standard error of the mean. **Bottom row:** P1-N1 magnitude. Group average and standard error of the mean shown by large symbols. Individual participant data (thin lines) are colored according to which P1-N1 is larger.

Target recognition (P300) responses to target words



- P300 was elicited strongly by color words in the target stream, but not by object words.
- P300 was not modulated by masker intelligibility: No differences between P300 to the target between Word and Scrambled masker conditions, except for Exp 1. (Object, Same Talker)

Fig. 6. ERPs over parietooccipital electrodes. **Top row:** Time traces averaged over participants, with bands showing the across-participant standard error of the mean. **Bottom row:** P300 magnitude. Group average and standard error of the mean shown by large symbols. Individual participant data (thin lines) are colored according to which P300 is larger.

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