Neural and acoustic characteristics of agreement *vs*. disagreement in dyadic debate observed using fNIRS hyperscanning

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Everyday conversations in a social world are made up of situations in which agreement and disagreement are components of transactions and negotiations communicated by language. While linguists have investigated the behavioral aspects of these interactions (e.g., Pickering & Garrod, 2004; Babel, 2012), and the neural correlates of spoken language exchanges within dyads have been previously described (Jiang et al., 2012; Hirsch et al., 2018) understanding how neural systems adapt to extended dialectical discussions between partners remains an open and timely research area.

In this work we investigate the neural correlates of face-to-face conversations between two individuals using functional near infrared spectroscopy (fNIRS) and acoustical analyses of concurrent audio recordings. Nineteen pairs of healthy adults engaged in live discussions on two controversial topics where their opinions were either in agreement or disagreement. Participants were matched according to their *a priori* opinions on these topics as assessed by questionnaire. As in formal debates each participant was given a limited amount of time, here 90 s in alternating 15 s turns, to 'make their case.' A conventional notion of the functional architecture of the brain is based on specificity of isolated regions and assigned functions. This theoretical framework predicts that neural responses to these two conditions would differ by modulating activity in core language-related regions. However, an alternative approach based on a constructionist model (Lindquist & Barrett, 2012) predicts that multiple functional networks in addition to the language system would dynamically adapt to the emerging social situation. Although not necessarily mutually exclusive, these two alternatives encompass a range of the unanswered questions related to dynamic language use in realistic social situations.

Acoustic measures of the recorded speech including the fundamental frequency range, median fundamental frequency, syllable rate, and acoustic energy were significantly elevated during disagreement relative to agreement (Figure 1). Neural measures were assessed using main effect comparisons based on the General Linear Model applied to the deoxygenated hemodynamic signals obtained from the 42-channel fNIRS datasets per speaker. Consistent with both the *a priori* opinion ratings and the acoustic findings, neural activity associated with long-range functional networks, rather than the canonical language areas, was also differentiated by the two conditions. Specifically, the frontoparietal system including bilateral dorsolateral prefrontal cortex, left supramarginal gyrus, angular gyrus, and superior temporal gyrus showed increased activity while talking during disagreement. In contrast, talking during agreement was characterized by increased activity in a social and attention network including right supramarginal gyrus, bilateral frontal eye-fields, and left frontopolar regions. Further, these social and visual attention networks were more synchronous across brains during agreement than disagreement (Figure 2). Together, these findings suggest that the adaptive processes that serve dynamic verbal exchanges support a model of multiple context-specific large-scale cortical networks including cross-brain neural coupling rather than localized modulation of the canonical language system.

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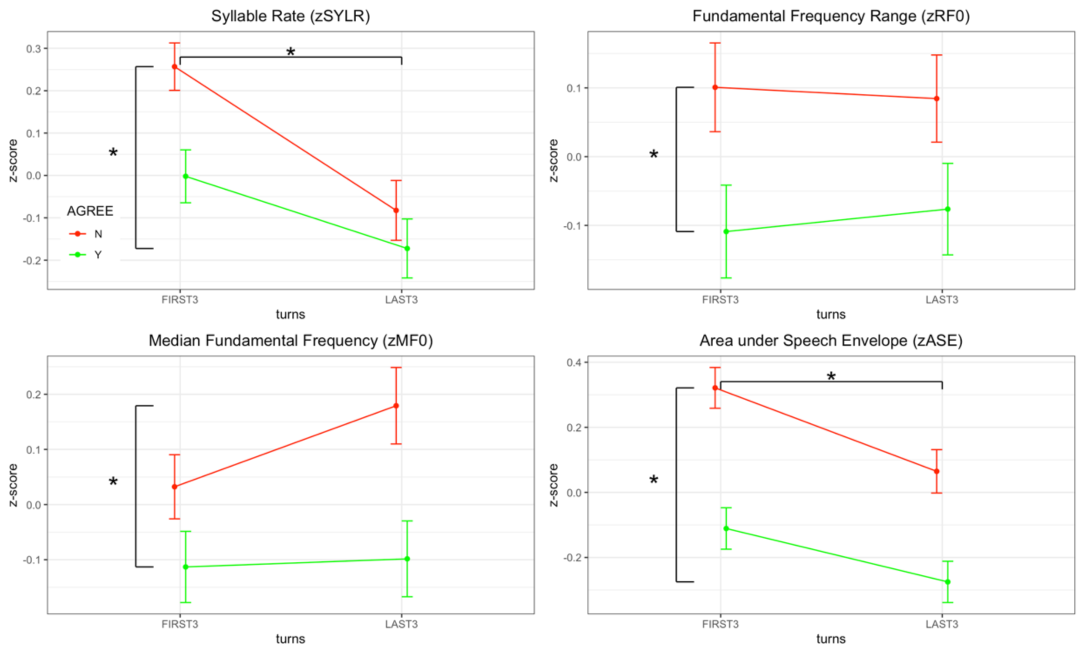

Figure 1. Acoustic measures, z-scored by speaker, grouped by agreement (yes or no) and turn (first 3 and last 3 turns) across all speakers; error bars show standard error of the mean (SEM). Asterisks mark significant comparisons assessed by LMM. Green represents agree (Yes) and red represents disagree (No). All measures show significant elevation under disagreement.

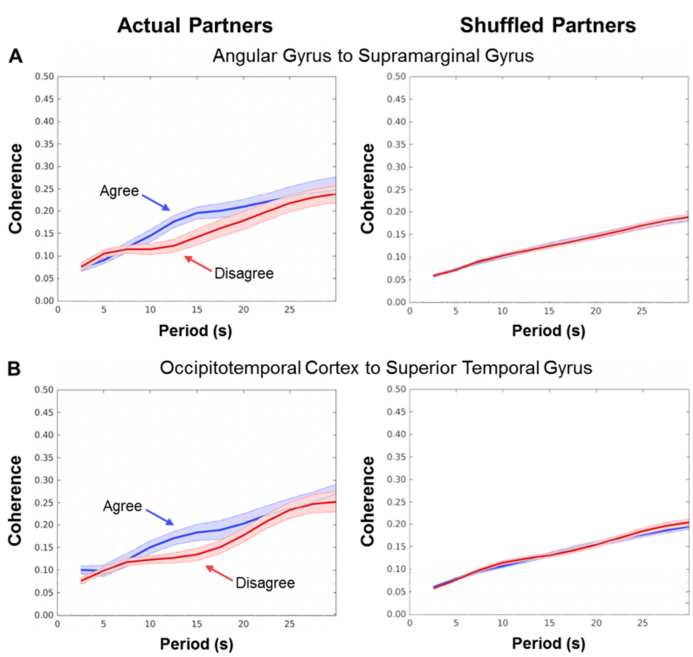

Figure 2. Cross-brain coherence. Signal coherence between dyads (y-axis) is plotted against the period (x-axis) for the Disagree (red) and Agree (blue) conditions (shaded areas: ±1 SEM). The left column shows coherence between actual partners, and the right column shows coherence between shuffled partners. Greater signal coherence was observed in agreement between actual partners in **A.** angular gyrus to supramarginal gyrus and **B.** occipitotemporal cortex to superior temporal gyrus. In contrast, no significant differences were found in coherence between shuffled partners under either condition.