Hyperscanning during natural dialogue between two individuals with high socioeconomic disparities

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Introduction and Methods

Neural substrates and mechanisms that mediate online[1] social cognition are poorly understood largely due to challenges of neuroimaging in natural conditions. However, recent developments in functional near-infrared spectroscopy (fNIRS) enable simultaneous neuroimaging (hyperscanning) of dyads during live social interactions.[2] Prior behavioral findings suggest that social disparities signal "in" and "out" group memberships, although neural encoding of social disparities during dynamic interpersonal interactions has not been investigated.

In this study, 84 individuals (19 high and 23 low disparity dyads) of mixed gender, race, and age (Table 1) were scanned during natural dialogues using an 84-channel fNIRS system (Shimadzu LABNIRS) with 42 channels covering both hemispheres of each person (Fig. 1).

We test the hypothesis that interpersonal interaction with variation in social disparity will modulate rule-based neural systems such as those associated with speech production.

Figure 1. Channel Layout. Two-person setup.

Turn-taking for dialogues was cued and alternated every 15 s (Fig. 2). Conversation topics were selected from a prepared list. Two categories were used: biographical, such as "What did you do last summer?", and objective, such as "Discuss the attractions in New Haven."

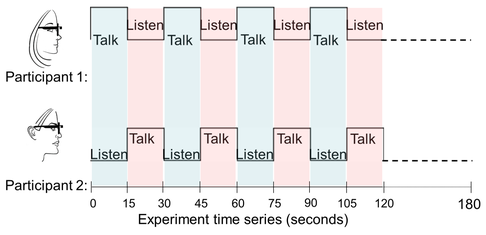


Figure 2. Two-person dialogue paradigm

Dyads completed two runs of biographical and two runs of objective topics. There was no evidence of a difference between the two types of conversations, and they were integrated for data analysis.

- **Recruitment:** In addition to recruitment on college lists, flyers with information about the experiment were located throughout the city of New Haven.
- **Classification of dyad disparity:** Subjects reported level of education and annual parental income. A point system was based on levels of each, and the sum of the two points was determined for every participant. Determination of high or low disparity dyads was based on the difference between the numbers for each individual.
- **Participants** were matched in the order that they arrived for the experiment. The dyad disparity classification number was determined at the time of the experimental run. None of the participants were previously acquainted with their partner.

Table 1. Demographic summary

	HIGH DISPARITY	LOW DISPARITY
N	38 (19 dyads)	46 (23 dyads)
AGE	32 ± 11	31 ± 14
GENDER		
Male	23	28
Female	15	18
DYAD PAIR TYPE		
F/F	4	3
F/M	7	12
M/M	8	8
RACE		
Af-Am	12	12
As-Am	10	6
Caus-Am	10	14
Lat-Am	1	6
Bi-Multi	4	2
Nat-Am	0	1
Other	1	3
HANDEDNESS		
Right	36	42
Left	2	4

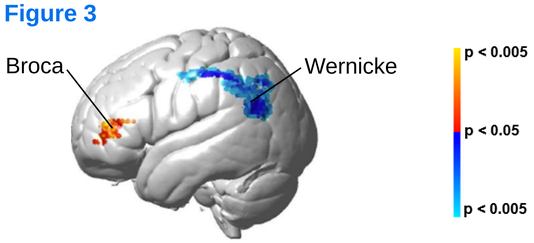
There is no evidence for group differences based on demographics.

ROI Results

Regions of Interest (ROI) determination:

ROIs [Talking > Listening] (Red)
[Listening > Talking] (Blue)

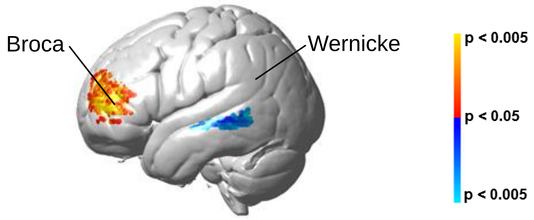
Figure 3



All data were combined for the ROI determinations of Broca's and Wernicke's regions (Fig. 3).

Figure 4

High Disparity > Low Disparity for ROIs



t = 2.617 0.0786
p ≤ 0.01 > 0.1

Figure 4. For [Talking > Listening] (red), activity increased in Broca's region of interest (p ≤ 0.01) for the [High disparity > Low disparity] contrast. There was no difference for the [Listening > Talking] (blue) function.

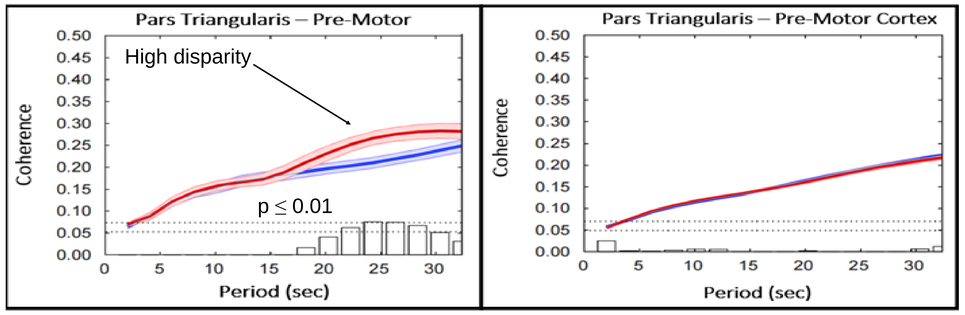
This finding suggests that conversation between high disparity individuals constitutes a greater load on regions associated with cognitive control and rule-based systems than low disparity dyads.

Cross-Brain Coherence Results

Cross-brain coherence: A measure of neural synchrony

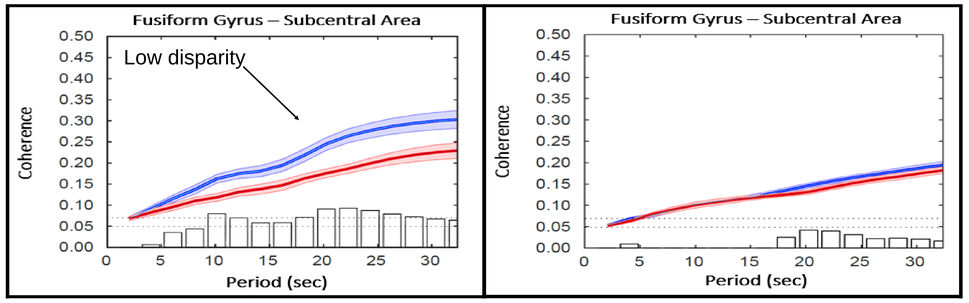
High disparity dyads demonstrate greater cross-brain coherence for Broca's Area.

Figure 5 **Actual Partners** **Scrambled Partners**



Cross-brain coherence is shown between pars triangularis and pre-motor cortex. A greater level of coherence was observed in the high disparity dyads than the low disparity dyads. There was no difference in coherence for the scrambled partners (Fig. 5).

Figure 6 **Actual Partners** **Scrambled Partners**



Low-Disparity dyads show greater cross-brain coherence between regions associated with face processing (fusiform gyrus) and typical interpersonal interaction processing (subcentral area), as previously observed for eye-to-eye contact[2] (Fig. 6).

Figures 5 and 6. Signal coherence between subjects (y-axis) is plotted against the wavelength (x-axis) for the high disparity (red) and the low disparity (blue) conditions (shaded areas: ±1 SEM). Bar graphs indicate significance levels for the separations between the two conditions for each of the period values on the x-axis. The upper horizontal dashed line indicates (p≤0.01) and the lower line indicates (p≤0.05). Left panels show coherence between actual partners, and right panels show coherence between scrambled partners.

Summary and Conclusion

- Left hemisphere Broca's Area and DLPFC were upregulated during dialogue between high disparity dyads relative to low disparity dyads.
- Cross-brain synchrony for high (relative to low) disparity dyads is consistent with the ROI findings. Coherence between pars triangularis (Broca's Area) and pre- and supplementary motor cortex is observed for high disparity dyads.
- These findings suggest that social disparity in interpersonal interaction upregulates rule-based systems associated with speech production, such as Broca's Area and DLPFC.

References

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2. Hirsch, J., Zhang, X., Noah, J. A., & Ono, Y. (2017). Frontal temporal and parietal systems synchronize within and across brains during live eye-to-eye contact. *Neuroimage, 157*, 314–330. doi: 10.1016/j.neuroimage.2017.06.018

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