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Spontaneous neural encoding of social network position

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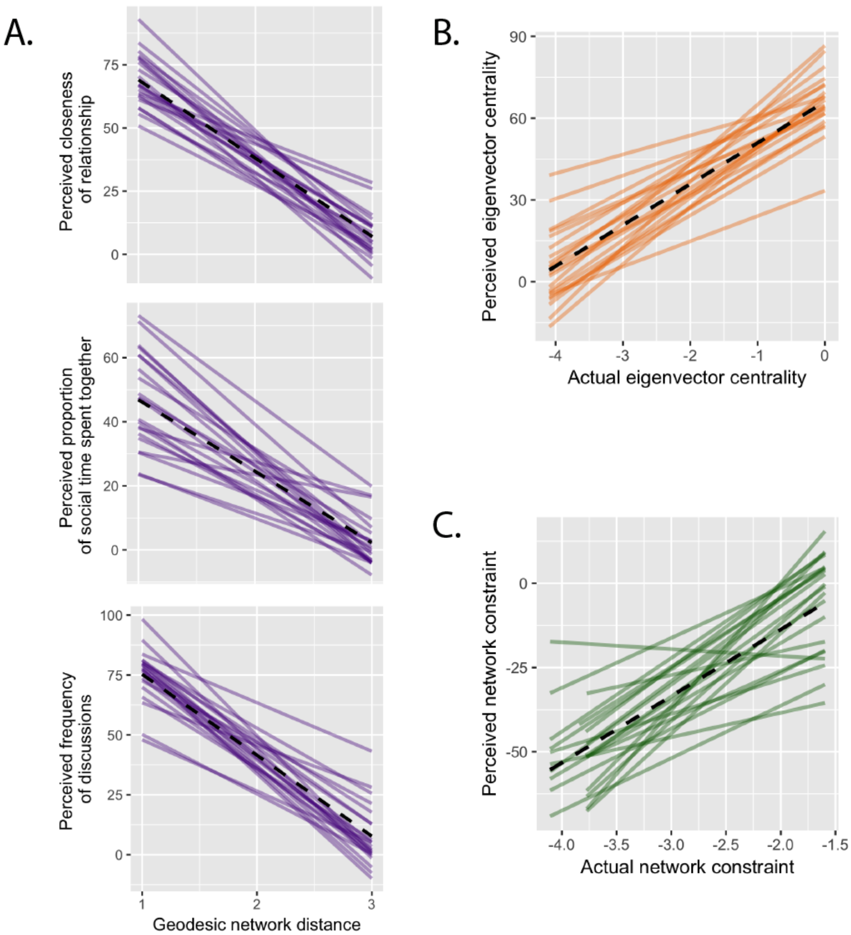
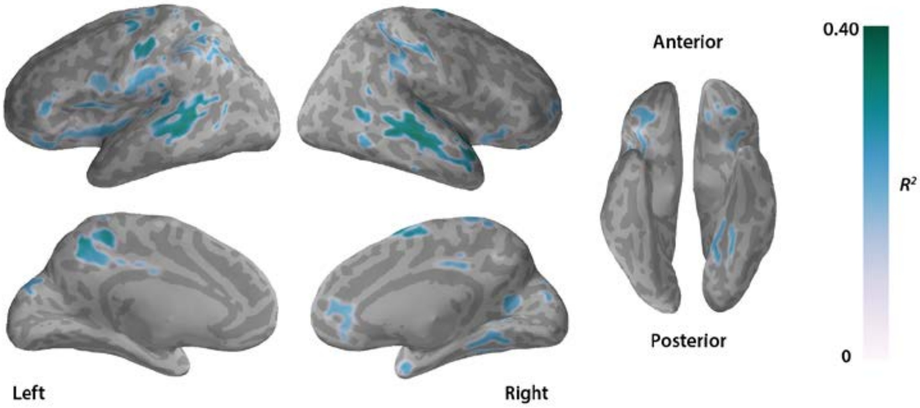
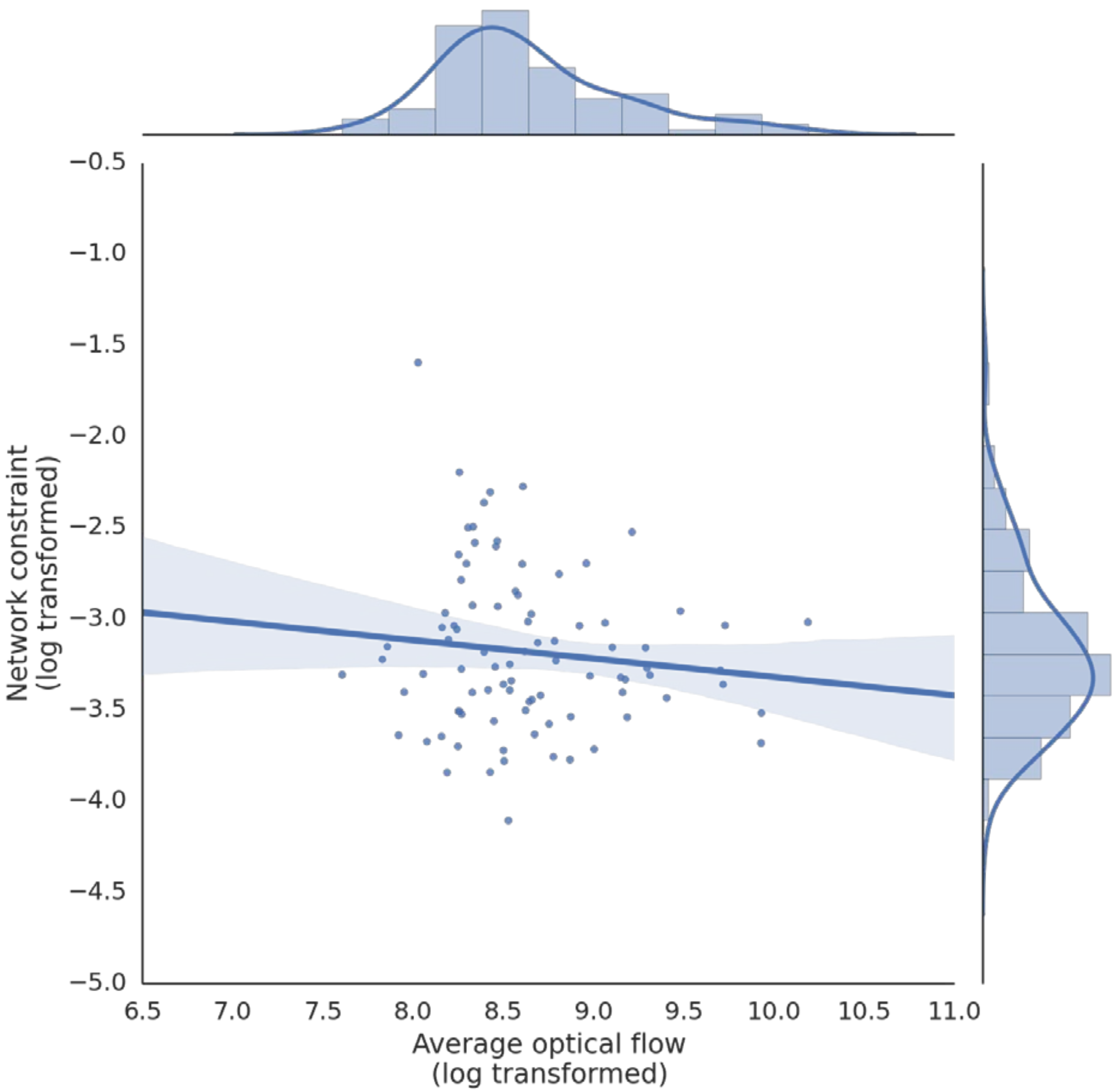
Supplementary Figures



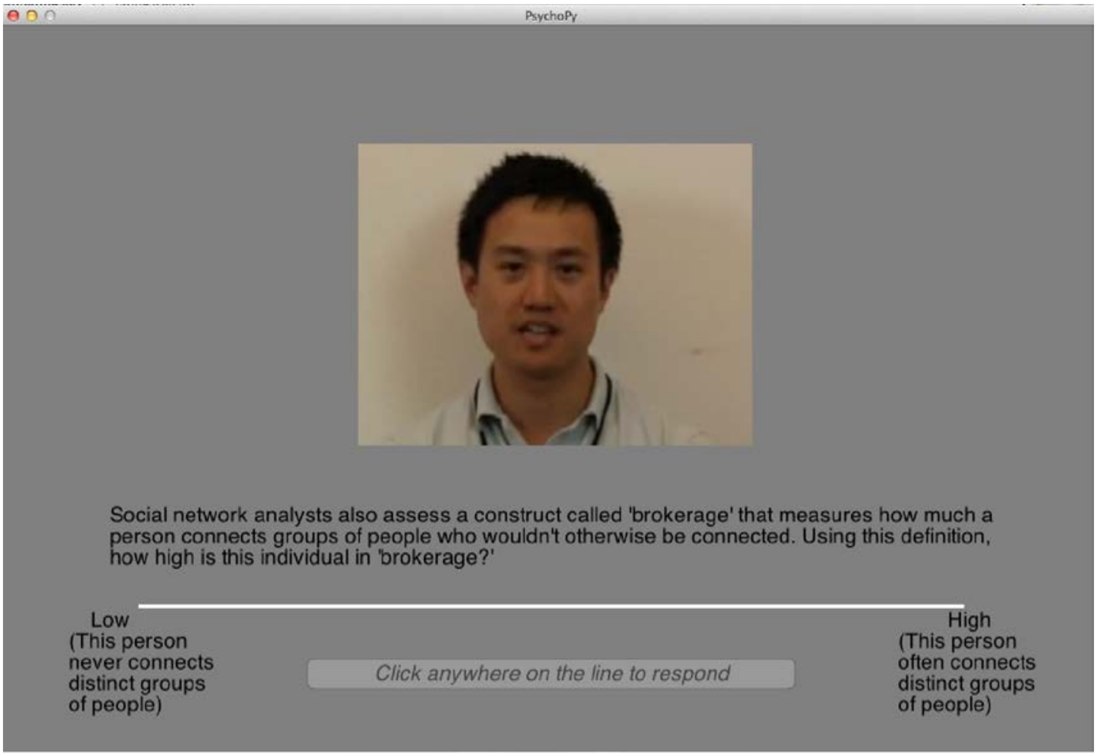
Supplementary Figure 1. Associations between perceived and actual social network characteristics. Black dashed lines depict the relationships between perceived and actual social network characteristics across all participants (fit using an ordinary least squares linear model). Solid purple, orange and green lines depict these relationships for each subject for social distance, eigenvector centrality, and constraint, respectively. **(A)** Neuroimaging study participants' subjective ratings of social closeness, proportion of social time spent together, and frequency of discussions with the individuals in their stimulus sets varied according to geodesic network distance from them in the network (all p's < .0001; see main text). **(B)** Participants' estimates of the eigenvector centrality of the individuals in their stimulus sets were closely related to those individuals' actual eigenvector centralities ($p < .0001$; see main text). **(C)** Participants' estimates of the network constraint of individuals in their stimulus sets were also associated with the actual constraint of those individuals' positions in the social network ($p < .0001$; see main text). As described in the main text, self-report data was obtained after scanning; network constraint and eigenvector centrality were log-transformed prior to plotting and analysis to alleviate skew. Perceived network constraint ratings were multiplied by -1 prior to plotting because the relevant question asked participants to rate perceived brokerage (which is inversely related to network constraint). Analyses of behavioral ratings were conducted using linear mixed models that included by-subject random slopes and intercepts.



Supplementary Figure 2. Voxel-wise R^2 values, averaged across subjects, are depicted within clusters that reliably signaled one or more of the tested aspects of social network position. The R^2 value corresponding to the GLM decomposition performed at each searchlight center indicates the extent to which the information contained in local multi-voxel response patterns can be explained by the social network positions of the classmates being viewed. Results are projected onto a cortical surface model of the Talairach[1] N27 brain using PySurfer (https://github.com/nipy/PySurfer). Brain regions the reliably signaled one or more of the tested aspects of social network position are shown in Fig. 4 of the main text.



Supplementary Figure 3. Relationship between network constraint and movement during videos. The amount of movement of the 88 individuals whose videos were used as stimuli was not significantly related to the constraint characterizing those individuals' positions in the social network of first-year MBA students, r = -0.12, p = 0.28. Solid line indicates an ordinary least squares fit to the data; shaded region indicates 95% bootstrapped confidence interval of the slope of the regression line.



Supplementary Figure 4. Post-scan questionnaire. Following scanning, participants responded to questions about their subjective perception of each aspect of social network position of interest for each individual in their stimulus set. A screenshot of the question corresponding to network constraint (reverse-scored) is shown.

Supplementary Tables

Supplementary Table 1: Brain regions where local neural information content is associated with the social distance of the individuals being viewed.

Hemi	Size (mm^3)	COG *x*	COG *y*	COG *z*	Location
R	4,397	49.6	-46.6	7.6	IPL (SMG), STG, STS, MTG

Hemi = hemisphere; COG = center of gravity; L = left; R = right; IPL = inferior parietal lobule; SMG = supramarginal gyrus; STG= superior temporal gyrus; STS = superior temporal sulcus; MTG = middle temporal gyrus. All reported results are significant at a statistical threshold of $p < .05$, FWE-corrected. All coordinates are in Talairach space.

Supplementary Table 2: Brain regions where local neural information content is associated with the eigenvector centrality of the individuals being viewed.

Hemi	Size (mm^3)	COG *x*	COG *y*	COG *z*	Location
L	24,483	-42.4	-18.5	33.6	IPL, IFG, Ins., pre-central gyrus
R	8,768	21.7	26.8	-4.9	MPFC, IFG, aIns., ant. PHG, TP
L	7,716	-32.7	12.9	-6.1	aIns., IFG
L, R	7,552	-9.4	-41.8	40.4	PCC, precuneus
R	6,802	20.4	-48.0	-2.8	PHG, LG, FG
R	6,065	48.0	-29.4	38.4	IPL, precuneus, post-central gyrus
L, R	5,233	-0.8	-44.4	65.4	Precuneus, post-central gyrus
L, R	4,961	-0.6	-83.3	28.5	EVC

Hemi = hemisphere; COG = center of gravity; L = left; R = right; a = anterior; IPL = inferior parietal lobule; IFG = inferior frontal gyrus; Ins. = insula; MPFC = medial prefrontal cortex; PHG = parahippocampal gyrus; TP = temporal pole; PCC = posterior cingulate cortex; LG = lingual gyrus; FG = fusiform gyrus; EVC = extrastriate visual cortex. All reported results are significant at a statistical threshold of $p < .05$, FWE-corrected. All coordinates are in Talairach space.

Supplementary Table 3: Brain regions where local neural information content is associated with the constraint of the individuals being viewed.

Hemi	Size (mm^3)	COG *x*	COG *y*	COG *z*	Location
R	11,872	51.5	-16.0	-3.0	STS, STG, MTG, ITS, pIns.
L	7,739	-51.6	-38.5	7.1	STS, STG, MTG, pIns.
R	4,363	11.5	-5.7	58.4	SMA, dorsal premotor cortex

Hemi = hemisphere; COG=center of gravity; L = left; R = right; STS = superior temporal sulcus; STG = superior temporal gyrus; MTG = middle temporal gyrus; ITS = inferior temporal sulcus; pIns. = posterior insula; SMA = supplementary motor area. All reported results are significant at a statistical threshold of $p < .05$, FWE-corrected. All coordinates are in Talairach space.

Supplementary Methods

Optical flow analysis. To quantify the amount of movement within each video clip used as a stimulus in the neuroimaging experiment, the average optical flow (i.e., the pattern of apparent motion between consecutive video frames) was computed for each video that was shown in the fMRI study. Given that the videos used as stimuli were recorded by a stable camera against a plain, static background, optical flow estimates for these videos capture of the amount that each individual moved his or her facial features and head in the video clip. Farneback's algorithm for motion estimation[2] as implemented in OpenCV[3] was used to estimate the average magnitude of optical flow in each video. This method extracts a pixel-wise motion vector for each pair of sequential frames in which each pixel is characterized by a magnitude and a direction. To estimate the magnitude of motion within each frame pair, the magnitude values (without respect to direction) were summed across pixels. To compute the mean magnitude of optical flow for a given video, the motion magnitude estimates were averaged across frames within that video.

In order to test whether or not individual differences in network constraint are related to movement in the videos used as stimuli, the correlation between network constraint and average motion magnitude was assessed among the 88 individuals whose videos were used as stimuli in the fMRI study. Given that distributions of both variables were highly skewed, data were log-transformed prior to analysis. The results of this procedure suggest that in the stimuli used in the current study, network constraint and amount of movement were not significantly correlated, $r = -0.12$, $p = 0.28$ (see Supplementary Fig. 3).

Post-scan questionnaire. Participants performed the post-scan questionnaire on a 13" MacBook laptop using Psychopy[4]. Participants first viewed an instruction screen that read, *"Now you will see the same people who you saw in the scanner. You will be asked questions about each person. These questions relate only to this person's interactions within the [institution name] MBA cohort. We understand that people have many social circles that they participate in (perhaps including family, friends outside of [the institution], other contacts, etc.). For these questions, please just consider interactions within the MBA cohort. You will be presented with a continuous rating scale for each question. You can choose any point along the continuum to respond. Press any key to continue."* During the survey, videos of the 12 individuals from the participant's stimulus set were presented in a random order. Participants responded to all questions about a given individual sequentially, and the same video that had played in the scanner repeated on a loop (without sound) above the question text and response scale (see Supplementary Fig. 4).

Participants were presented with questions concerning lay definitions of eigenvector centrality (*"In social network analysis, scientists assess a construct that measures how many friends a person has, and how many friends a person's friends have. How would you rate this person on this construct?"* Responses ranged from *"Low (few friends who have few friends)"* to *"High (many friends who have many friends)"*) and constraint (*"Social network analysts also assess a construct called 'brokerage' that* *measures how much a person connects groups of people who wouldn't otherwise be connected. Using this definition, how high is this individual in 'brokerage'?"* Responses ranged from "*Low (this person never connects distinct groups of people*" to "*High (This person often connects distinct groups of people)*"). Responses to the item assessing brokerage were reverse scored in order to estimate perceived network constraint.

Participants were also presented with the name generator that had originally been used to construct the network ("*Consider the people with whom you like to spend your free time. During the last month, is this one of the classmates who you have been with most often for informal friendship activities, such as going out to lunch, dinner, drinks, films, visiting one another's homes, and so on?*" Responses ranged on a continuum from "*None of my social activities in the past month have included this person*" to "*All of my social activities in the past month have included this person*"), as well as questions designed to assess tie strength ("*How close are you with this person?*" Responses ranged from "*Distant*" to "*Less than close*" to "*Close*" to "*Especially Close*") and frequency of interactions ("*On average, how often do you talk to this person (any social or business discussion)*?" Responses ranged from "*Less often*" to "*Monthly*" to "*Weekly*" to "*Daily*").

Supplementary References

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