Mesoscopic functional interactions in the human brain reveal small-world properties

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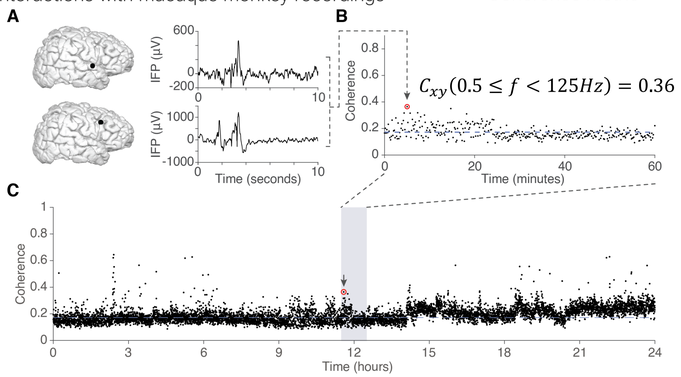
1. Interactions were measured by coherence

A. Superior Temporal gyrus and Pars Opercularis
B. 1 hour segment C. 24 hour segment
Not pictured. Validation against known interactions with macaque monkey recordings

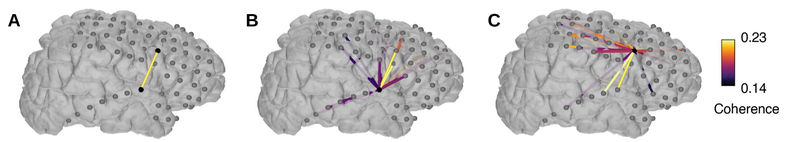
$$C_{xy}(f) = \frac{|G_{xy}(f)|}{\sqrt{G_{xx}(f)}\sqrt{G_{yy}(f)}}$$

Coherence metric



2. Coherences vary by location

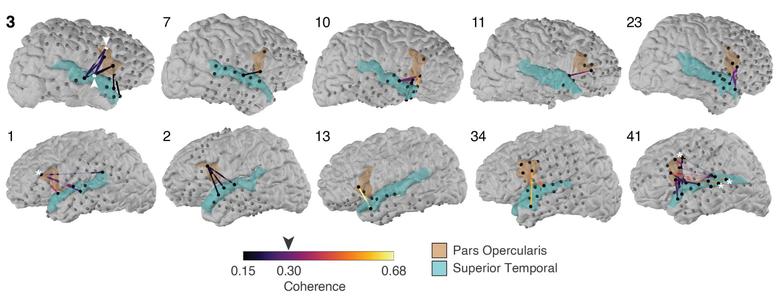
A. Significant coherences averaged over time for electrodes in 1A
B,C. Significant coherences for each individual electrode



20 (27%) of 75 23 (38%) of 60

4. Coherences were consistent across subjects

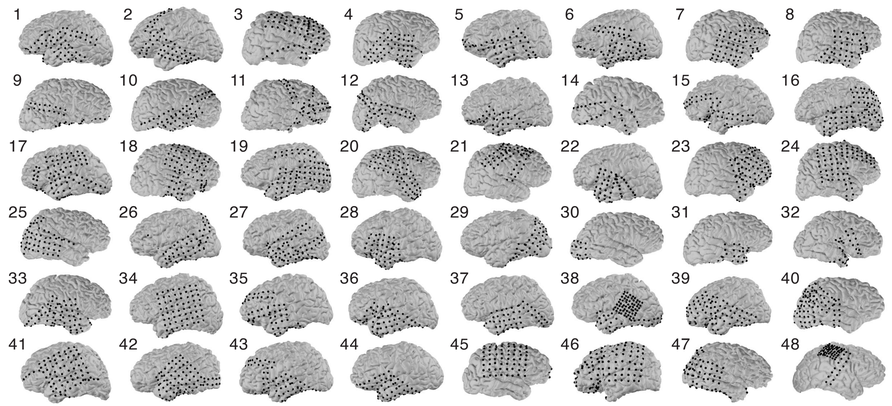
30 of 48 subjects had coverage. 10 of 30 subjects had significant interactions. 49 of 448 electrode pairs (11%) showed interactions. Mean coherence: 0.30±0.13.



Summary

We report "housekeeping" interactions between areas of the human brain using intracranial EEG signals and reveal small-world network properties

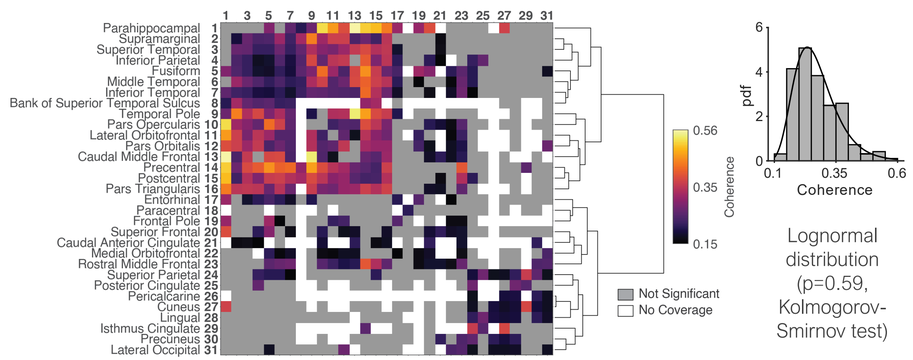
Interactive 3D data viewer and code: braininteractome.com



48 subjects, 4,142 electrodes, 251 days, 148,404 bipolar electrode pairs

5. Coherence matrix followed a lognormal distribution

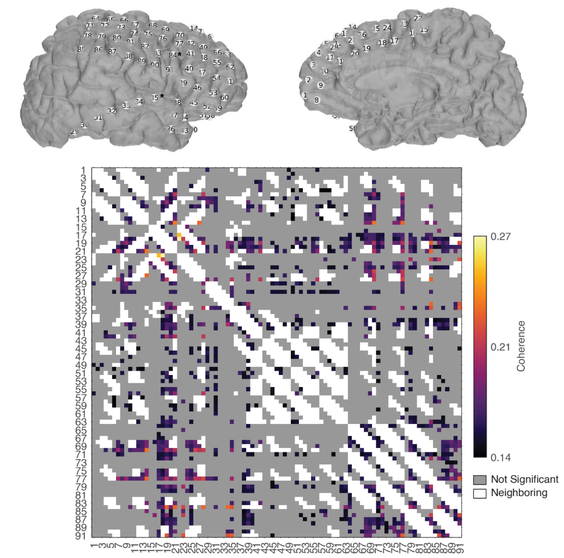
31 out of 36 areas were covered. In total, 465 area pairs (31 choose 2) were examined. Electrode coverage was adequate in 378 area pairs. 193 of 378 (51%) showed significant interactions (*left*). These 193 coherence measurements followed a lognormal distribution (*right*).



Lognormal distribution (p=0.59, Kolmogorov-Smirnov test)

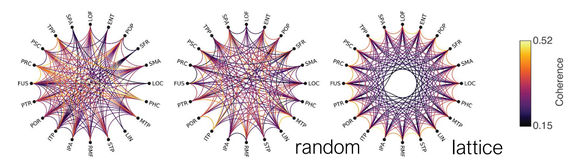
3. Coherences for one subject

Of the 4,095 electrode pairs (91 choose 2), 3,193 pairs (78%) were analyzed. 557 (17%) of these pairs showed significant interactions



6. Small-world properties

Small-worldedness was observed in the subject-averaged network, individual networks, and in a macaque monkey network



	Broadband		Gamma Band	
	Monkeys	Humans	Monkeys	Humans
L	8.82	5.23	8.08	5.34
C	0.57	0.49	0.73	0.53
L_{random}	8.50 (0.03)	4.36 (0.03)	7.87 (0.02)	4.37 (0.03)
$L_{lattice}$	8.85 (0.01)	4.93 (0.004)	8.09 (0.004)	4.92 (0.004)
C_{random}	0.48 (0.01)	0.34 (0.01)	0.58 (0.01)	0.34 (0.01)
$C_{lattice}$	0.49 (0.00)	0.40 (0.00)	0.59 ($4 \cdot 10^{-5}$)	0.42 ($2 \cdot 10^{-5}$)
σ	1.1 (0.03)	1.2 (0.03)	1.2 (0.03)	1.3 ($5 \cdot 10^{-2}$)
ω	–0.190 (0.003)	–0.41 (0.01)	–0.26 (0.002)	–0.44 (0.006)