Complex Networks and Measures of Psychosis
Speech Graphs Provide a Quantitative Measure of Thought Disorder in Psychosis

Natalia B. Mota$^{1,2,3}$, Nivaldo A. P. Vasconcelos$^{1,4,5}$, Nathalia Lemos$^1$, Ana C. Pieretti$^1$, Osame Kinouchi$^6$, Guillermo A. Cecchi$^7$, Mauro Copelli$^8$, Sidarta Ribeiro$^1$

1 Brain Institute, Federal University of Rio Grande do Norte, Natal, Brazil, 2 Hospital Onofre Lopes, Federal University of Rio Grande do Norte, Natal, Brazil, 3 Edmond and Lily Safra International Institute of Neuroscience of Natal, Natal, Brazil, 4 Faculdade Natalense para o Desenvolvimento do Rio Grande do Norte, Natal, Brazil, 5 Department of Systems and Computation, Federal University of Campina Grande, Campina Grande, Brazil, 6 Department of Physics, Universidade de São Paulo, Ribeirão Preto, Brazil, 7 Biometaphorical Computing, Computational Biology Center, IBM Research Division, IBM T. J. Watson Research Center, Yorktown Heights, New York, United States of America, 8 Department of Physics, Federal University of Pernambuco, Recife, Brazil
What is Psychosis?

- Psychosis: loss of contact with reality.
- Can arise from schizophrenia or mania.
- Schizophrenia: failure to understand what is real.
- Mania: abnormally elevated state of arousal, mood or energy level
Problems with diagnosis?

- Look for symptoms
- Relies on psychiatric interviews
- Qualitative analysis of body and verbal language

Common criticisms:
- Too qualitative
- Not very scientific
- Too subjective
Solution: Complex Networks

- Quantitative Speech Analysis.
- Subjects were asked to talk about a dream.

A

I / walked / into a place, / and I / found / my grandma. / I / hugged / her / strongly, / I / woke up.

- About dreaming
- About waking

B

Diagram showing network connections between words like 'walked', 'found', 'hugged', and 'woke up'.
Quantitative Speech Analysis

- Networks are directed
- Self-loops allowed
- Multiple edges allowed

A

I walked into a place, and I found my grandma. I hugged her strongly, I woke up.

- **Blue**: About dreaming
- **Red**: About waking

B
Types of Psychoses studied

Schizophrenia

not
saw
Jesus

sometimes
for me
laughing
appears
crying

Control

alone
leave
stirring

way
slipped
fell

water
barrier

Mania

dream

man

am

replied
did

to

bought

Week

never liked

assumed

family

commitment

time

two hours

had

took

reached

money

carpet

wore

corner

sample

pocketful

Godfather

first

need

was

remained

particularly

who

gave

fixed

born

had

unwanted

shopping

cement

dreamed

worked

know

sudden

wanted

money

corner

bought

bought

bought

bought
Measures

- Number of Nodes
- Number of Edges
- Size of largest component
- Number of edges of largest component
- Average total degree
- Number of parallel edges
- Number of loops with 1, 2 and 3 nodes
- Number of waking nodes and edges
- Diameter
- Average shortest path between pairs of nodes
- N: Number of Nodes
- E: Number of Edges
- ATD: Average total degree $<k>$
- LLC: Size of largest component
- PE: Number of parallel edges
- L1, L2, L3: Number of loops with 1, 2 and 3 nodes
- WN: Number of waking nodes
- WE: Number of waking edges
Normalized Data
Conclusions from network data

- Manics statistically talk more, have more parallel edges, self-loops, loops, waking edges, and higher average degree than schizophrenics.
- Maniacs are prone to “flights of thought” and “logorrhea”.
- Statistical differences are consistent.
What does this mean?

- Future of Psychology/Psychiatry
- Systematization of psychology
- Deep Learning / Artificial Intelligence
- Will computers replace therapists for diagnostic purposes?