Space of Dream Data through the Lens of Multilevel Graph

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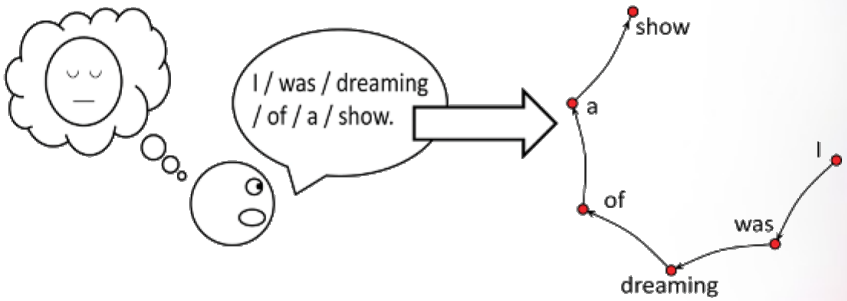
Existing literature



Existing literature

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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*]

npj Schizophrenia www.nature.com/npjschz

ARTICLE OPEN

Thought disorder measured as random speech structure classifies negative symptoms and schizophrenia diagnosis 6 months in advance

Natália B. Mota[1], Mauro Copelli[2] and Sidarta Ribeiro[1]

SCIENTIFIC REPORTS

OPEN

Graph analysis of dream reports is especially informative about psychosis

Natália B. Mota[1], Raimundo Furtado[1], Pedro P. C. Maia[1], Mauro Copelli[2*] & Sidarta Ribeiro[1*]

SUBJECT AREAS: APPLIED PHYSICS HUMAN BEHAVIOUR DIAGNOSTIC MARKERS

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* Shared corresponding authorship.

Early psychiatry investigated dreams to understand psychopathologies. Contemporary psychiatry, which neglects dreams, has been criticized for lack of objectivity. In search of quantitative insight into the structure of psychotic speech, we investigated speech graph attributes (SGA) in patients with schizophrenia, bipolar disorder type I, and non-psychotic controls as they reported waking and dream contents. Schizophrenic subjects spoke with reduced connectivity, in tight correlation with negative and cognitive symptoms measured by standard psychometric scales. Bipolar and control subjects were undistinguishable by waking reports, but in dream reports bipolar subjects showed significantly less connectivity. Dream-related SGA outperformed psychometric scores or waking-related data for group sorting. Altogether, the results indicate that online and offline processing, the two most fundamental modes of brain operation, produce nearly opposite effects on recollections. While dreaming exposes differences in the mnemonic records across individuals, waking dampens distinctions. The results also demonstrate the feasibility of the differential diagnosis of psychosis based on the analysis of dream graphs, pointing to a fast, low-cost and language-invariant tool for psychiatric diagnosis and the objective search for biomarkers. The Freudian notion that "dreams are the royal road to the unconscious" is clinically useful, after all.

Differential diagnosis in psychiatry is more often than not a difficult task, unsupported by objective tests and necessarily performed by experts[1]. Standard psychiatric diagnosis has been harshly criticized, despite century-old efforts towards an accurate classification of mental illnesses[1–4]. Multi-site and cross-cultural expert agreement is low, most diseases do not have unequivocal biomarkers, and clear-cut distinctions between certain maladies may be unwarranted[5,6]. For instance, subjects with schizophrenia or bipolar disorder type I may share several positive psychotic symptoms such as hallucinations, delusions, hyperactivity and aggressive behavior[7].

The development of quantitative methods for the evaluation of psychiatric symptoms offers hope to overcome this foggy scenario[8,9]. In particular, we have recently shown that the graph-theoretical analysis of dream reports produced by psychotic patients can separate schizophrenic from manic subjects[10]. This was possible because their speech features are usually quite different. Schizophrenic subjects frequently display negative symptoms including alogia, i.e. they speak laconically and with little digression[7,10]. Subjects with bipolar disorder, especially during the manic stage, tend to present the opposite symptom called logorrhea, with much recursiveness in association with positive symptoms[7,11]. These differences in symptomatology led us to hypothesize that schizophrenic and bipolar subjects would produce less connected word graphs than control subjects, in correlation with negative symptoms. It also remains unsettled whether dream reports are crucial for the differential diagnosis of psychosis, as early psychiatrists would have sustained[1,3,12], or whether waking contents are equally informative.

To elucidate these issues, we quantified the speech graph attributes (SGA; Figure 1a, Figure 2) of dream and waking reports obtained from clinical oral interviews of schizophrenic, bipolar type I, and control subjects (Supplementary Table S1). Using a Bayesian classifier, we compared the differential diagnosis of psychosis provided by dream-related SGA, waking-related SGA or standard psychometric scores. Translation of the reports into five major Western languages was performed to assess language-related variations.

Results

Speech samples were recorded during psychiatric interviews as answers to two different requests: "Please report a recent dream" and "Please report your waking activities immediately before that dream". Each report was transcribed and represented as a speech graph, in which every word represented a node, and every temporal connection between consecutive words represented an edge. The visual inspection of speech graphs suggests that dream reports (Figure 1b) vary more across groups than waking reports from the same subjects (Figure 1c).

SCIENTIFIC REPORTS | 4 : 3691 | DOI: 10.1038/srep03691 1

"In chronic psychotic patients, word graph analysis shows potential as ***complementary psychiatric assessment****."*

"The results demonstrate the feasibility of the differential diagnosis of psychosis based on the analysis of dream graphs, pointing to a ***fast, low-cost and language-invariant tool*** *for psychiatric diagnosis and the* ***objective search for biomarkers****."*

"The results also show that ***dream reports are substantially more informative*** *about the mental state of psychotic subjects than waking reports."*

Sources of dreams

Sources of dreams

DreamBank
www.dreambank.net

Query: I Search [HELP]

Dream series:
David: teenage dreams [n=166]
Detlev von Uslar, auf Deutsch [n=6100]
Dorothea: 53 years of dreams [n=900]
Edi: dreams of his late wife [n=143]
Edna: a blind woman [n=19]
Elizabeth: a woman in her 40s [n=1707]
Emma's Husband [n=72]
Emma: 48 years of dreams [n=1221]
Esther: an adolescent girl [n=110]
German dreams (F) [n=397]

Filters F M any ind. coll. all [clear]

more info [ALL info]

Matching mode: AND OR subtotals
Case-sensitive? Yes No
Results display: Lists Table Contingency
Consistency chart: n= 100 Numbers Graphs

Dream series: **Emma: 48 years of dreams**
Query: **I**
Search mode: **find all terms (AND)**
Case-sensitive: **no**

Number of dreams searched: 1221
(Search took 0 seconds.)

	I
Emma: 48 years of dreams [n=1221]	1221 (100.0%)

1949-001 1949-002 1949-003 1950-001 1950-002 1950-003 1950-004 1950-005 1950-006 1950-007 1950-008 1950-009 1950-010 1950-011 1950-012 1950-013 1950-014 1950-015 1950-016 1950-017

Show dreams
Abbreviate dreams
Highlight matches
Count words

Emma: 48 years of dreams

I (1038 dreams)

Redisplay: Full dreams Abbreviated dreams Highlight matches Count words

(Click here to jump to the bottom of the list)

#1949-001
We are standing in front of a hotel at a resort and we have to take a boat to another beach where it is 'calm,' but there is a big storm with breakers out at sea and there are French doors closing off the exit from the boat house to the sea. I remember holding the doors closed against the onslaught of the breakers. Later everyone has to leave the boat house and then, in a few minutes, a huge wave tears the boat house away and whips it out to sea. Only the boatman and a few stragglers remain and they are eventually saved. We must stay at a hotel. (111 words) [CODINGS]

#1949-002
Dr. Brooke (thesis advisor) asks me to go to a night club called "Iowa Park" where they usually drink till 4 AM. I don't want to go but he said that he would not look at my paper otherwise. He even buys me a tiara! Shift: Mother is still alive (she died 4/13/47). She prevents me from going. She is jealous and she wants me to help her clean the house. (71 words) [CODINGS]

#1949-003
I am a queen: much admired. M. (lover) is at my side and service. Feeling of ultimate achievement. Shift: Mrs. Jones (professor and supervisor) has died. Mr. Jones is very bereft. I offer him help and services. Much ado about it all. The newspapers carry headlines and are tacked up all along the corridor of the psychology department. Bouquets of flowers sent. General feeling of sorrow. I am consulted by Mr. Jones about the funeral arrangements and then offer to go to live with him in his house as I am divorcing Edward (first husband). (95 words) [CODINGS]

#1950-001
Driving to mountains with Edward; we go ahead while mother-in-law and my father follow. Father is in a hearse, dragged along the ground by a truck. He said he liked it that way. W. and I have a regal meal but W. forgets to give some to father. I insist even though I realize that he really is dead already. (Reality: he died 1949). Shift: I meet K. (old lover); we drive together and then walk down the mountain. We find a spot that was 'only waiting to be painted by Cezanne (very vivid impression). It is a Doge-like palace in yellow and greens in Cezanne's style. A house by the sea. K. and I swim in this warm water standing on a sand bar and gradually pushes us back against the house; also see my brother somewhere in the background of the house. Shift: I invite K. to stay at our place in L. City telling him that no one will be there, but when we arrive Mrs. L. (our renter) is asleep and father is in my brother's bedroom. Therefore K. is 'forced' to stay with me in my bed. Remember only a few kisses. In the morning father worrying about Mrs. L.'s political views. (207 words) [CODINGS]

#1950-002
Parents 'come to life' out of the grave, despite having been cremated. Father looks the same and mother tries to run my life again. They don't seem astonished. I understand that Forest Lawn is being sued for burying them alive! Shift: I walk along a ramp with A.S. (University instructor) and think of him as my therapist. He says, "In two years mother's cancer could have been cured," but he can't explain it. He is very understanding. At home mother sees a daughter born after mother's death and she says: "So that is what you have been up to." Much commotion and people. Feeling of incredulity: how could it have happened? But no guilt. (114 words) [CODINGS]

An Arlie's dream

"I am at a lake in my hometown. Something is going on there and we are in a hurry to get away. We get in a station wagon and have a hard time getting two pet deer, with the same names as my son and daughter, corralled. Finally we get them into the vehicle and we are almost all the way out when the wheel goes off one side of the road and the vehicle is stuck and the deer is about halfway out. At this point I notice my mother-in-law is cutting off a Christmas tree which is growing in the water at the end of the dock."

An Arlie's dream

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STOPWORDS REMOVAL

An Arlie's dream

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LEMMATIZATION

An Arlie's dream

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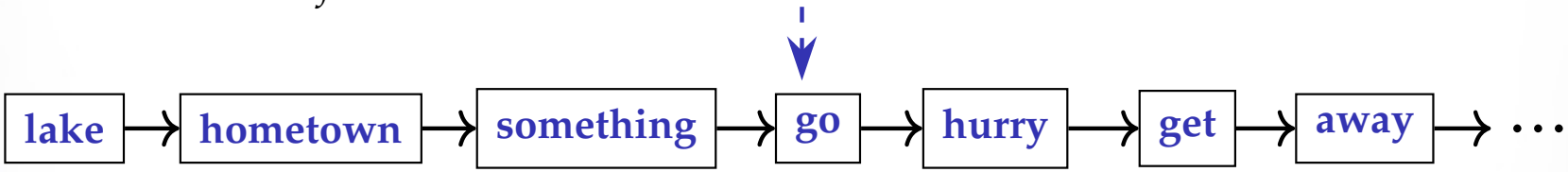

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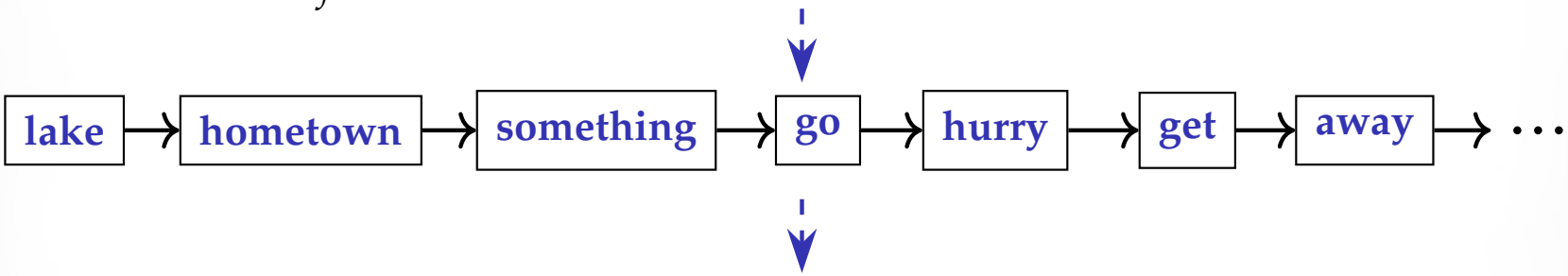

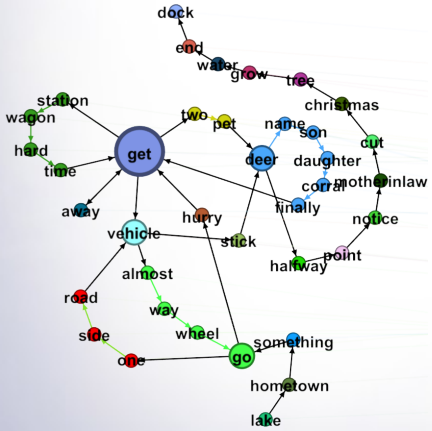

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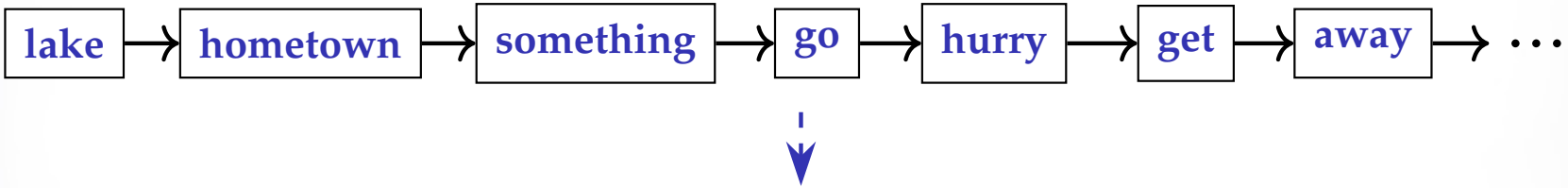
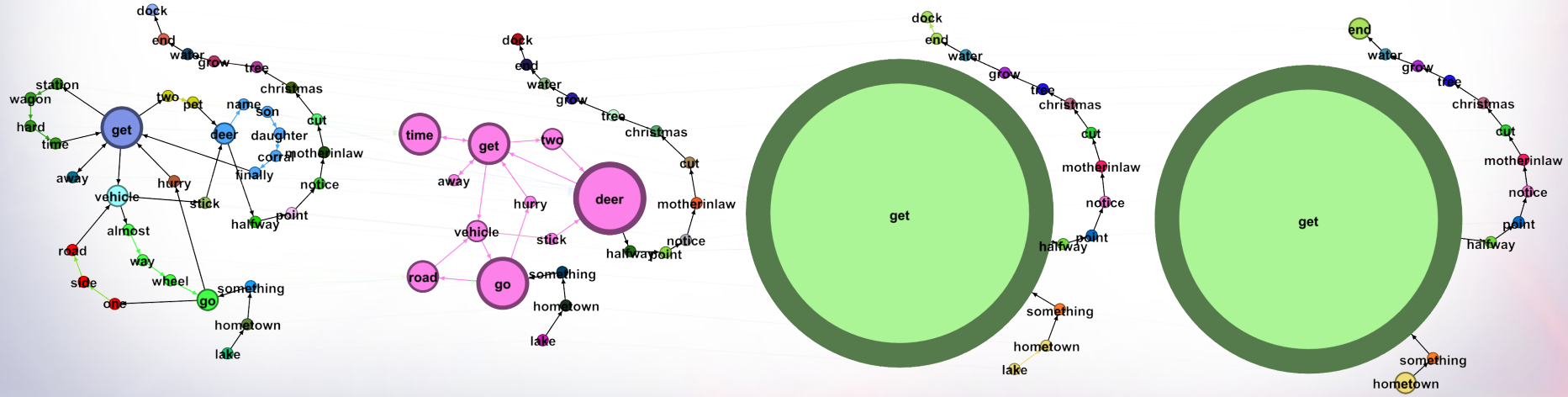
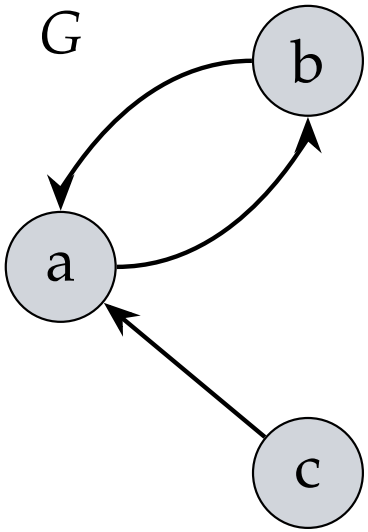




Graphs

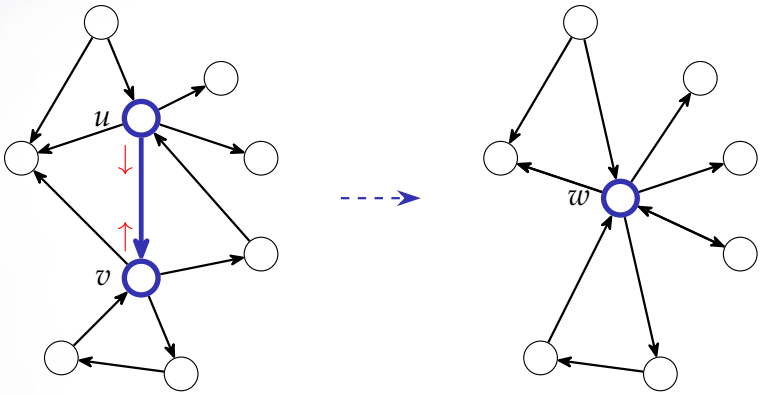


$$G = (V, E)$$

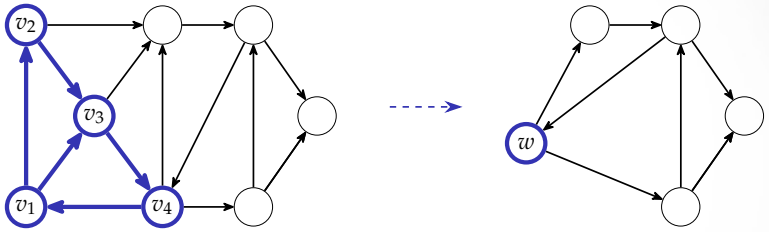
$$V = \{a, b, c\}$$
$$E = \{(a, b), (b, a), (c, a)\}$$

Graph contraction

Edge contraction



Subgraph contraction



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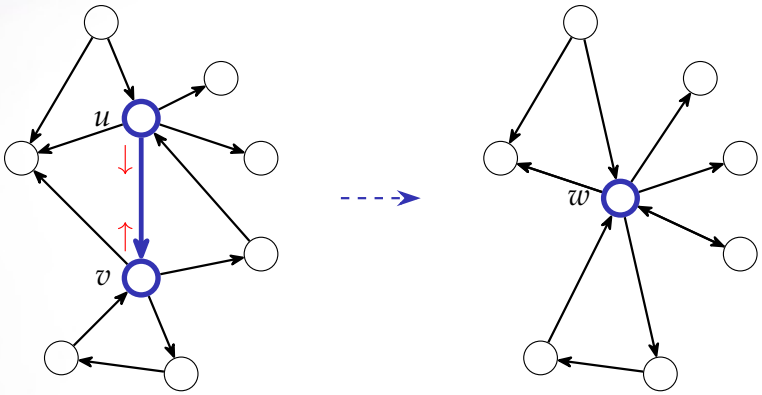

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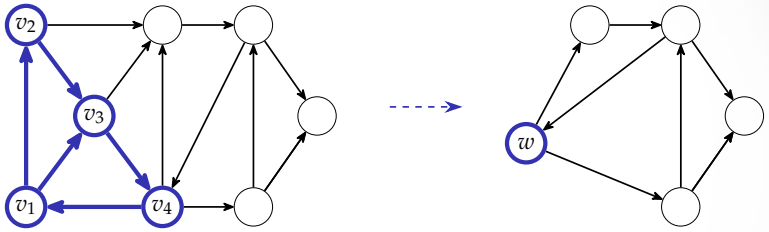
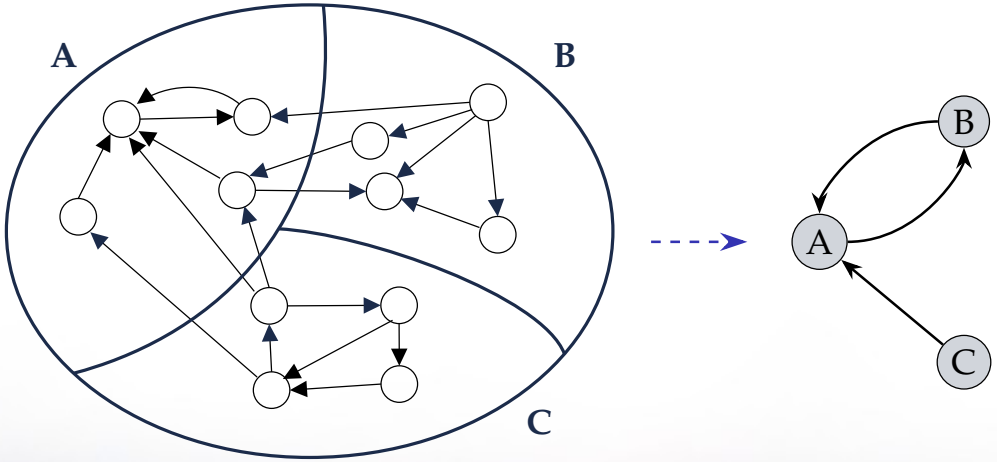


Quotient graph



Multilevel graph

Definition (Multilevel graph)

A **multilevel graph** M is a couple (G, Γ) where:

- $G = (V, E)$ is a graph;
- $\Gamma = \langle f_{C_1}, f_{C_2}, .., f_{C_k} \rangle$ is a sequence of contraction functions.

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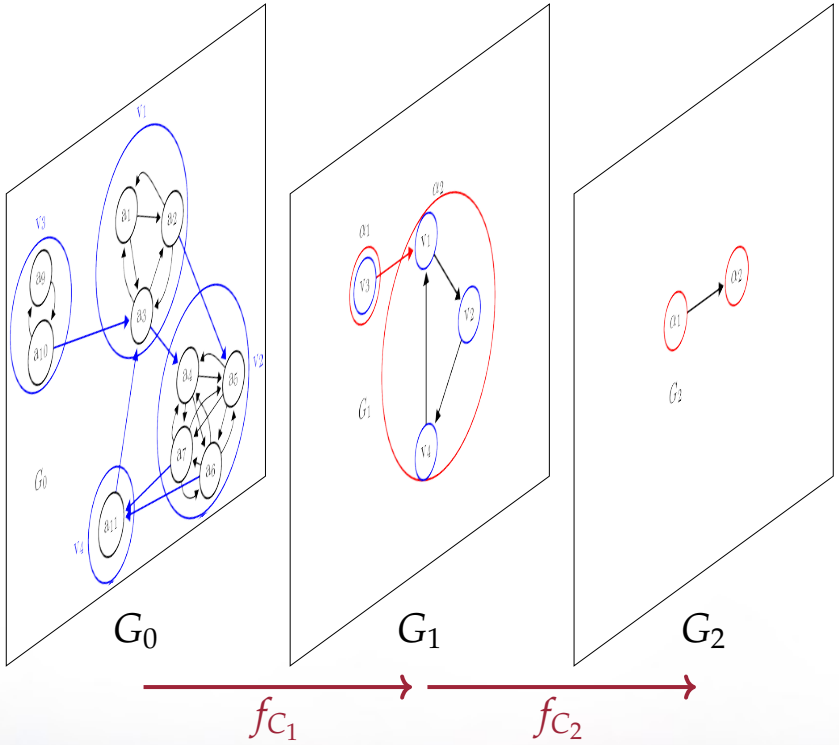

Contraction schemes

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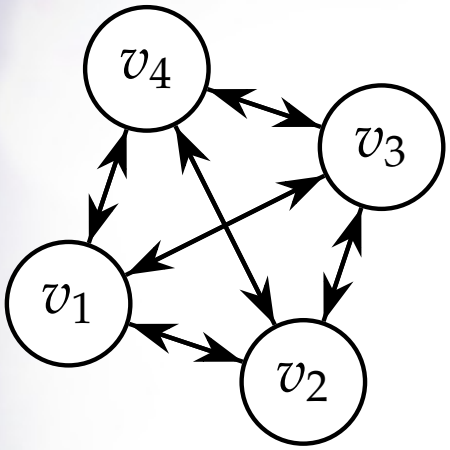

Cliques

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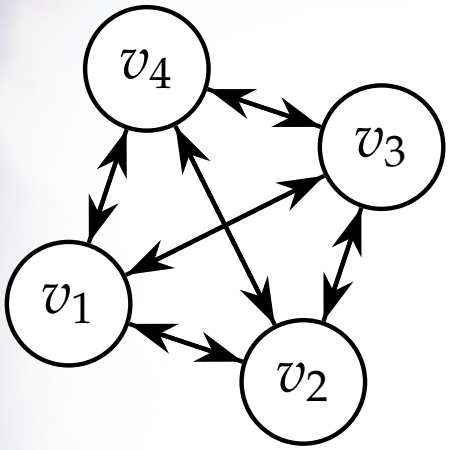

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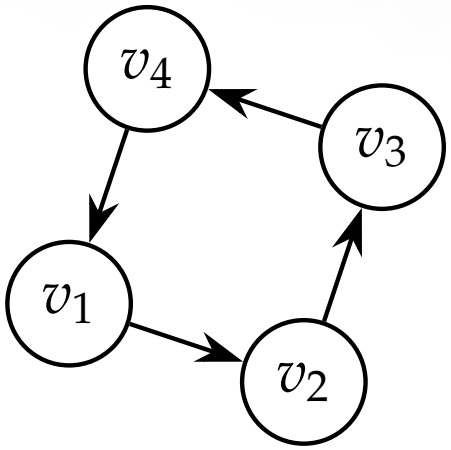
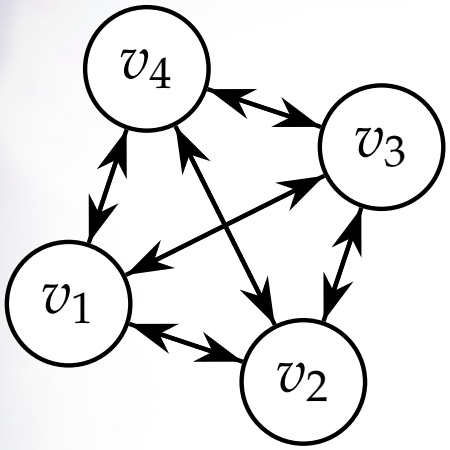


Simple cycles

Contraction schemes



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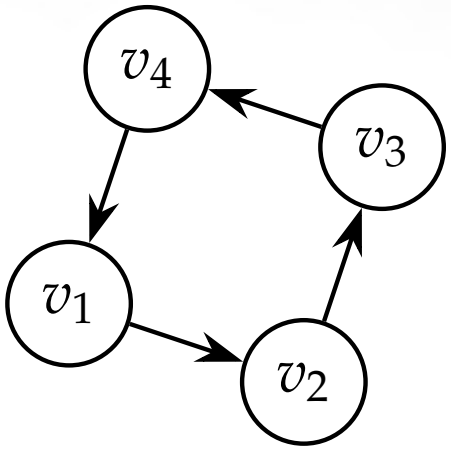

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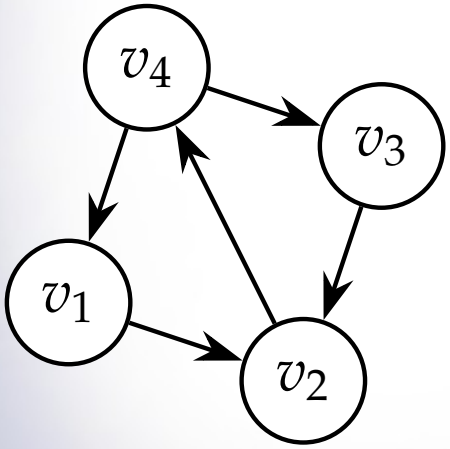
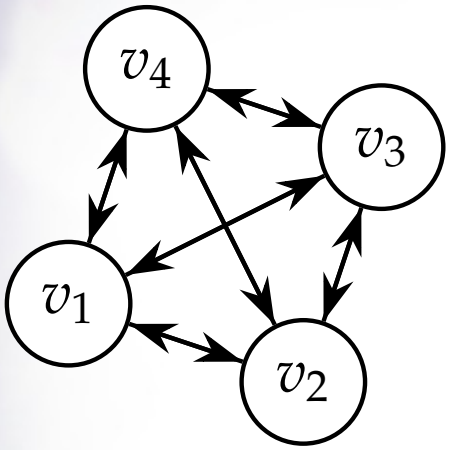


Strongly connected components

Contraction schemes



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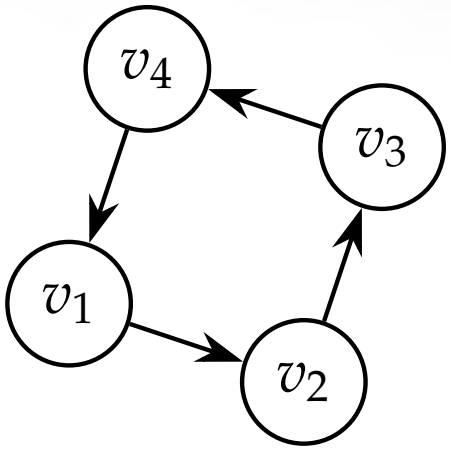

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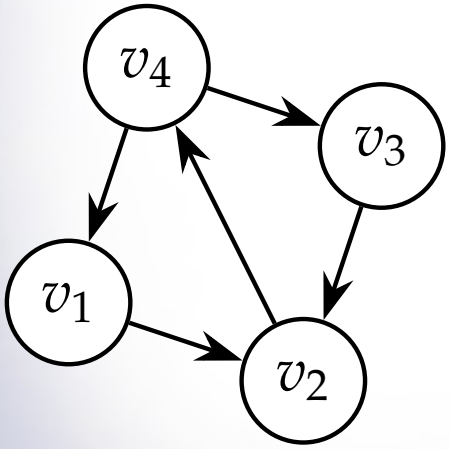

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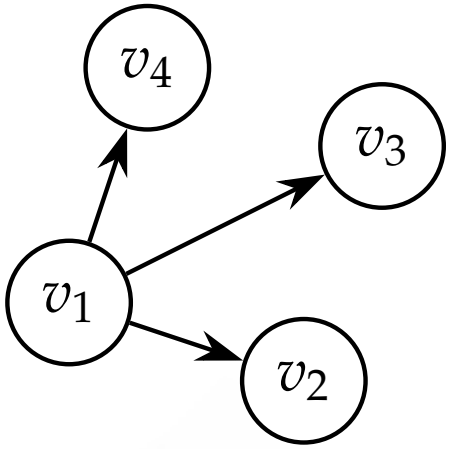
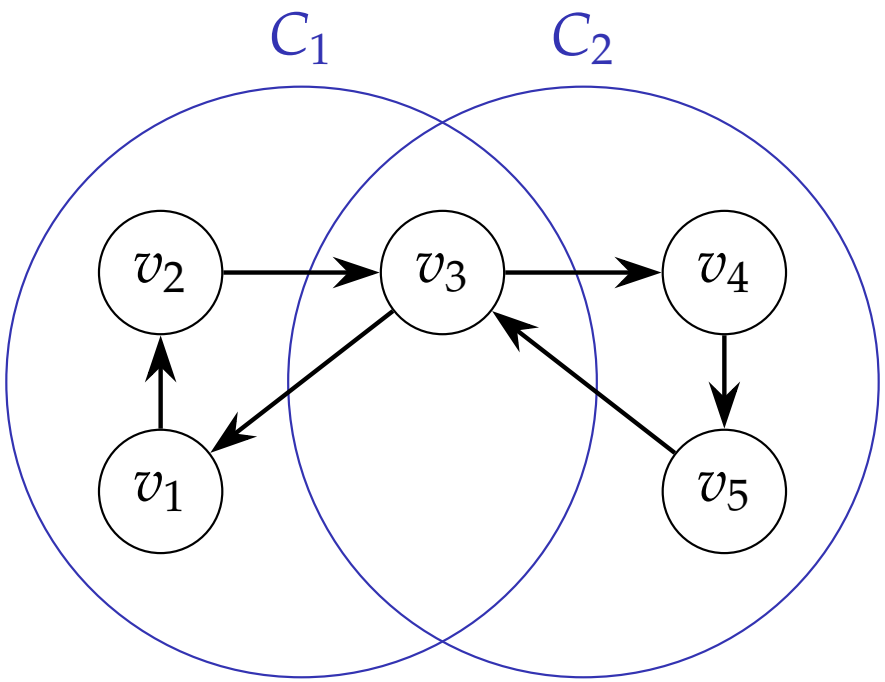
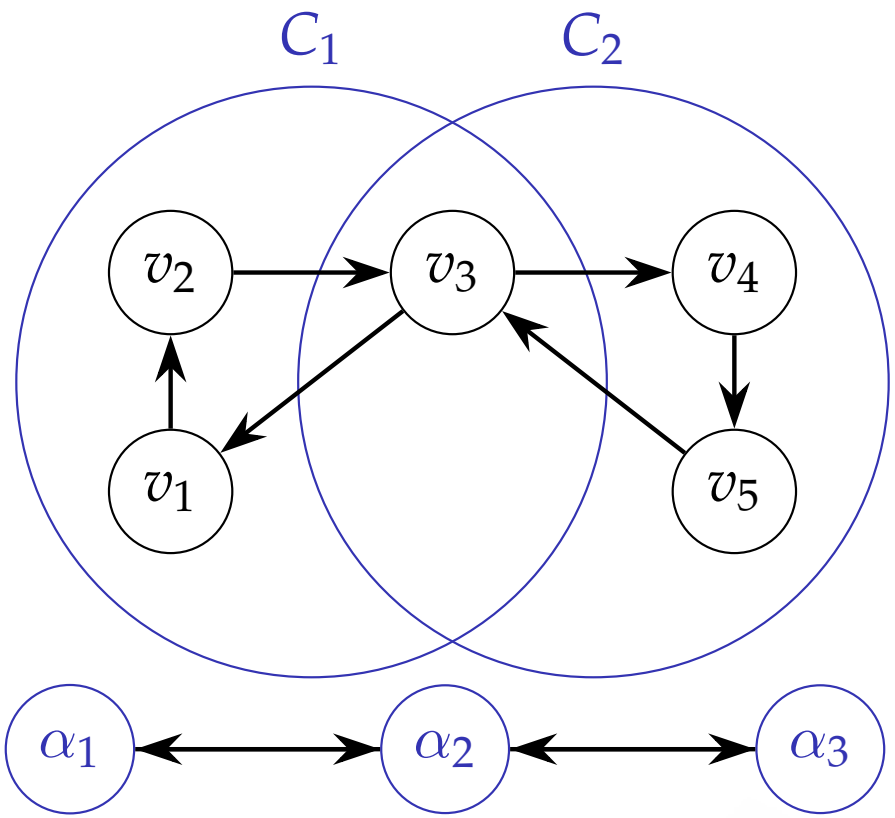


Stars

Subsets contraction



Subsets contraction



Syntactic analysis of dreams

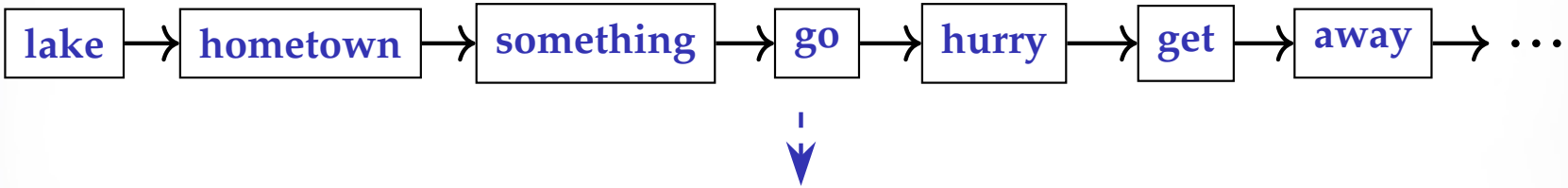
The aim is to examine the typical syntactic structure of individual dreams of a particular dreamer, with possible implications related to mental health.

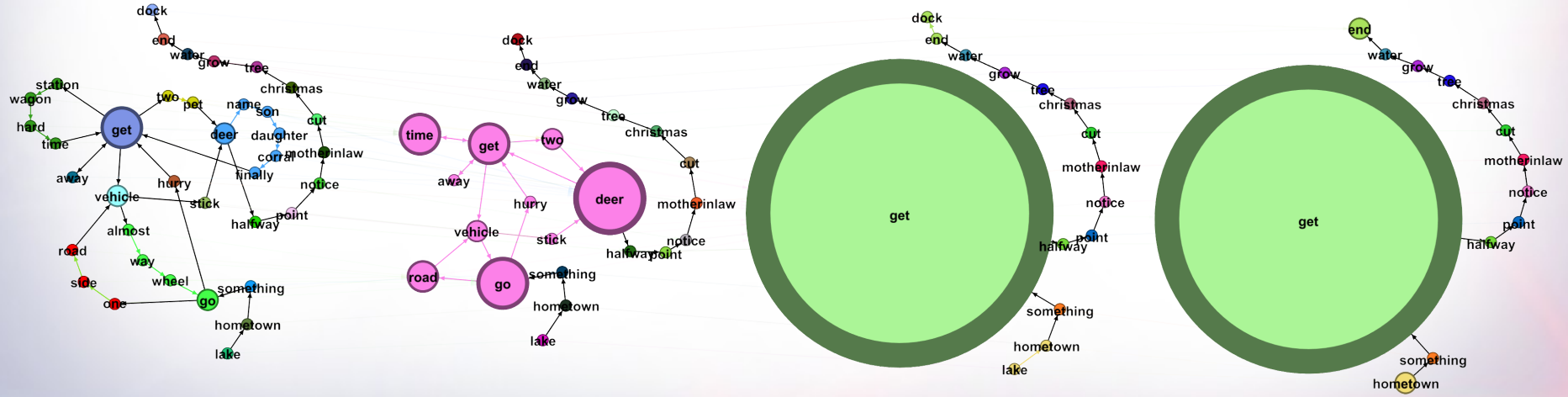
An Arlie's dream

"~~I~~ ~~am~~ ~~at~~ ~~a~~ lake ~~in~~ ~~my~~ hometown. something ~~is~~ go ~~on~~ ~~there~~ ~~and~~ ~~we~~ ~~are~~ ~~in~~ ~~a~~ hurry ~~to~~ get away. ~~We~~ get ~~in~~ ~~a~~ station wagon ~~and~~ ~~have~~ ~~a~~ hard time get two pet deer, ~~with~~ ~~the~~ ~~same~~ name ~~as~~ ~~my~~ son ~~and~~ daughter, corral. finally ~~we~~ get ~~them~~ ~~into~~ ~~the~~ vehicle ~~and~~ ~~we~~ ~~are~~ almost ~~all~~ ~~the~~ way ~~out~~ ~~when~~ ~~the~~ wheel go ~~off~~ one side ~~of~~ ~~the~~ road ~~and~~ ~~the~~ vehicle ~~is~~ stick ~~and~~ ~~the~~ deer ~~is~~ ~~about~~ halfway ~~out~~. ~~At~~ ~~this~~ point ~~I~~ notice ~~my~~ mother-in-law ~~is~~ cut ~~off~~ ~~a~~ christmas tree ~~which~~ ~~is~~ grow ~~in~~ ~~the~~ water ~~at~~ ~~the~~ end ~~of~~ ~~the~~ dock."

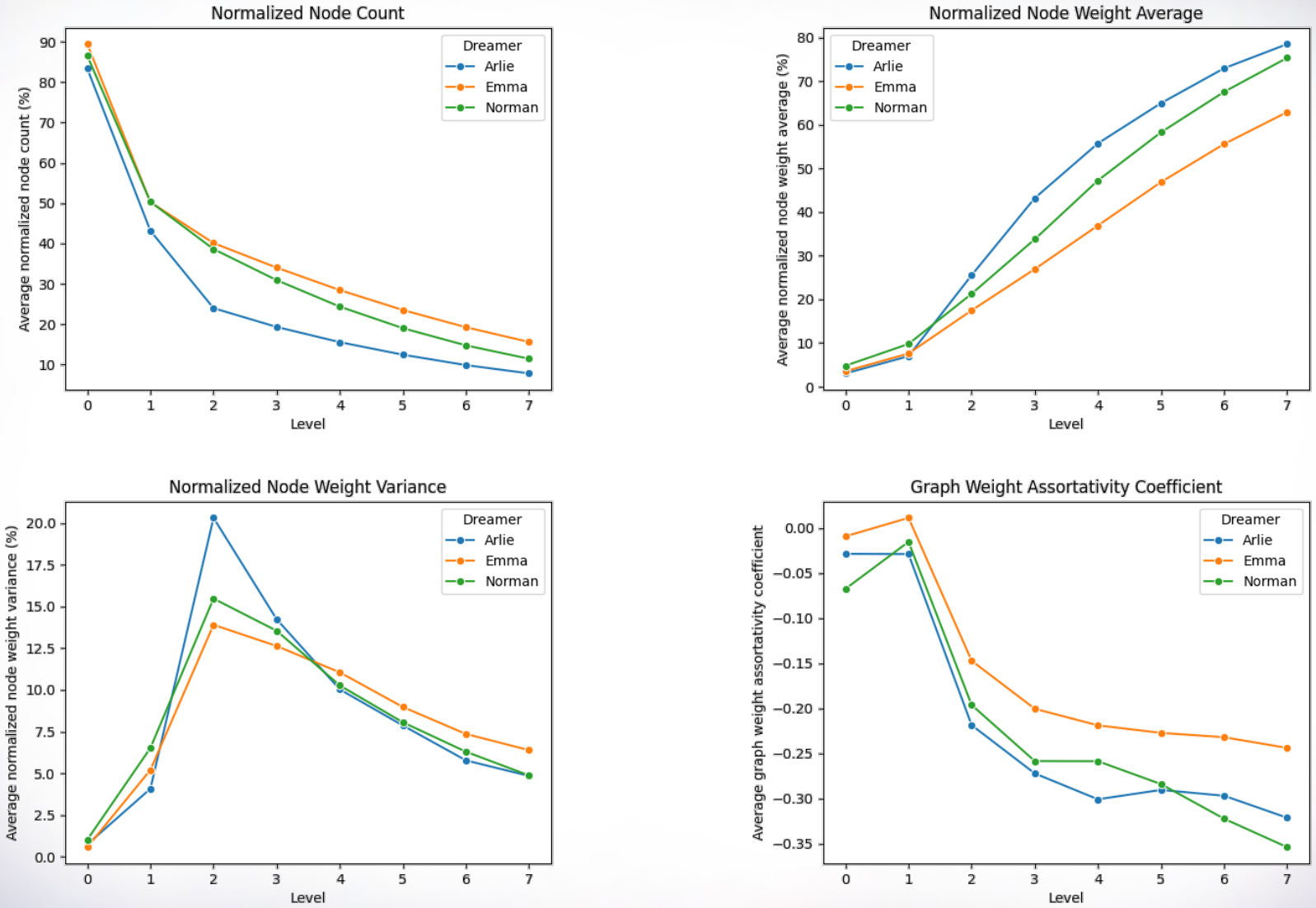
STOPWORDS REMOVAL

LEMMATIZATION

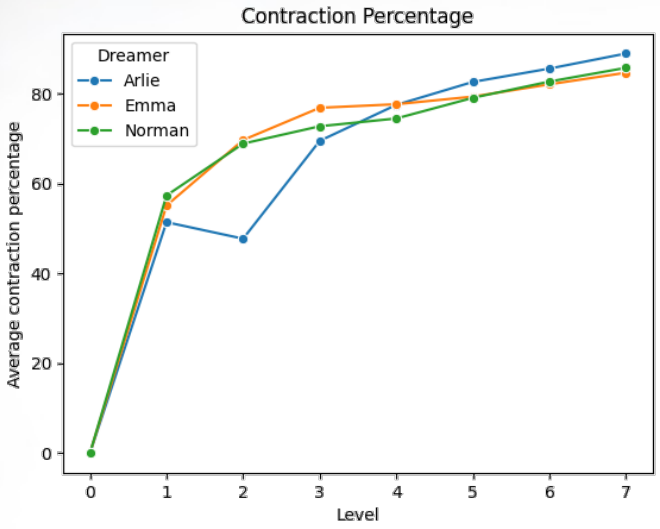


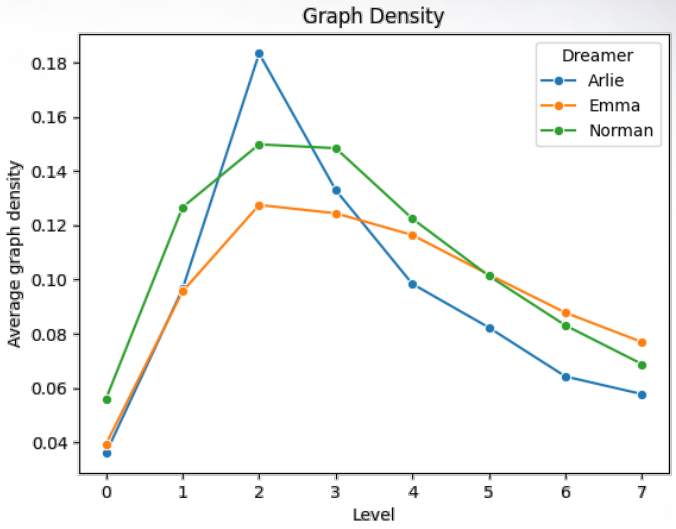


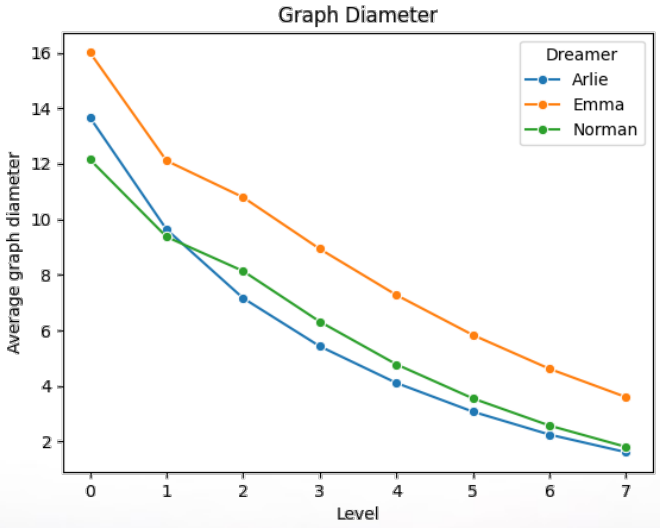
Arlie, Emma and Norman results



Arlie, Emma and Norman results



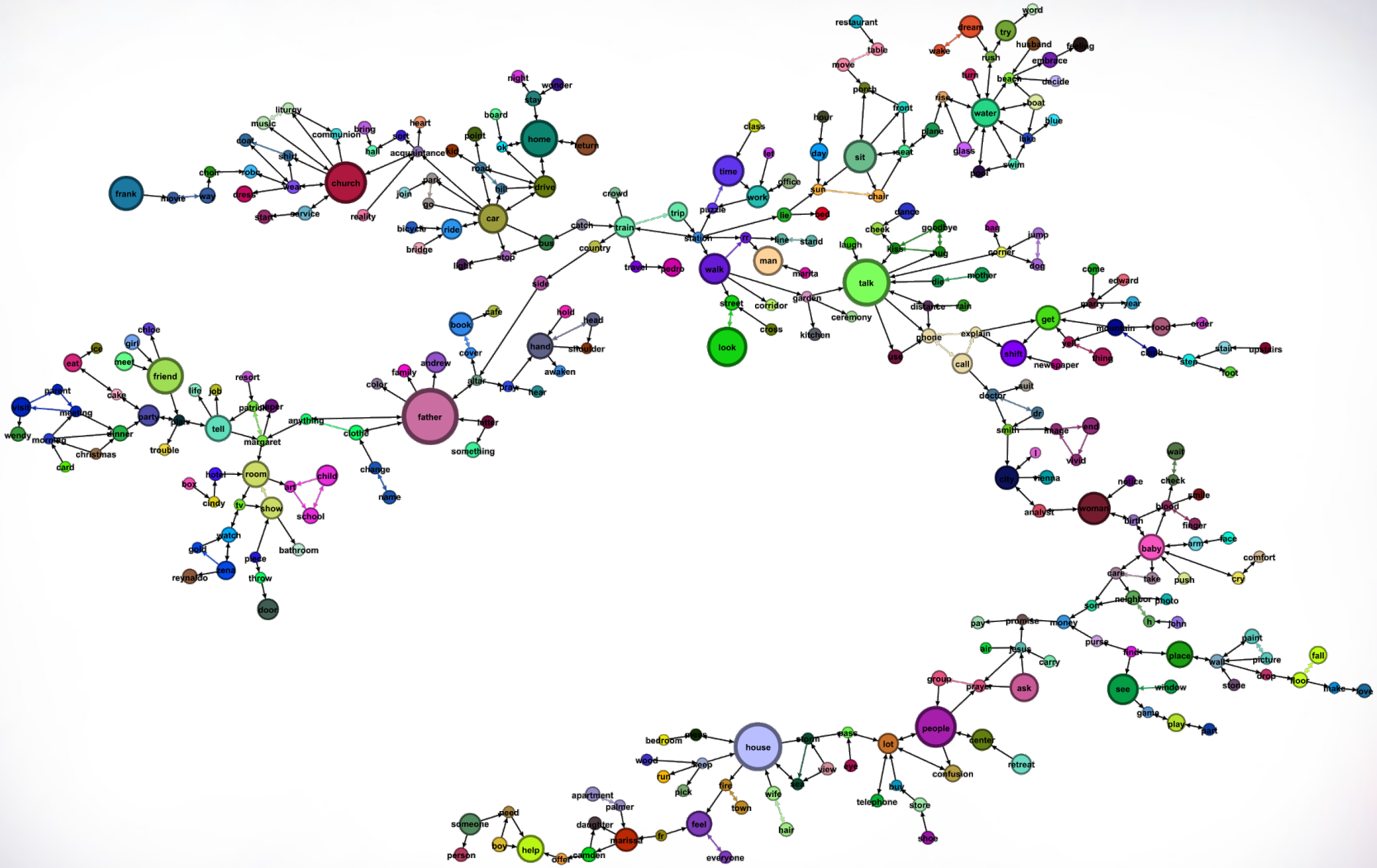




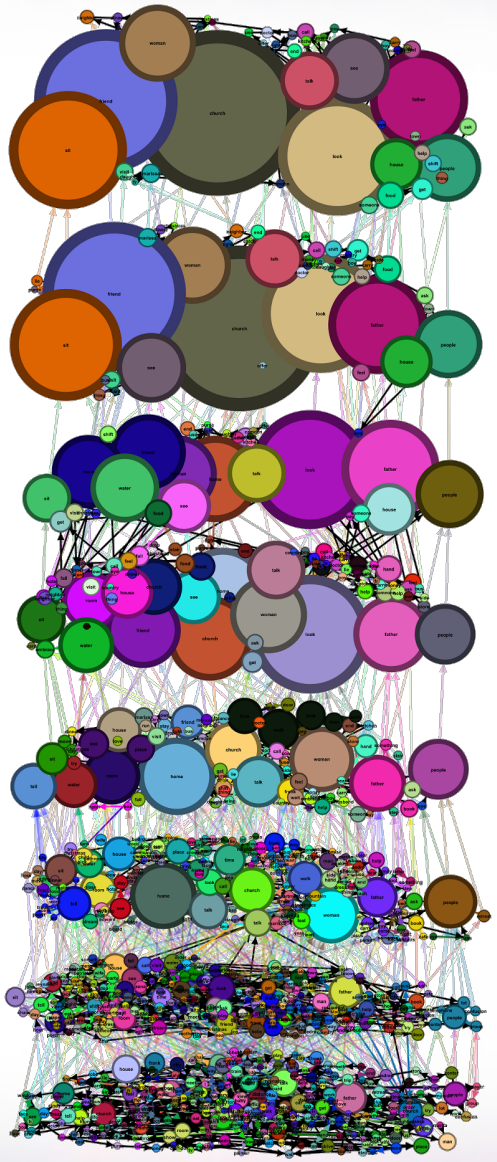
Semantic analysis of dreams

The aim is to build a multilevel semantic space of words that depicts the content themes in a collection of dreams of a particular dreamer.

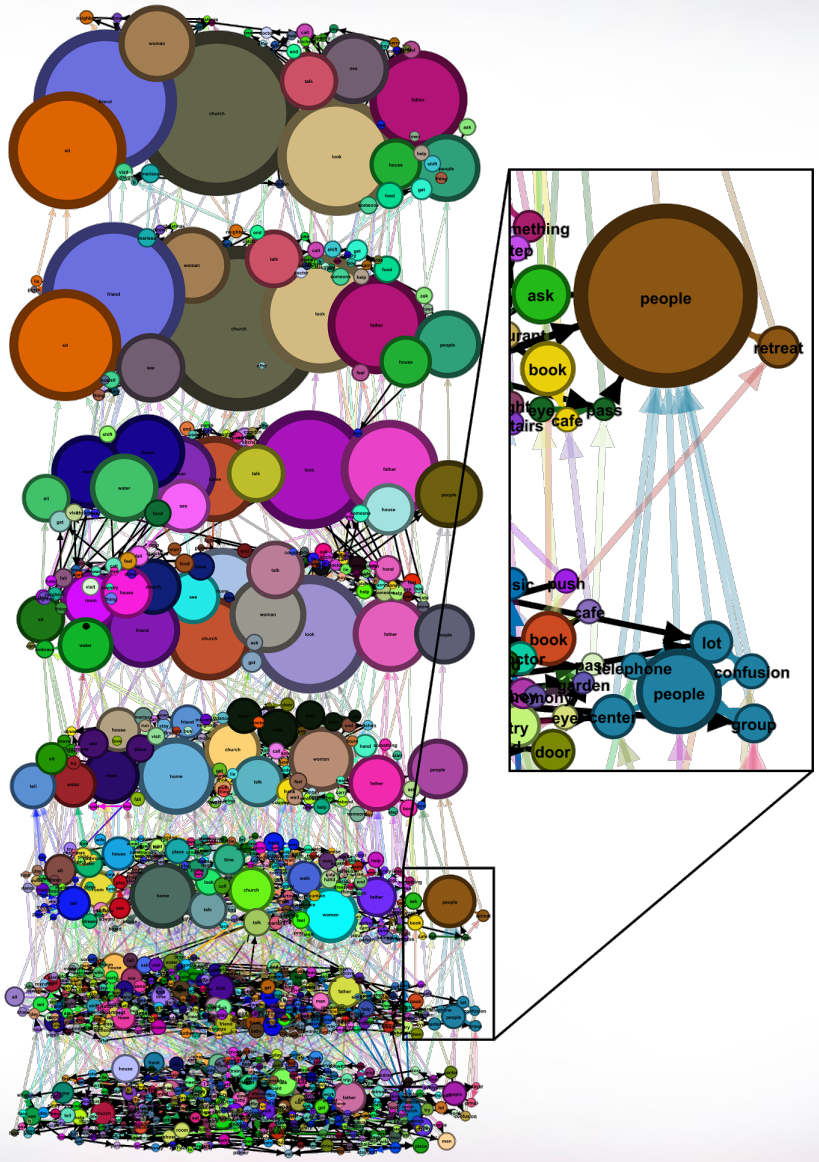
Emma's graph


church
home
car
drive
train
station
walk
time
work
man
talk
look
sit
water
friend
tell
father
hand
room
show
house
people
lot
feel
help
get
shift
call
phone
baby
woman
place
see
ask

Emma's multilevel graph



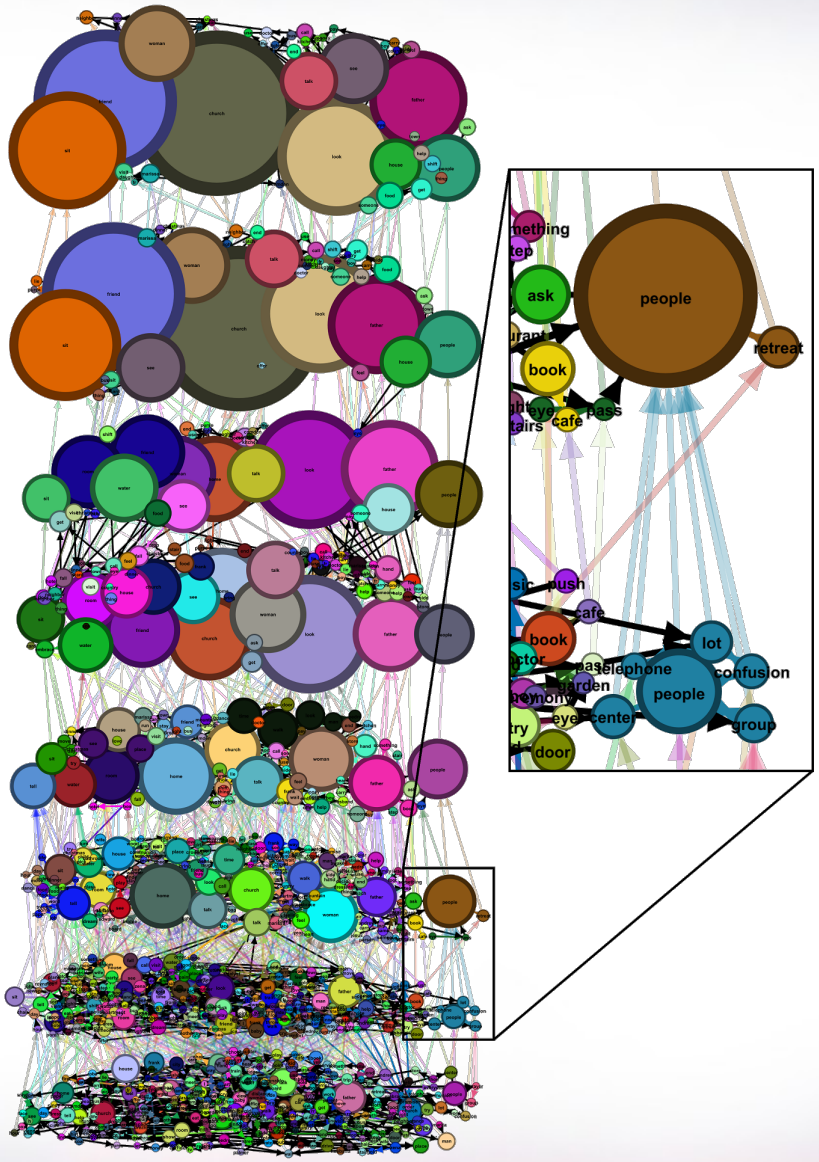
Emma's multilevel graph



Emma's multilevel graph

Examples of cycles

- "cake"-"party"
- "boat"-"lake"-"water"
- "trip"-"train"-"station"
- "road"-"car"-"drive"-"hill"
- "liturgy"-"church"-"music"



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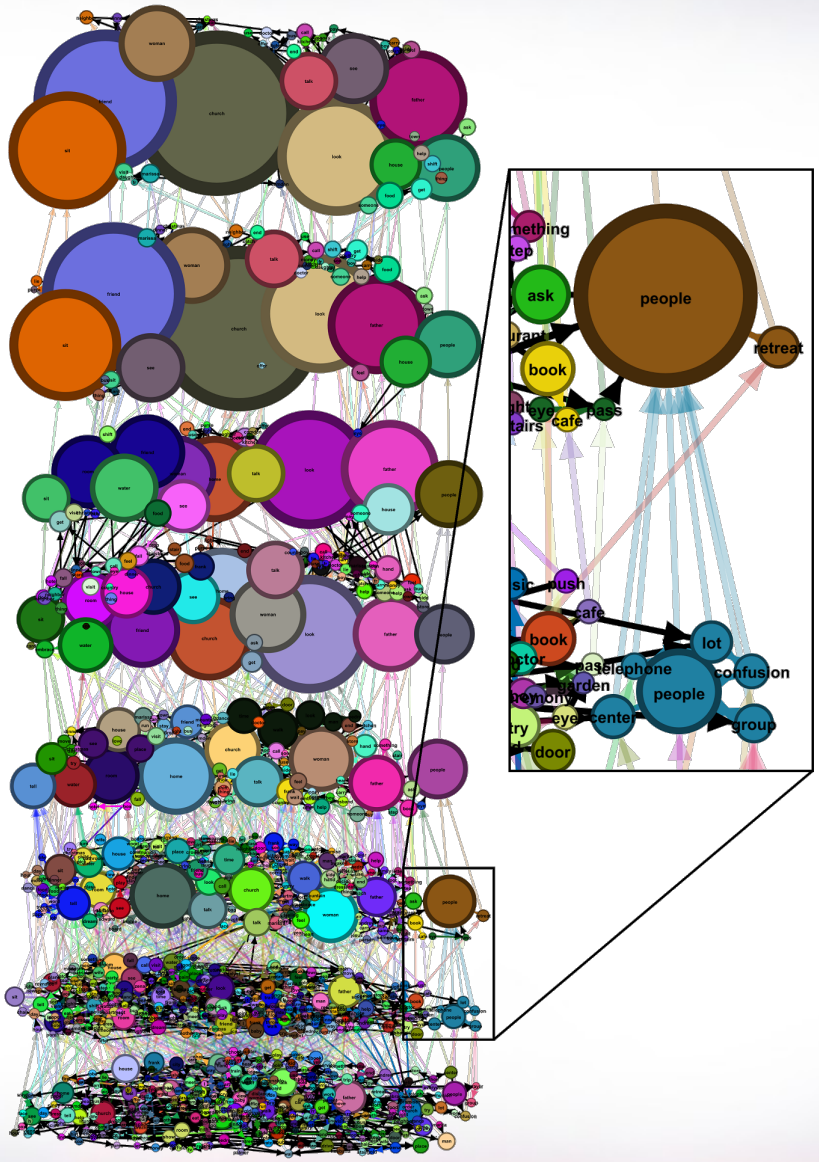
- "liturgy"-"church"-"music"

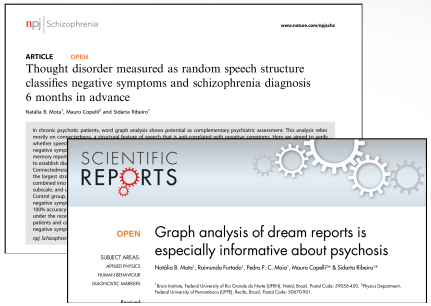
Examples of SCCs

- "sit"-"chair"-"front"-"porch"-"seat"-"plane"
- "lake"-"boat"-"water"-"rise"-"pool"-"swim"-"rush"



Conclusions and future work

- Global and dynamic perspective, beyond single-level analysis


npj | Schizophrenia

ARTICLE OPEN

Thought disorder measured as random speech structure classifies negative symptoms and schizophrenia diagnosis 6 months in advance

Natália B. Mota[1], Mauro Copelli[2] and Sidarta Ribeiro[1]

SCIENTIFIC REPORTS

OPEN

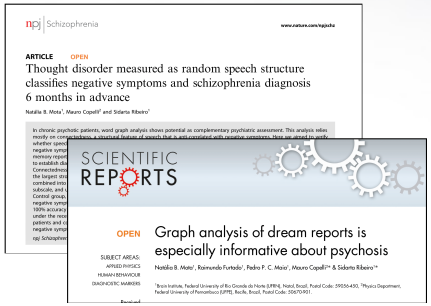
Graph analysis of dream reports is especially informative about psychosis

Natália B. Mota[1], Raimundo Furtado[1], Pedro P. C. Maia[1], Mauro Copelli[2]* & Sidarta Ribeiro[1]*

SUBJECT AREAS:
APPLIED PHYSICS
HUMAN BEHAVIOUR
DIAGNOSTIC MARKERS

Conclusions and future work

- Global and dynamic perspective, beyond single-level analysis
- Application of multi-level analysis techniques to categorized data



Thank you
for your attention!