Space of Dream Data through the Lens of Multilevel Graph

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EXISTING LITERATURE

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PLoS one

Speech Graphs Provide a Quantitative Measure of Thought Disorder in Psychosis

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npj | Schizophrenia

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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]*

[1]Brain Institute, Federal University of Rio Grande do Norte (UFRN), Natal, Brazil, Postal Code: 59056-450, [2]Physics Department, Federal University of Pernambuco (UFPE), Recife, Brazil, Postal Code: 50670-901.

SUBJECT AREAS: APPLIED PHYSICS, HUMAN BEHAVIOUR, DIAGNOSTIC MARKERS

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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].

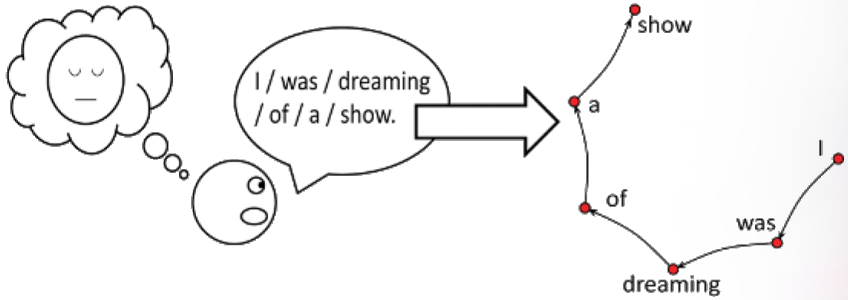
The development of quantitative methods for the evaluation of psychiatric symptoms offers hope to overcome this foggy scenario[8,9]. In particular, we have recently shown that the graph-theoretical analysis of dream reports produced by psychotic patients can separate schizophrenic from manic subjects[10]. 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[11,12], 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



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

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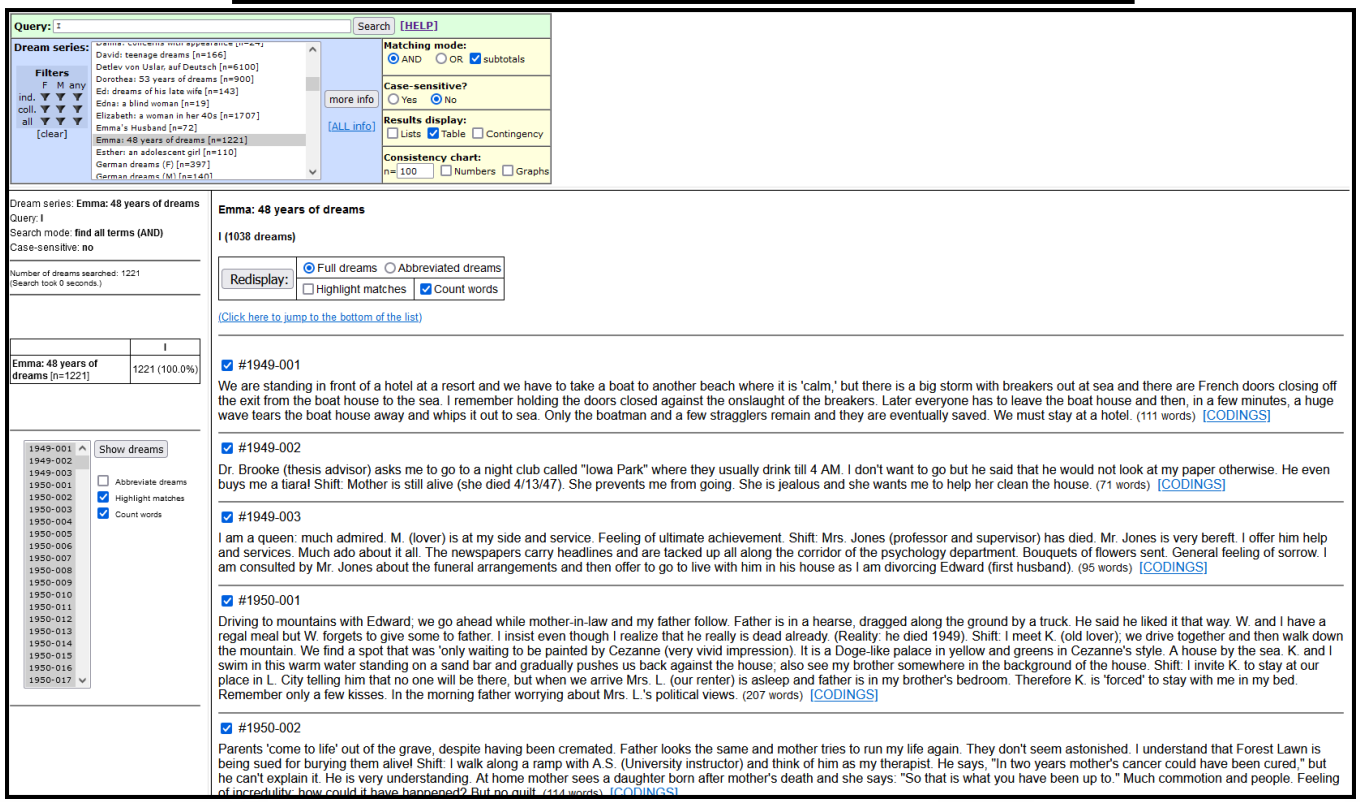
*"The results also show that **dream reports are substantially more informative** about the mental state of psychotic subjects than waking reports."*

SOURCES OF DREAMS

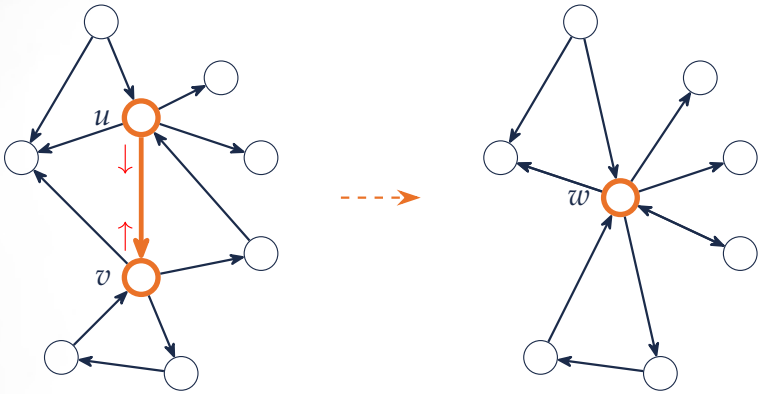
SOURCES OF DREAMS

DreamBank
www.dreambank.net



Graph contraction

Edge contraction



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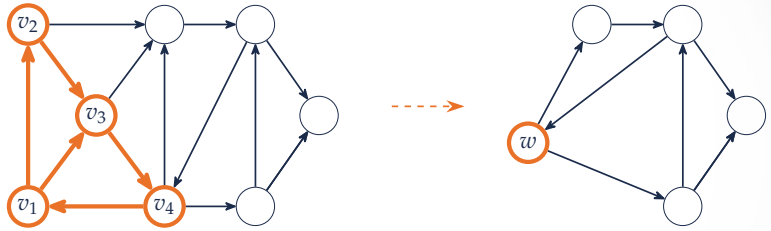

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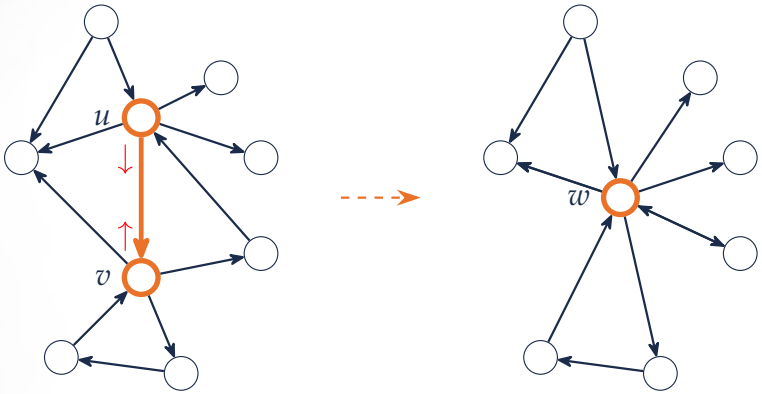

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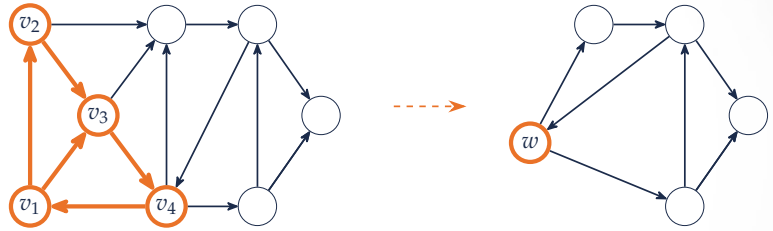
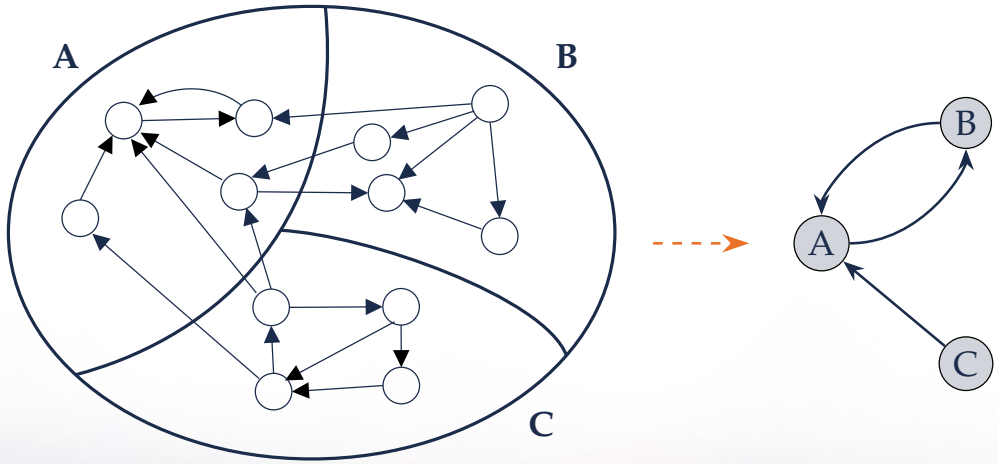


Quotient graph



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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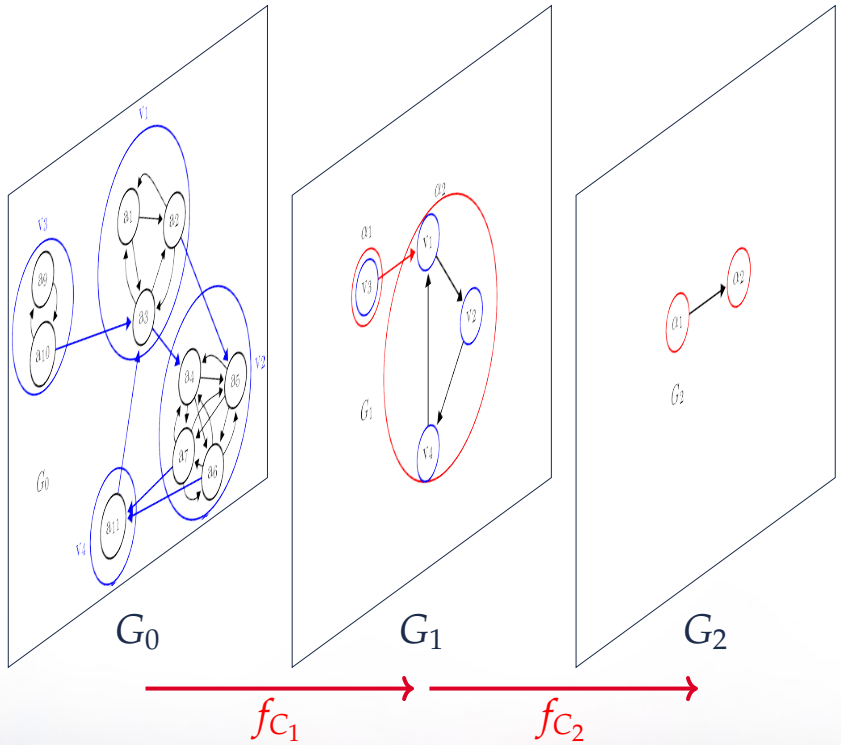
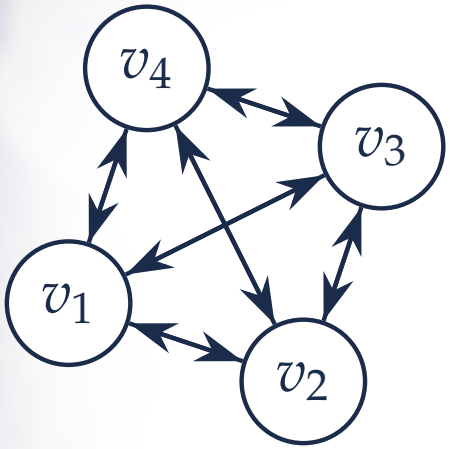


Contraction schemes

Contraction schemes



Cliques

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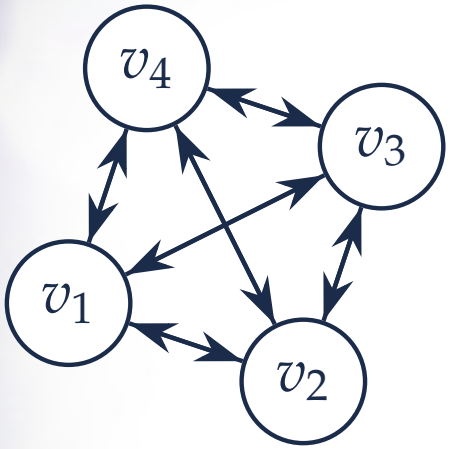

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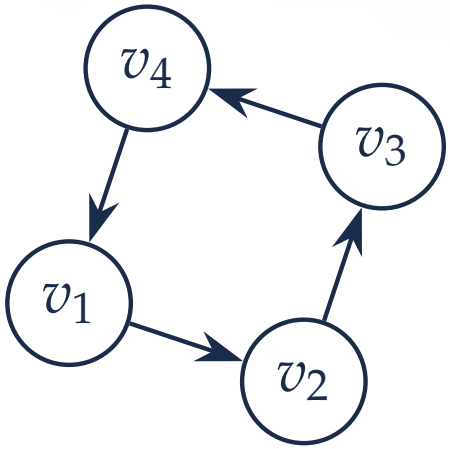
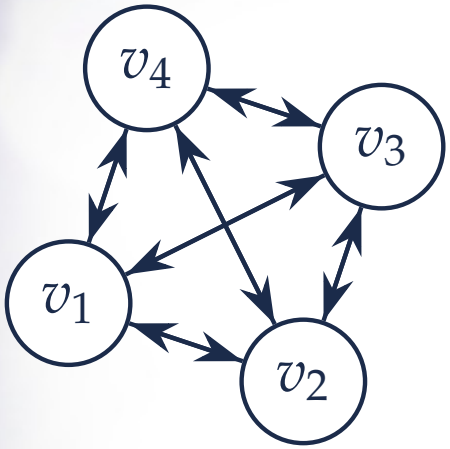


Simple cycles

Contraction schemes



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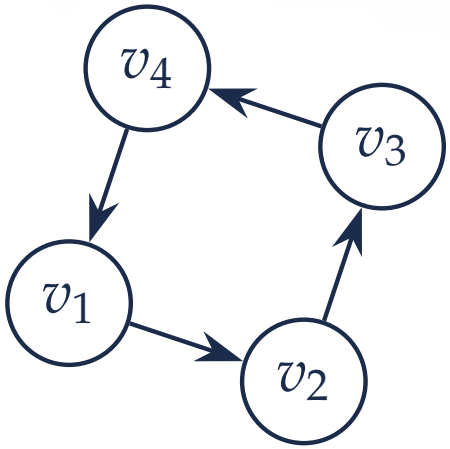

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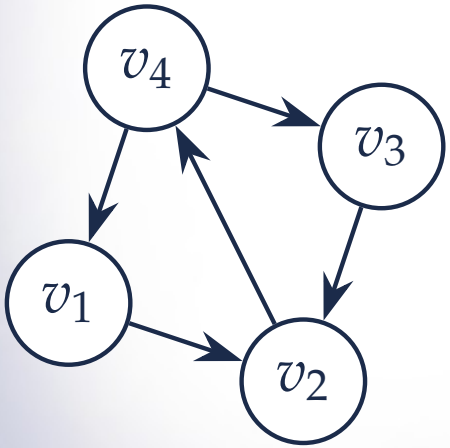
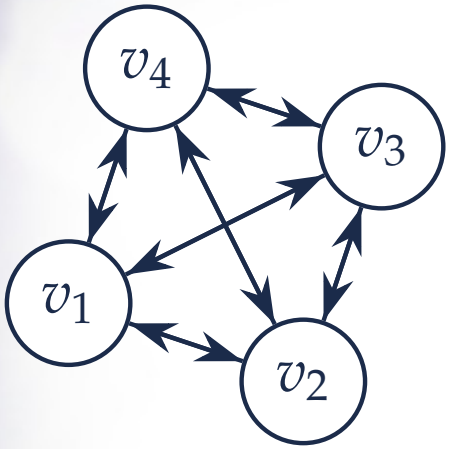


Strongly connected components

Contraction schemes



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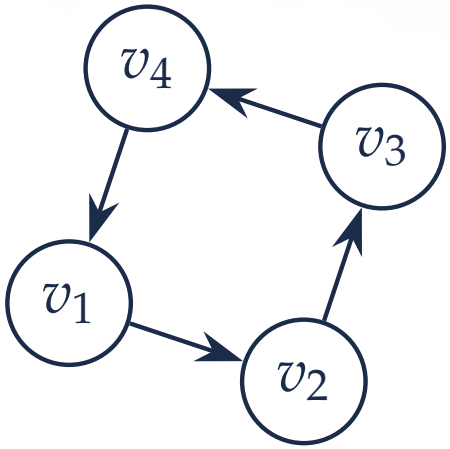

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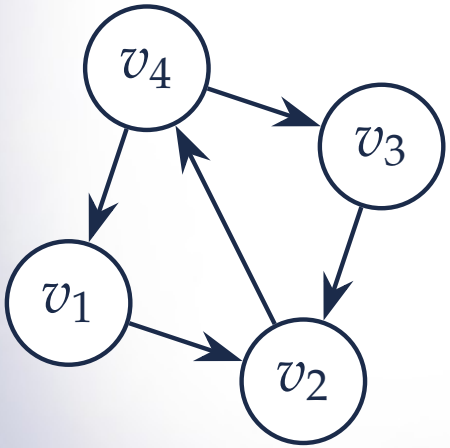

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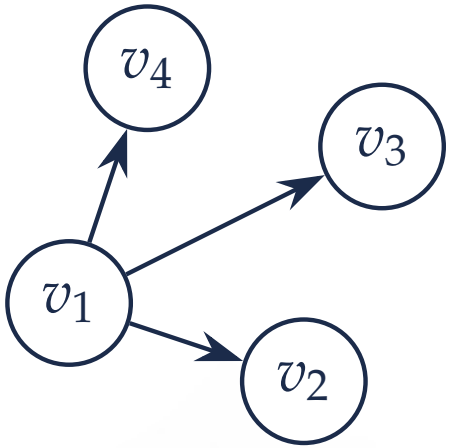
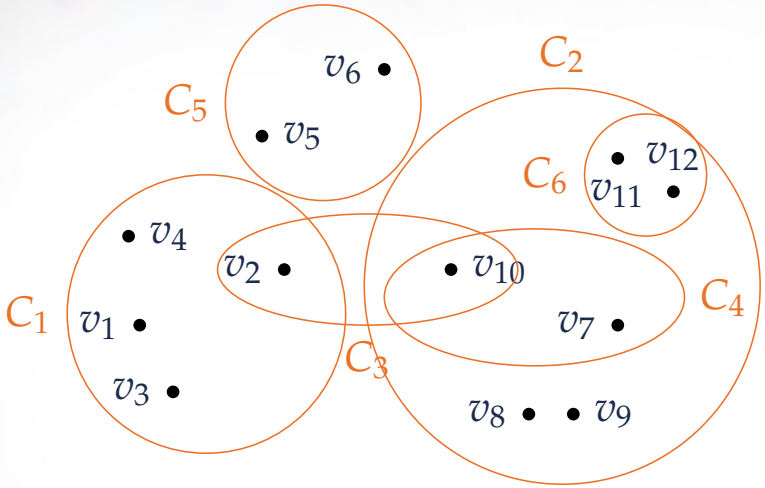


Stars

Subsets contraction



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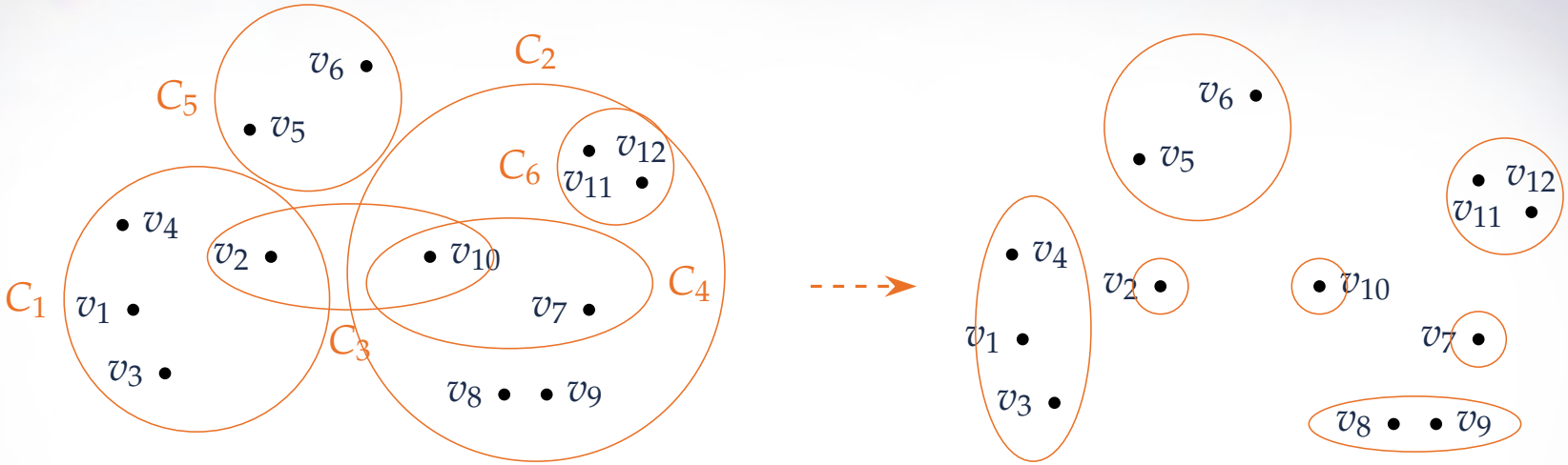

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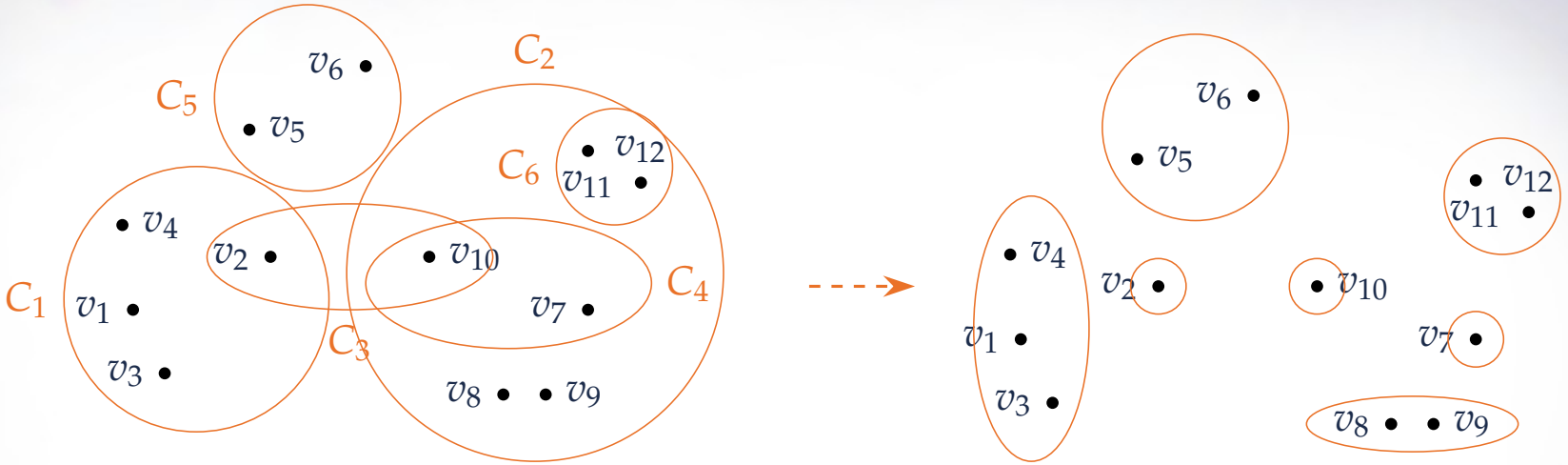
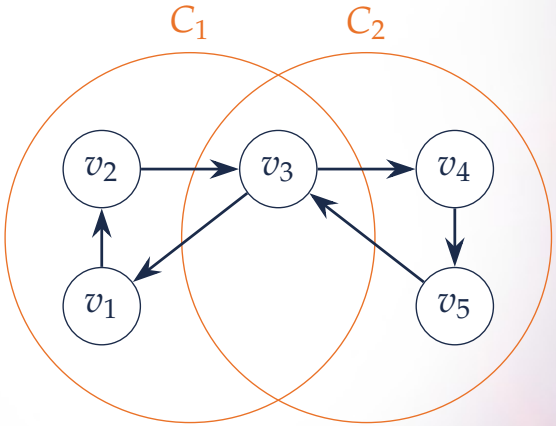


T

v_1	$\{C_1\}$
v_2	$\{C_1\}$
v_3	$\{C_1, C_2\}$
v_4	$\{C_2\}$
v_5	$\{C_2\}$



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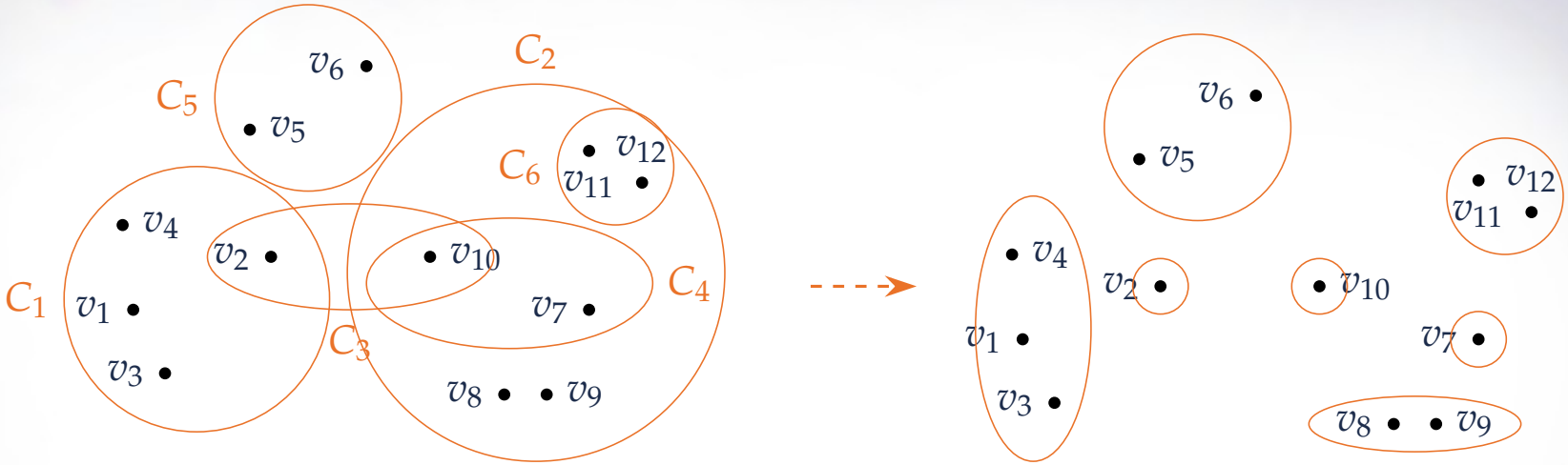

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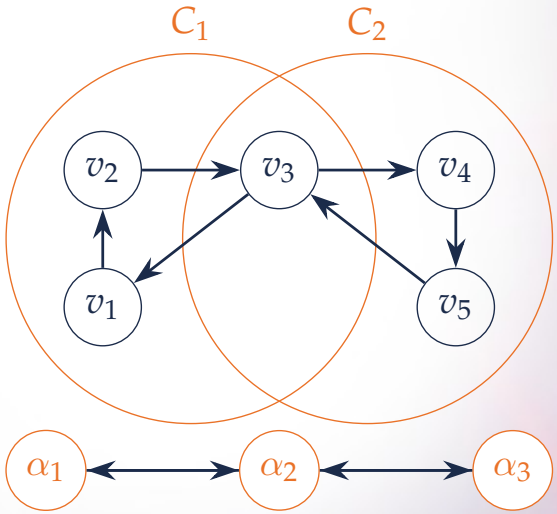
v_1	$\{C_1\}$
v_2	$\{C_1\}$
v_3	$\{C_1, C_2\}$
v_4	$\{C_2\}$
v_5	$\{C_2\}$

T'

$\{C_1\}$	α_1
$\{C_1, C_2\}$	α_2
$\{C_2\}$	α_3



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 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."

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Stopwords removal

An Arlie's dream

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Stopwords removal

Lemmatization

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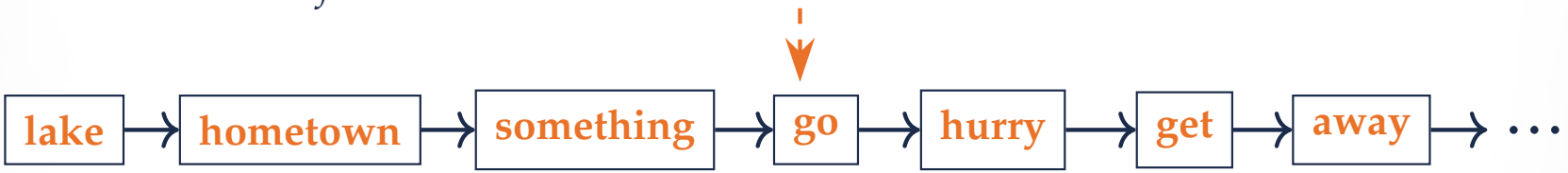

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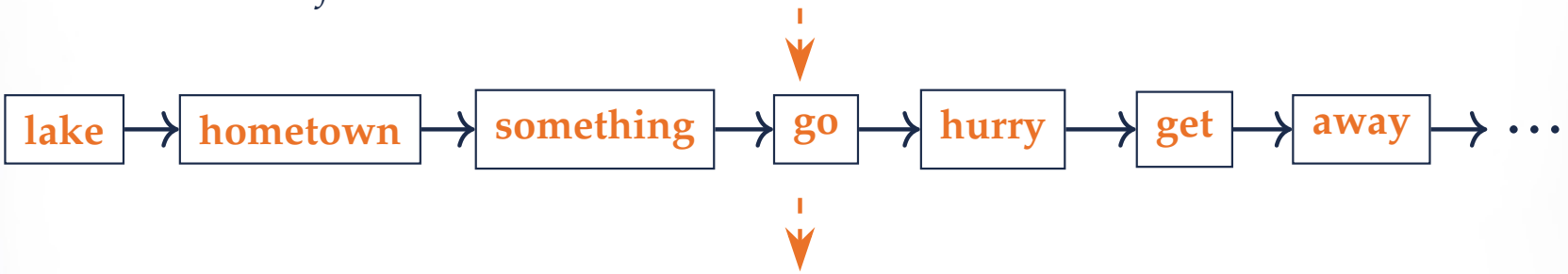

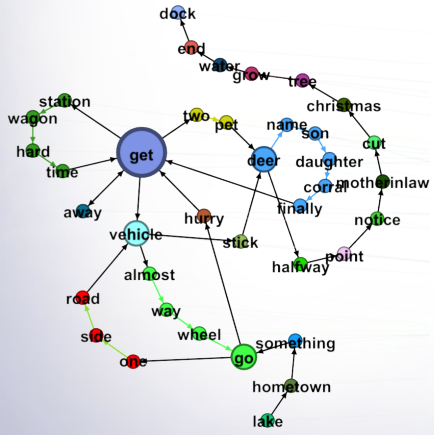

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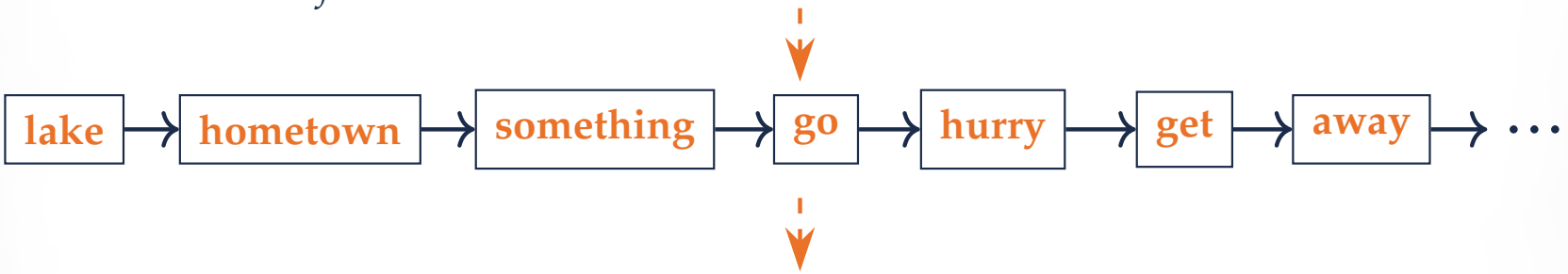
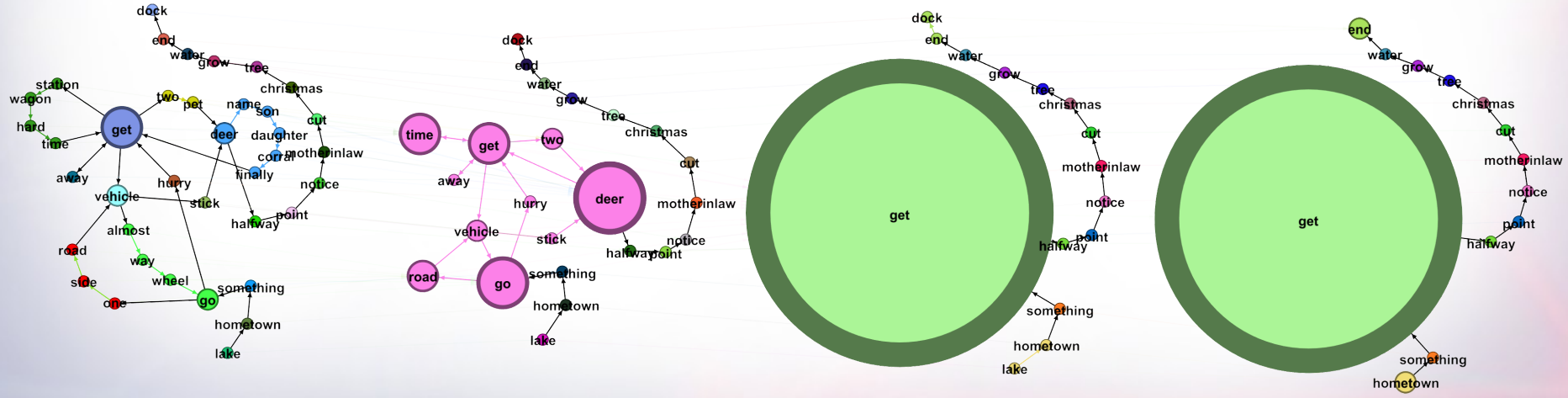
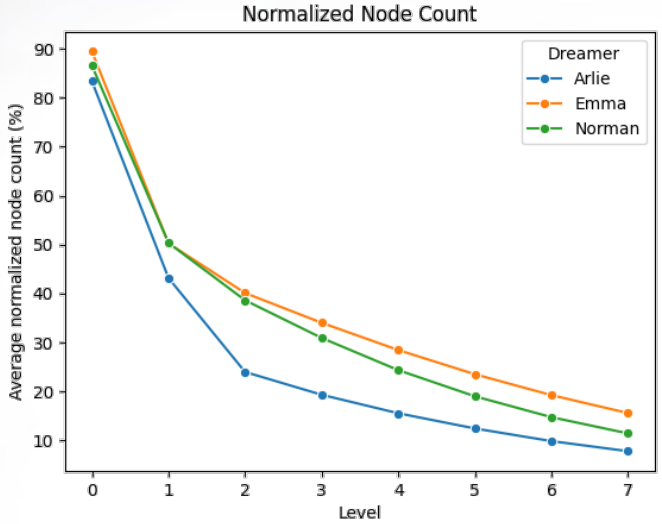
Stopwords removal

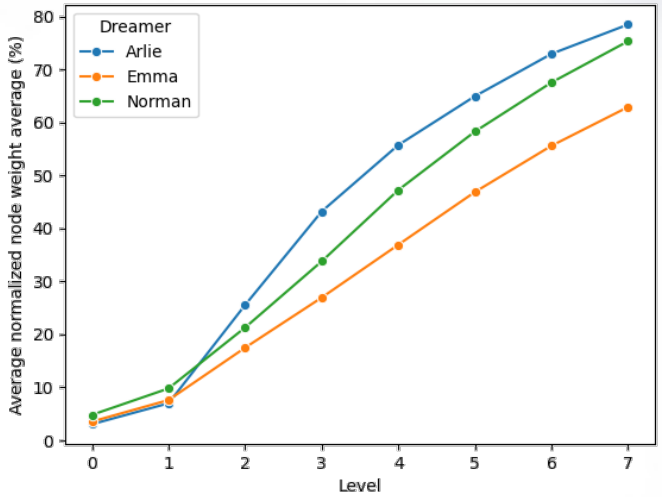
Lemmatization

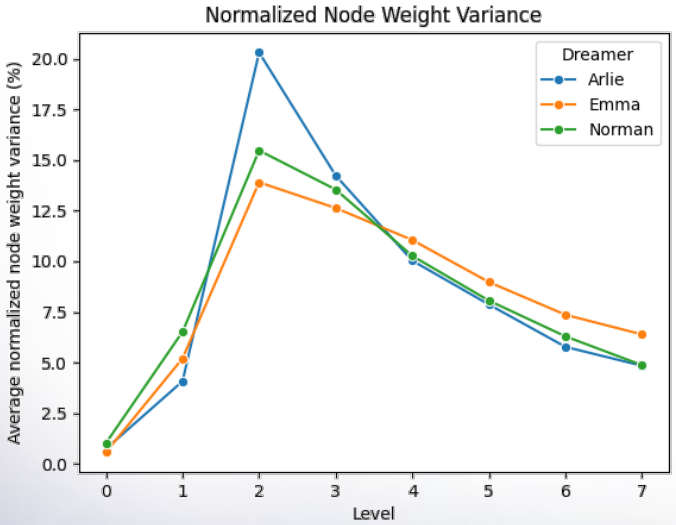


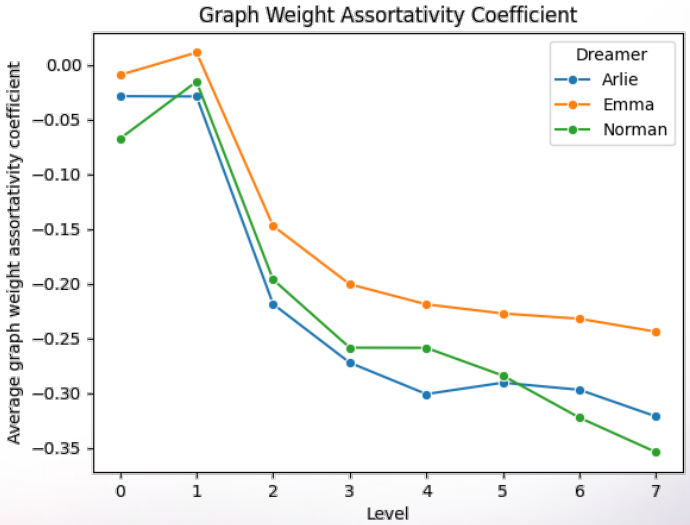


Arlie, Emma and Norman results









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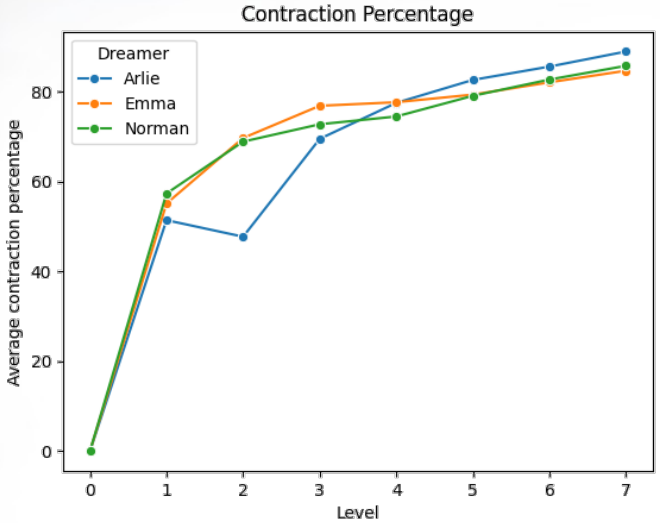
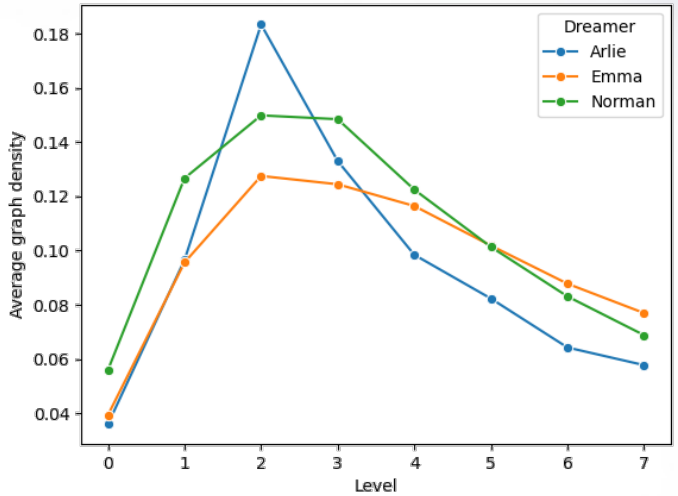
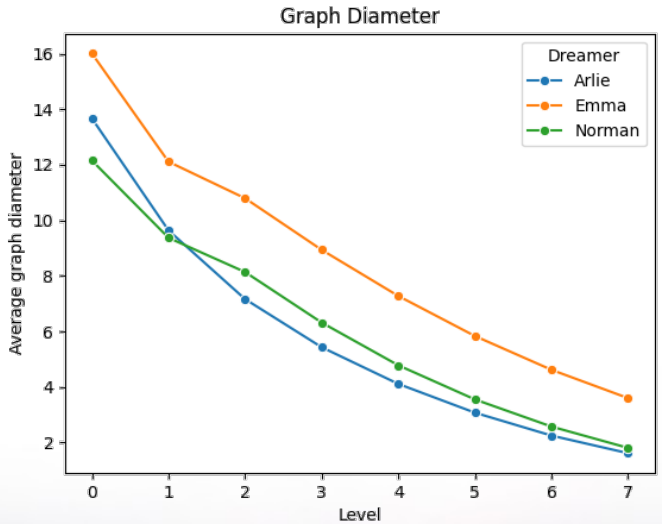


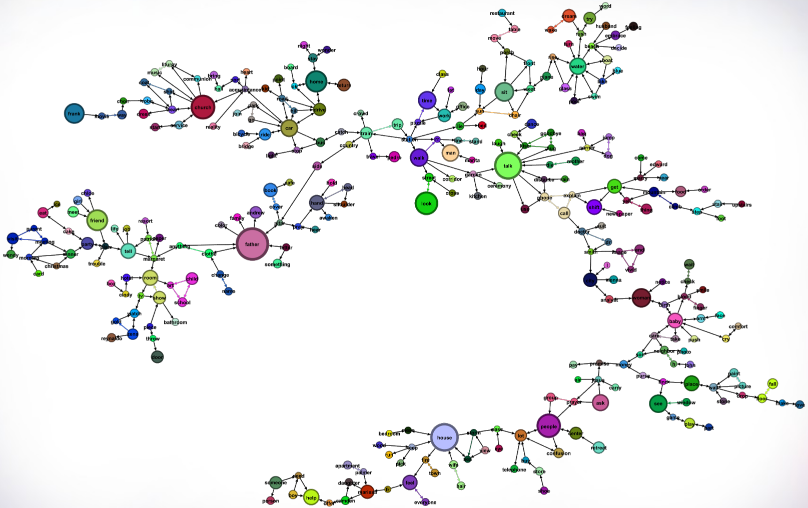




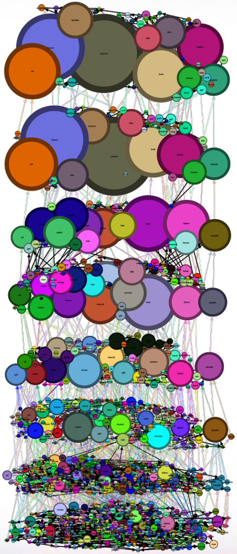
Semantic analysis of dreams

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.

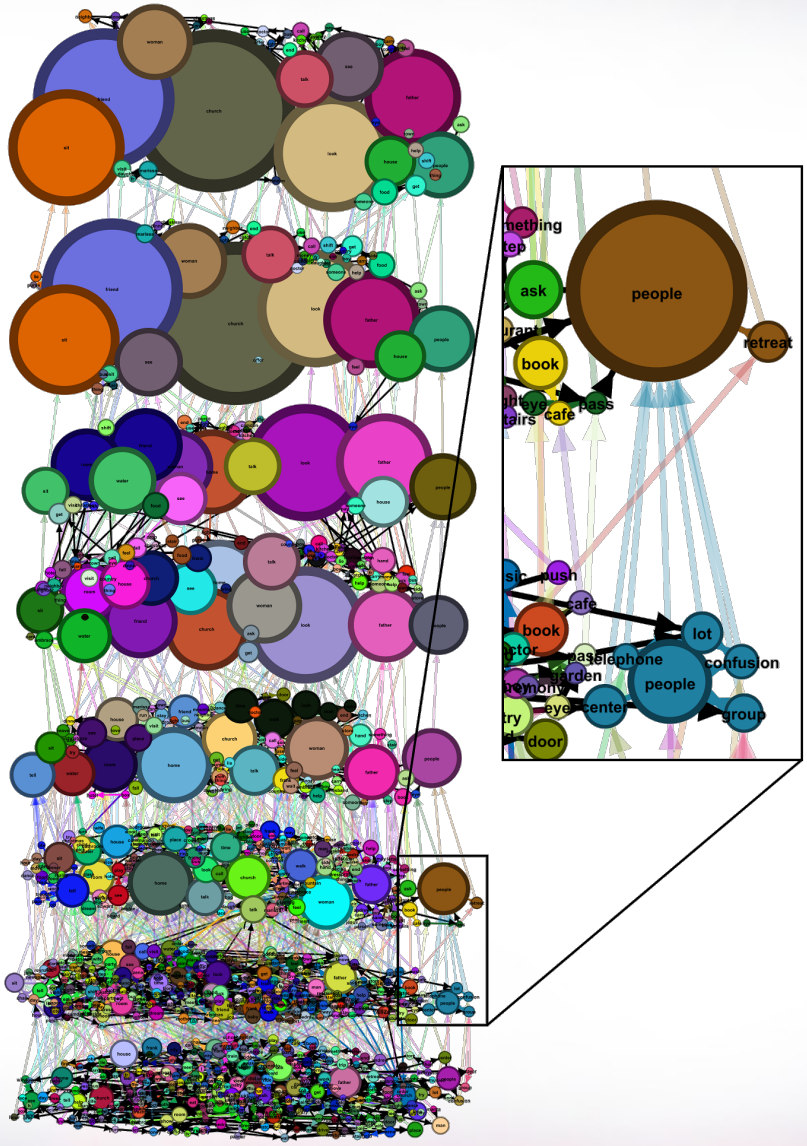
Emma's graph


restaurant
table
move
porch
front
seat
sit
chair
sun
day
hour
dream
wake
try
word
rush
husband
embrace
decide
turn
beach
boat
rise
water
blue
lake
plane
glass
swim
time
work
office
class
puzzle
trip
train
crowd
catch
country
travel
pedro
station
walk
man
line
stand
street
look
corridor
cross
garden
kitchen
ceremony
marta
talk
laugh
cheek
kiss
dance
goodbye
hug
mother
distance
rain
phone
call
explain
get
come
edward
year
food
order
stair
upstairs
step
foot
shift
newspaper
thing
doctor
suit
smith
image
vivid
city
vienna
analyst
woman
wait
check
notice
smile
birth
finger
baby
face
comfort
arm
take
push
cry
care
neighbor
photo
john
money
promise
pay
purse
carry
air
place
wall
paint
picture
drop
store
floor
fall
make
love
see
window
game
play
group
prayer
ask
people
center
retreat
confusion
lot
telephone
buy
shoe
house
bedroom
wood
keep
run
pick
town
wife
hair
view
eye
feel
everyone
apartment
palmer
daughter
marissa
camden
offer
help
boy
need
someone
person
church
music
liturgy
communion
bring
heart
coat
shirt
robe
wear
chair
dress
start
service
reality
frank
movie
way
hall
acquaintance
park
join
go
ride
bicycle
bridge
car
road
point
board
home
return
drive
stay
night
wonder
bus
stop
light
side
book
cafe
cover
hold
head
hand
shoulder
awaken
pray
hear
altar
andrew
family
color
father
other
something
anything
clothe
change
name
friend
chloe
girl
meet
eat
parent
visit
meeting
wendy
morning
christmas
card
dinner
party
cake
trouble
life
job
tell
resort
margaret
room
child
art
school
show
hotel
box
cindy
tv
watch
bathroom
place
throw
door
reynaldo

Emma's multilevel graph



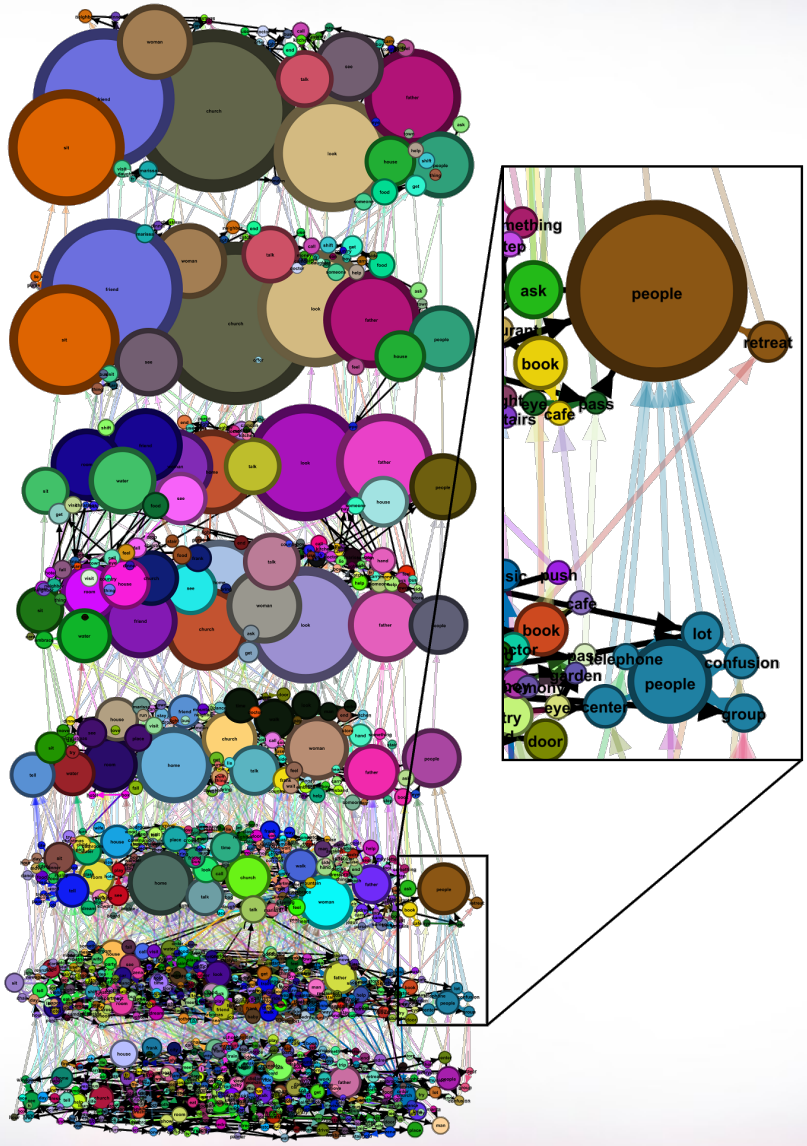
Emma's multilevel graph



Emma's multilevel graph

Examples of cycles

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



Emma's multilevel graph

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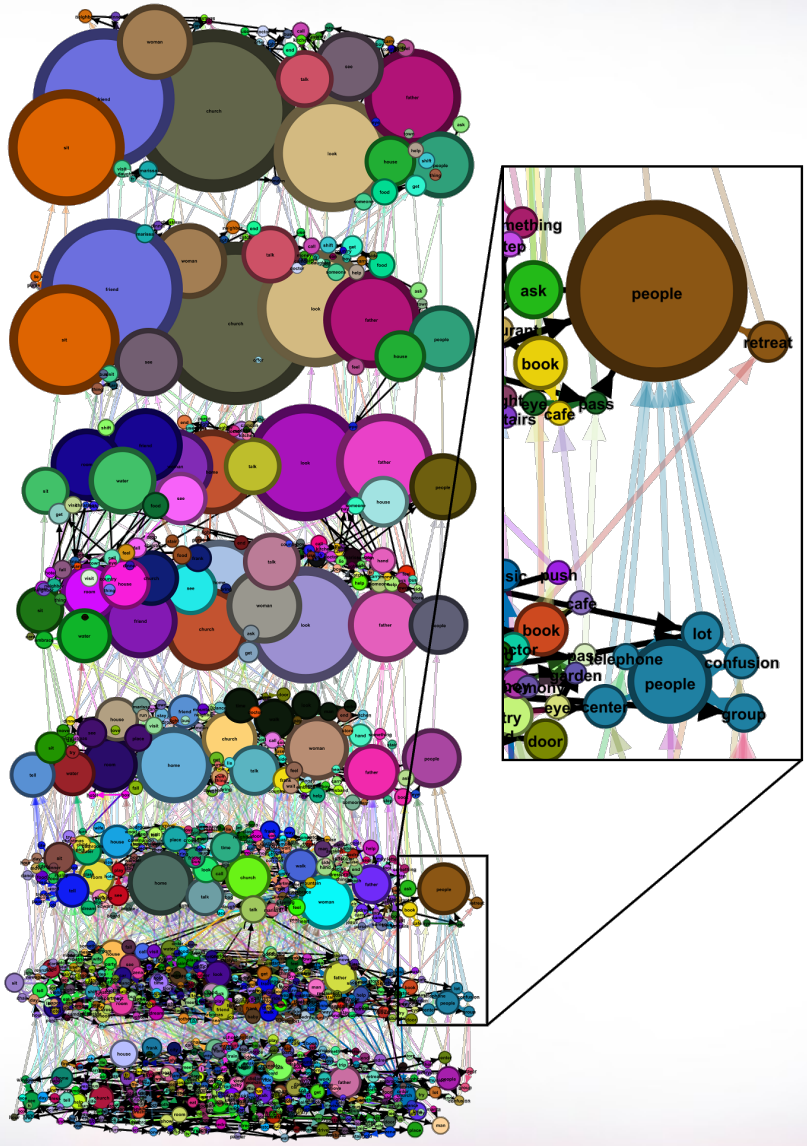
- "liturgy"-"church"-"music"

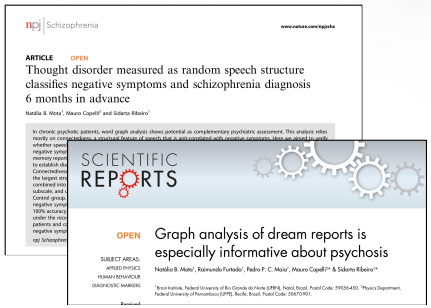
Examples of SCCs

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



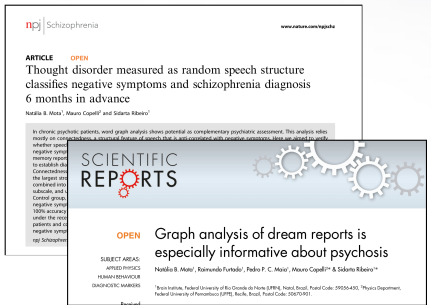
CONCLUSIONS AND PROSPECTS

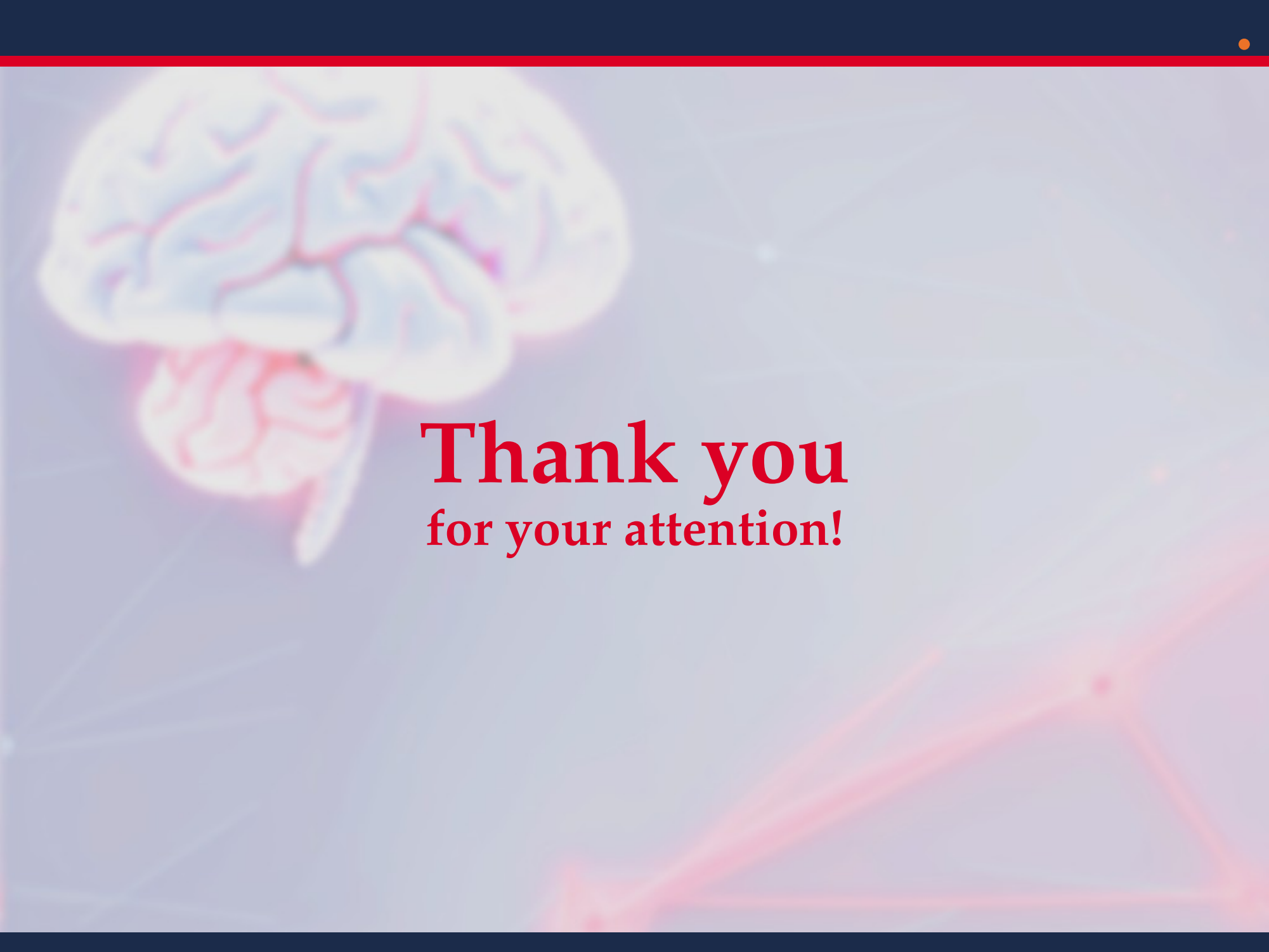
- Global and dynamic perspective, beyond single-level analysis



CONCLUSIONS AND PROSPECTS

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




Thank you
for your attention!