A Personalized Approach to Studying the Subjective Experience of Spontaneous Thoughts using PCA and Hierarchical Clustering.

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Can we identify groups of people who share similar spontaneous thinking patterns?

Patterns of spontaneous thinking are diverse

from **creative** thinking, to **freely-moving daydreaming**, to repetitive negative thinking and **rumination**[1].

Typically, only group trends are considered

where patterns of thinking that tend to cooccur across individuals are discovered by first asking people what they're thinking and then analyzing the results with **principal components analysis** (PCA)[2].

We instead want to examine how thoughts change within individuals

by having people report their spontaneous thoughts using experience sampling probes during a wakeful resting state, followed by analyzing each person's results with a PCA, yielding one PCA result per person.

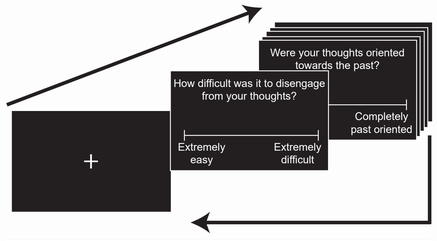
We will group similar thinkers together

by taking the PCA results for each person and comparing their similarity with agglomerative hierarchical clustering.

This will lead to a more personalized understanding of spontaneous thinking

which we can associate with more personalized measures of spontaneous brain activity, leading to more personalized treatments of psychiatric conditions like rumination[3].

Participants stared at a blank screen and occasionally reported their thoughts.



Resting state experience sampling

- N = 50
- 50 thought probes per subject, each consisting of 13 experience sampling items.

Experience sampling items:

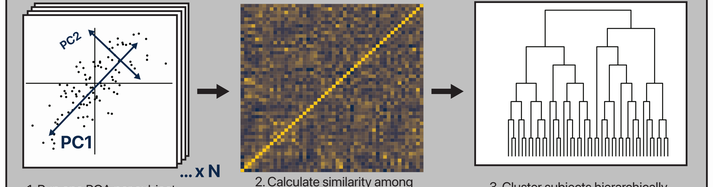
- Mental or physical
- Past or future
- Self or other
- Visual or non-visual
- Verbal or non-verbal

CONTENT

- Low or high energy
- Negative or positive
- Easy or hard to disengage
- Unmoving or moving freely
- Unintentional or intentional

DYNAMICS

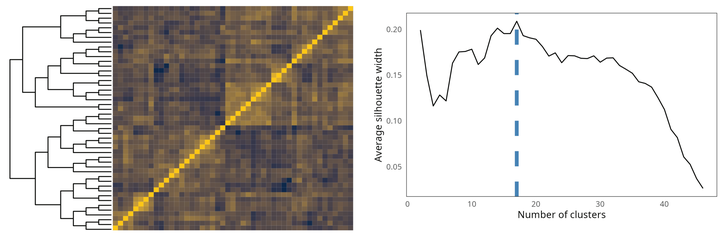
Analysis approach



1. Run one PCA per subject
2. Calculate similarity among subject PCAs
3. Cluster subjects hierarchically

Using PCA and hierarchical clustering to identify similar thinkers

THOUGHT CONTENT



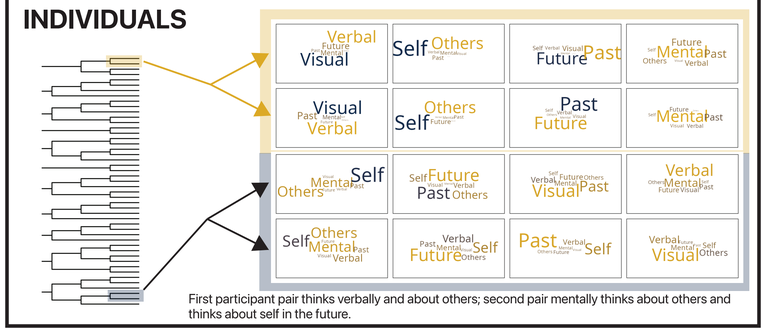
Ideal number of participant clusters for thought content is 17, although 2 clusters also characterized the data well.

GROUPS

Gold reflects positive loading; navy reflects negative loading.

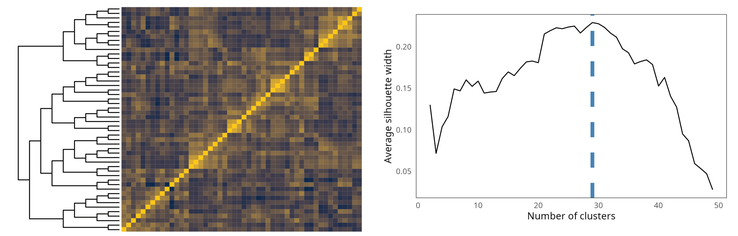
Group 1 thinks mostly about others; Group 2 has co-occuring thoughts about self and future.

INDIVIDUALS



First participant pair thinks verbally and about others; second pair mentally thinks about others and thinks about self in the future.

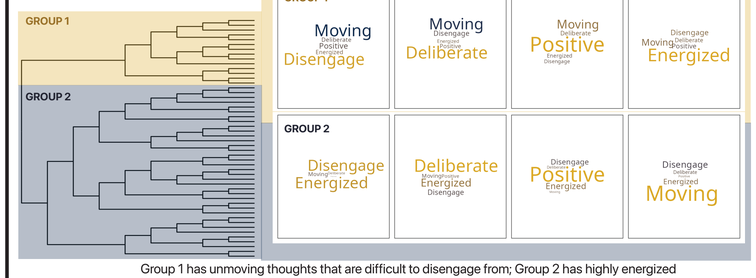
THOUGHT DYNAMICS



Thought dynamic groups appear more heterogeneous; data is best characterized by 29 groups.

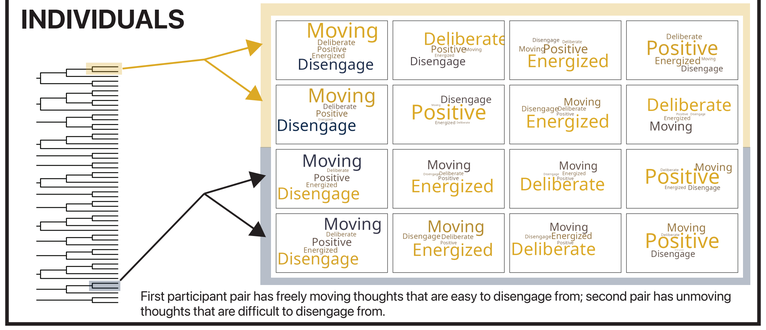
GROUPS

Gold reflects positive loading; navy reflects negative loading.



Group 1 has unmoving thoughts that are difficult to disengage from; Group 2 has highly energized thoughts that are difficult to disengage from.

INDIVIDUALS



First participant pair has freely moving thoughts that are easy to disengage from; second pair has unmoving thoughts that are difficult to disengage from.

Yes, we are able to identify groups of people who share similar spontaneous thinking patterns by running individualized PCAs and grouping results with hierarchical clustering.

We observed that fewer groups better characterized differences in thought content, while more groups better characterized differences in thought dynamics,

suggesting that individuals may differ more from one another with respect to the dynamics of their thoughts rather than the types of content people are thinking about.

Our next steps will be to:

(1) Validate these results by looking for correlations with trait and cognitive performance measures.

For example, we could assess whether groups or inidividuals who have thoughts that are more unmoving, more negative, and harder to disengage from are also higher in trait rumination.

(2) Assess the degree to which these groups map on to personalized patterns in brain networks measured with fMRI.

Past evidence from our lab[3] suggests that brain networks showing associations with mind wandering vary between people. It's possible that this variability may be accounted for by individual differences in the subjective experience of thought content and dynamics.

REFERENCES

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3. Kucyi, A., Anderson, N., Bounyarith, T., Braun, D., Shareef-Trudeau, L., Treves, I. ... & Hung, S. (*In press*). Individual variability in neural representations of mind wandering. *Network Neuroscience*.