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Neural correlates of context transitions in continuous internal thoughts

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Introduction

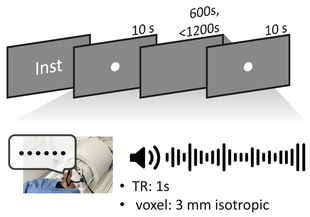
- During spontaneous thinking, thoughts often transition to new topics, reflecting shifts in internal context[1].
- Continuous narratives can be organized into discrete events, and the boundaries of these events elicit neural responses in the hippocampus[2].
- Transitions in mental context trigger neural responses that are common to both internal and external modes[3].

Research Questions:

- **What are the neural correlates of transitions in internally generated thoughts?**
- **How are internally generated thoughts represented as discrete structures when situational context changes?**

Tasks

- Participants spoke on different topics without explicit cues for topic changes.



Think-aloud (N=63): Freely speaking about any topic that comes to mind

Topic-alternating (N=53): Repeatedly alternating between two topics at one's own pace

Movie-recall (N=32): Recalling movies that had been watched before the recall task

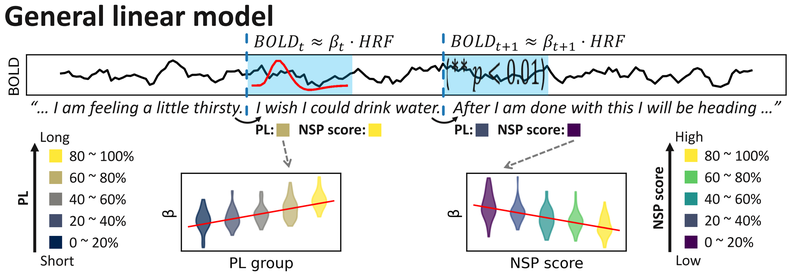
Methods

Measurements of transitions in speech

Pause length	Start (s)	End (s)	Sentence	Next sentence prediction scores
	356.90	360.00	*Right now, I am feeling a little thirsty.*	
2.40s	362.40	365.20	*I wish I could drink water.*	$P(\text{IsNext}) = 0.97$
1.90s	367.10	369.50	*After I am done with this I will be heading straight to dinner.*	$P(\text{IsNext}) = 0.13$
⋮				⋮

- **Next sentence prediction (NSP) scores**: The probability of one sentence following another, computed using a pretrained language model (BERT)[4], reflecting the degree of transition in speech content
- **Pause length (PL)**: The time interval between consecutive sentences
- **Topic boundaries**
  - Think-aloud: Transition of topics annotated by participants
  - Topic-alternating: Transition between two pre-given topics
  - Movie-recall: Movie event boundaries reported by annotators

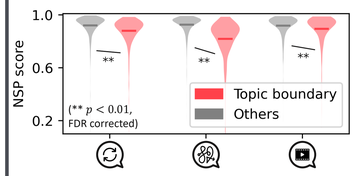
General linear model



- At the end of each sentence, a linear regression coefficient (β) between BOLD (from 0 TR to +20 TR) and HRF was computed.

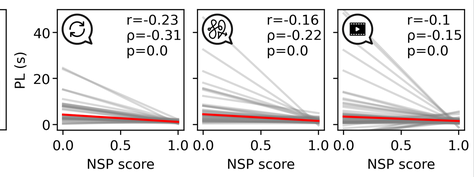
Behavioral Results

NSP scores at topic boundary



- NSP scores are low when topics change between sentences.

Correlation of NSP scores & PL

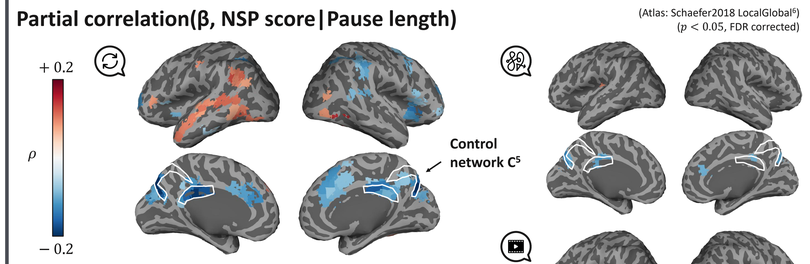


- The pause length at the end of sentences is correlated with NSP scores.

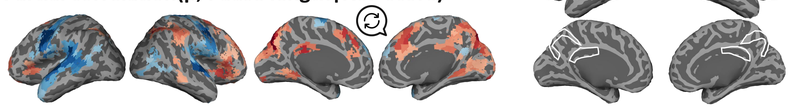
FMRI Results: Topic transitions as measured by NSP

Whole-brain analysis

Partial correlation(β, NSP score | Pause length)

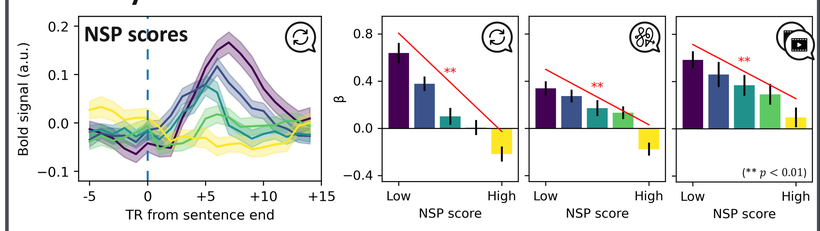


Partial correlation(β, Pause length | NSP score)

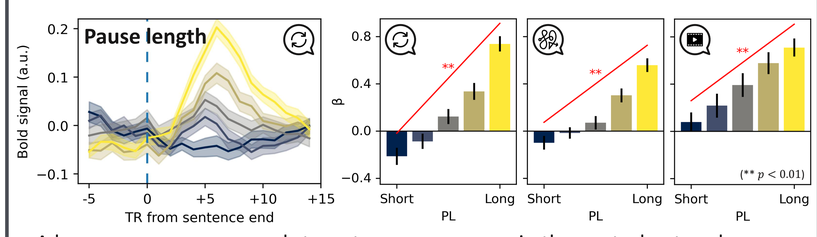


- The activity in the control network is associated with NSP scores when controlling for pause length, reflecting the degree of transition in speech content.

ROI analysis: Control network

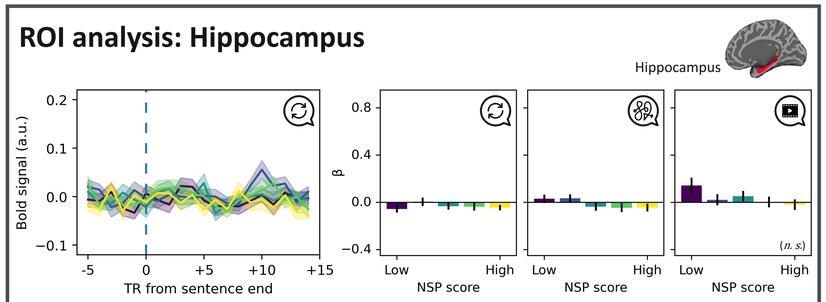


- When NSP scores are lower, indicating a higher likelihood of topic transitions, the response in the control network is higher.



- A longer pause corresponds to a stronger response in the control network.

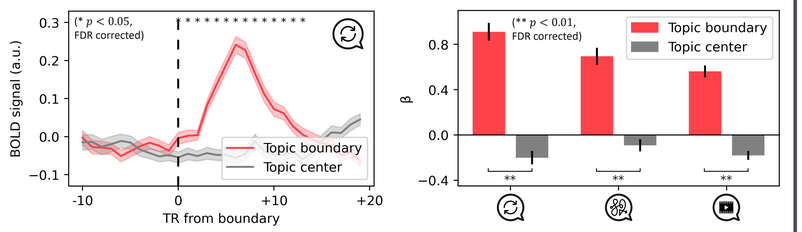
ROI analysis: Hippocampus



- The activity of the hippocampus is not correlated with NSP scores.

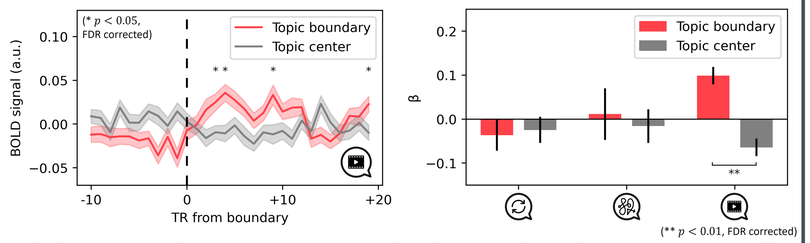
FMRI Results: Annotated topic boundaries

Control network



- Responses in the control network increase following annotated topic boundaries across all speaking tasks.

Hippocampus



- The hippocampal responses increase only after event boundaries in movie-recall.

Discussion

- The control network reflects the degree of topic transitions in internally generated thoughts.
- The hippocampus is more likely to be engaged in processing narratives, whether by observing existing narratives or self-generating them, which may involve memory retrieval and integration.
- We suggest that the brain areas respond to transitions in the external situational context also signal transitions in the flow of spontaneous thoughts, potentially involved in the discretization of our experiences into meaningful units.

1. Sripada, Chandra, and Aman Taxali. "Structure in the stream of consciousness: Evidence from a verbalized thought protocol and automated text analytic methods." *Consciousness and Cognition* 85 (2020): 103007.
2. Brunec, Iva K., Morris Moscovitch, and Morgan D. Barense. "Boundaries shape cognitive representations of spaces and events." *Trends in cognitive sciences* 22.7 (2018): 637-650.
3. Lee, Hongmi, and Janice Chen. "A generalized cortical activity pattern at internally generated mental context boundaries during unguided narrative recall." *Elife* 11 (2022): e73693.
4. Devlin, Jacob, et al. "Bert: Pre-training of deep bidirectional transformers for language understanding." *arXiv preprint arXiv:1810.04805* (2018).
5. Yeo, BT Thomas, et al. "The organization of the human cerebral cortex estimated by intrinsic functional connectivity." *Journal of neurophysiology* (2011).
6. Schaefer, Alexander, et al. "Local-global parcellation of the human cerebral cortex from intrinsic functional connectivity MRI." *Cerebral cortex* 28.9 (2018): 3095-3114.

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