

Supplemental materials for: High-order cognition is supported by information-rich but compressible brain activity patterns

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Topic label	Cognitive label	Term 1	Term 2	Term 3	Term 4	Term 5	Term 6	Term 7	Term 8	Term 9	Term 10
Cognitive control and task performance	Cognitive control	tasks	control	network	conditions	comparison	performed	experiment	correlates	pre	
Developmental aging and maturation	-	age	adults	children	development	aged	childhood	adult	adolescence	target	
Eye movements and visual attention	Attention	eye	gaze	eyes	visual	saccades	gait	target	direction	target	
Facial and voice recognition	Sensory perception	recognition	context	unfamiliar	interaction	voiced	fg	interactions	voices	facial	
Social interaction and contextual behavior	Social cognition	semantic	game	human	lexical	ppti	time	fluency	agency	partner	
Language processing and semantic knowledge	Language processing	semantic	words	word	trial	verbal	event	events	naming	phonological	
Experimental design and behavioral performance	-	trials	stimulus	responses	genotype	met	cont	target	target	times	
Genetic polymorphisms and risk factors	-	carriers	allele	gene	genotype	primary	val	val	agency		
Sensorimotor integration and movement control	Motor control	motor	movement	movements	ppi	controls	imaging	imagery	target		
Drug addiction and substance abuse	-	cocaine	users	drug	auditory	musicians	craving	craving	target	execution	
Music perception and auditory processing	Sensory perception	music	pitch	pitch	phases	menstrual	dependent	dependent	target	heroin	
Musical cycle and hormonal regulation	-	phase	cycle	play	plays	cognitive	rhythm	listening	target	singing	
Cognitive functions and role playing	Cognitive control	role	humans	humans	sex	evidence	sex	sex	target	folicular	
Inhibition and gender differences	-	inhibition	women	inhibitory	males	gender	key	distinct	target	follicular	
Somatosensory stimulation and motor control	Motor control	stimulation	stimulus	inhibitory	genotype	genetic	luteal	luteal	target	female	
Sensory perception and cognition	Sensory perception	auditory	movement	time	finger	addiction	luteal	luteal	target	female	
Social cognition	-	social	users	time	cannabis	rhythm	luteal	luteal	target	female	
Attention	-	target	musical	sequences	hf	expression	luteal	luteal	target	female	
Reward	-	design	women	play	critical	critical	luteal	luteal	target	female	
Alcohol cue reactivity	-	design	play	inhibition	males	males	luteal	luteal	target	female	
Neuroimaging and metabolism	-	cue	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Abnormalities in schizophrenia	Schizophrenia	pet	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Eating and body weight	-	food	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Sleep and olfactory processing	Sensory perception	sleep	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Alzheimer's disease and cognitive impairment	-	ad	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Working memory and executive function	Memory	memory	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Moral decision making and phobias	-	moral	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Neurobiological variability and individual diff...	Language processing	language	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Language laterality	Attention	attention	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Resting-state brain activity in smokers	Resting state	reho	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Social cognition/judgment	Social cognition	social	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Reward and decision making	Reward	reward	block	inhibition	genotype	genetic	luteal	luteal	target	female	
ADHD and attention deficits	Attention	adhd	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Spatial cognition	-	individual	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Spatial cognition	Language processing	spatial	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Therapeutic interventions and deception	Sensory perception	color	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Neurodegenerative diseases and disorders	-	disease	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Cognitive control and inference	Cognitive control	conflict	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Fear conditioning and extinction	Emotion	gray	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Memory	Memory	learning	block	inhibition	genotype	genetic	luteal	luteal	target	female	
PTSD and trauma	Emotion	fear	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Neural oscillations and electrophysiology	-	learning	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Temporal dynamics of stimulus processing	Sensory perception	frequency	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Tinnitus and hearing loss	-	time	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Abstract categories and representations	Language processing	tinnitus	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Pain perception and sensory stimulation	Sensory perception	category	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Body and primates	-	pain	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Phonological processing in reading	Language processing	body	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Cognitive control and control	Cognitive control	reading	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Social cognition	-	rule	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Emotion	-	asd	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Sensory perception	Sensory perception	blind	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Blindsight and vision	-	condition	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Deafness and sign language	Language processing	risk	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Genetic risk and familial factors in psychosis	-	action	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Action observation and imitation	Motor control	performance	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Cognitive performance and complexity	Cognitive control	disorder	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Autism Spectrum Disorder (ASD) and social impair...	-	placebo	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Major depression disorder and emotions	Social cognition	anxiety	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Pain perception and sensory stimulation	-	mental	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Body and primates	-	priming	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Rule-based performance and complexity	Language processing	wm	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Sentience comprehension and syntax	Resting state networks	sentences	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Memory	Memory	network	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Personality and anxiety	-	memory	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Mental illness and math abilities	Cognitive control	object	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Priming and repetition effect	Memory	positive	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Working memory and error monitoring	Language processing	negative	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Episodic memory encoding and retrieval	Resting state	negative	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Sensory perception	-	positive	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Relational reasoning and fluid intelligence	-	negative	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Affective valence and fluid intelligence	Memory	negative	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Autobiographical memory in epilepsy	-	autobiographical	block	inhibition	genotype	genetic	luteal	luteal	target	female	
Evidence and effect in behavioral studies	-	evidence	block	inhibition	genotype	genetic	luteal	luteal	target	female	

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Stress and physiological responses	-	cortisol	autonomic	heart	responses	rate	regulation	physiological	induced		
Speech and language processing	Language processing	tds	language	perception	comprehension	acoustic	acoustic	linguistic	prosody		
Network interactions and evidence in human systems	-	evidence	systems	support	process	integration	integration	provide	engaged		
Neuroimaging techniques	-	images	time	void	test	distinct	test	clinical	mapping		
Visual perception of motion and form	Sensory perception	visual	perceptual	image	spatial	spatial	human	static	illusion		
Emotional processing and regulation	Emotion	emotion	facial	biological	dynamic	moving	negative	regulation	emotions		
				expressions	affective	responses					

Table S1: Neurosynth-derived topics. We report the top-weighted terms for each of 80 topics identified using Latent Dirichlet Allocation (Blei et al., 2003) applied to 9,204 functional neuroimaging articles in the Neurosynth database (Rubin et al., 2017). See *Reverse inference* for additional information.

Cognitive label	Rank
Cognitive control	10
Language processing	9
Memory	8
Emotion	7
Social cognition	6
Spatial cognition	5
Attention	4
Reward	3
Sensory perception	2
Motor control	1
Resting state	0

Table S2: **Ranking cognitive processes.** The table displays the output of a ChatGPT (OpenAI, 2023) prompt asking for a ranking of the cognitive processes reflected in the labels from Table S1. See *Ranking cognitive processes* for additional detail.

Supplemental references

- Blei, D. M., Ng, A. Y., & Jordan, M. I. (2003). Latent dirichlet allocation. *Journal of Machine Learning Research*, 3, 993–1022.
- OpenAI. (2023, March). *ChatGPT*. Personal communication.
- Rubin, T. N., Kyoejo, O., Gorgolewski, K. J., Jones, M. N., Poldrack, R. A., & Yarkoni, T. (2017). Decoding brain activity using a large-scale probabilistic functional-anatomical atlas of human cognition. *PLoS Computational Biology*, 13(10), e1005649.

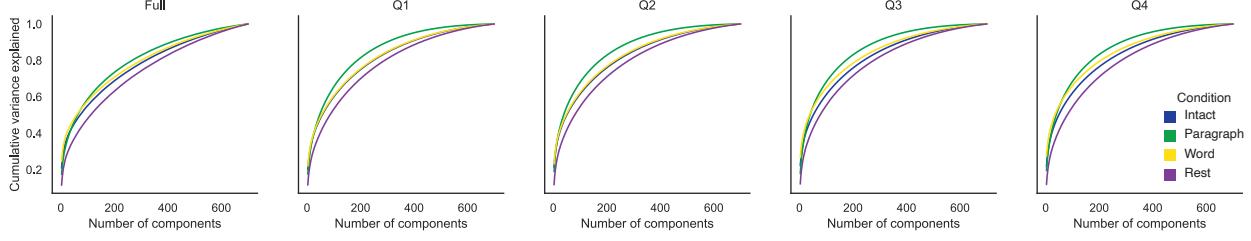


Figure S1: Cumulative variance explained by component, condition, and part. Each panel displays the cumulative variance explained in the neuroimaging data as a function of the number of principal components. Colors denote experimental conditions. The left panel displays results for all data, and the right panels display results separated by story segment (Q1: first quarter; Q2: second quarter; Q3: third quarter; Q4: fourth quarter).

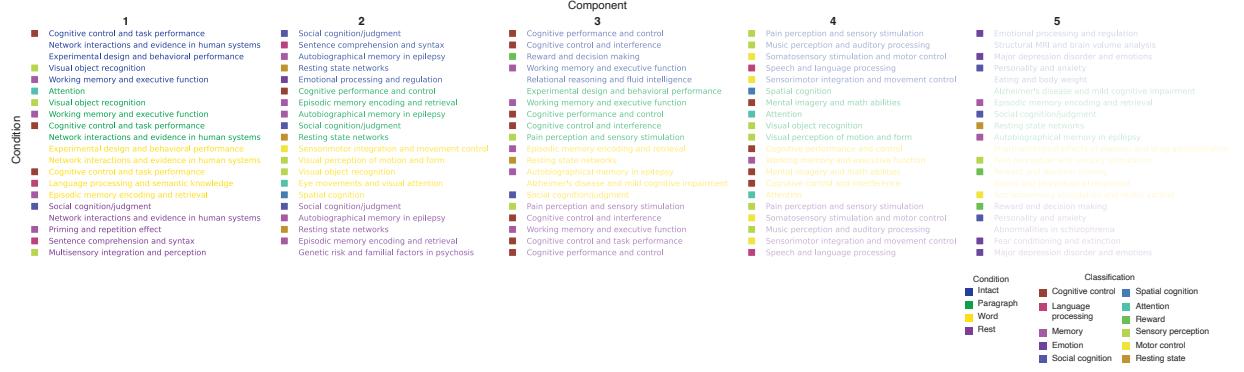


Figure S2: Highest-weighted topics associated with the highest-weighted components by condition, broken down by story segment. Each group of five rows corresponds to an experimental condition (denoted by color, as indicated in the legend in the lower right), and the columns and shading correspond to the component number (ranked by proportion of variance explained). The colored squares in front of many of the topics denote manually identified cognitive labels (Tab. S1).

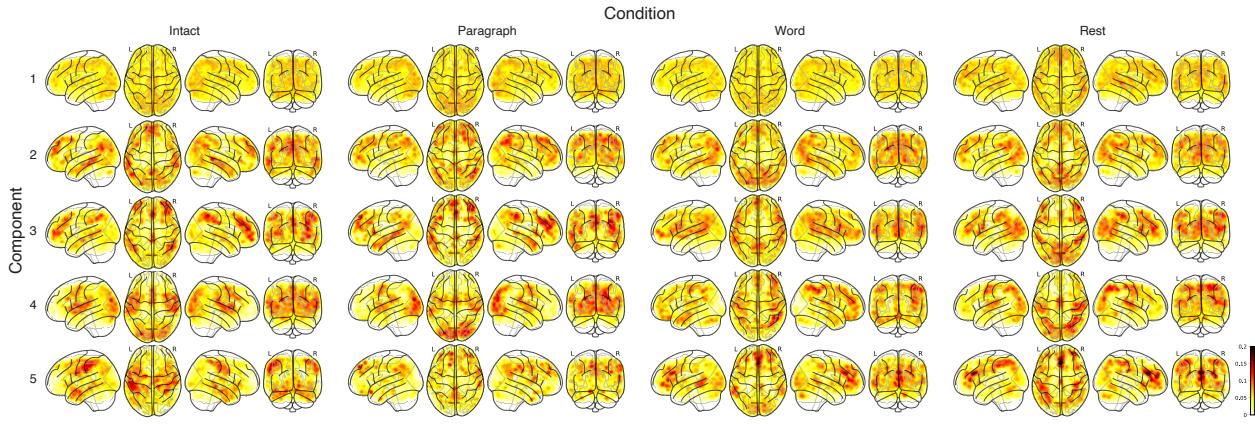


Figure S3: Brain maps by component and condition. For the top five highest-weighted principal components (rows), from each experimental condition (columns), the components' brain maps are projected onto four views: left sagittal, axial, right sagittal, and coronal. The color scale is the same for all panels and matches the coloring in Figure 5C.

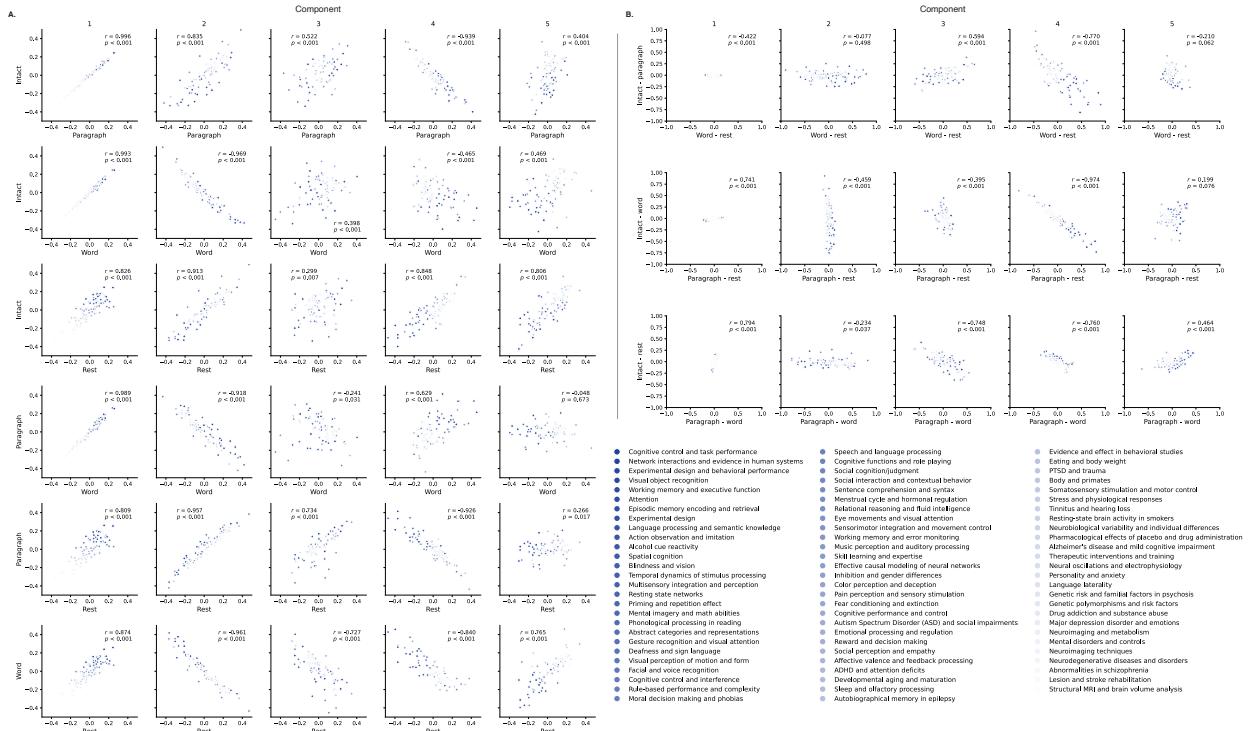


Figure S4: Comparisons between per-component topic correlations across conditions. Each sub-panel displays a scatterplot comparing the per-topic correlations for two or more experimental conditions. Each dot denotes the correlations for a single topic (indicated by the legend on the right). The topics are colored according to the ranked order of the correlations between the topic's brain maps and the brain map for the first principal component in the intact condition. **A. Comparisons between correlations for each pair of experimental conditions.** The conditions being compared are marked on the x and y axes. Each sub-panel (column) reflects the correlations for one principal component. **B. Comparisons between differences in correlations for pairs of experimental conditions.** In these sub-panels, the x and y coordinates reflect differences in correlations for the indicated experimental conditions, for the given component (column). All panels: the across-topic correlations reported in each panel are between each topic's x and y coordinates.

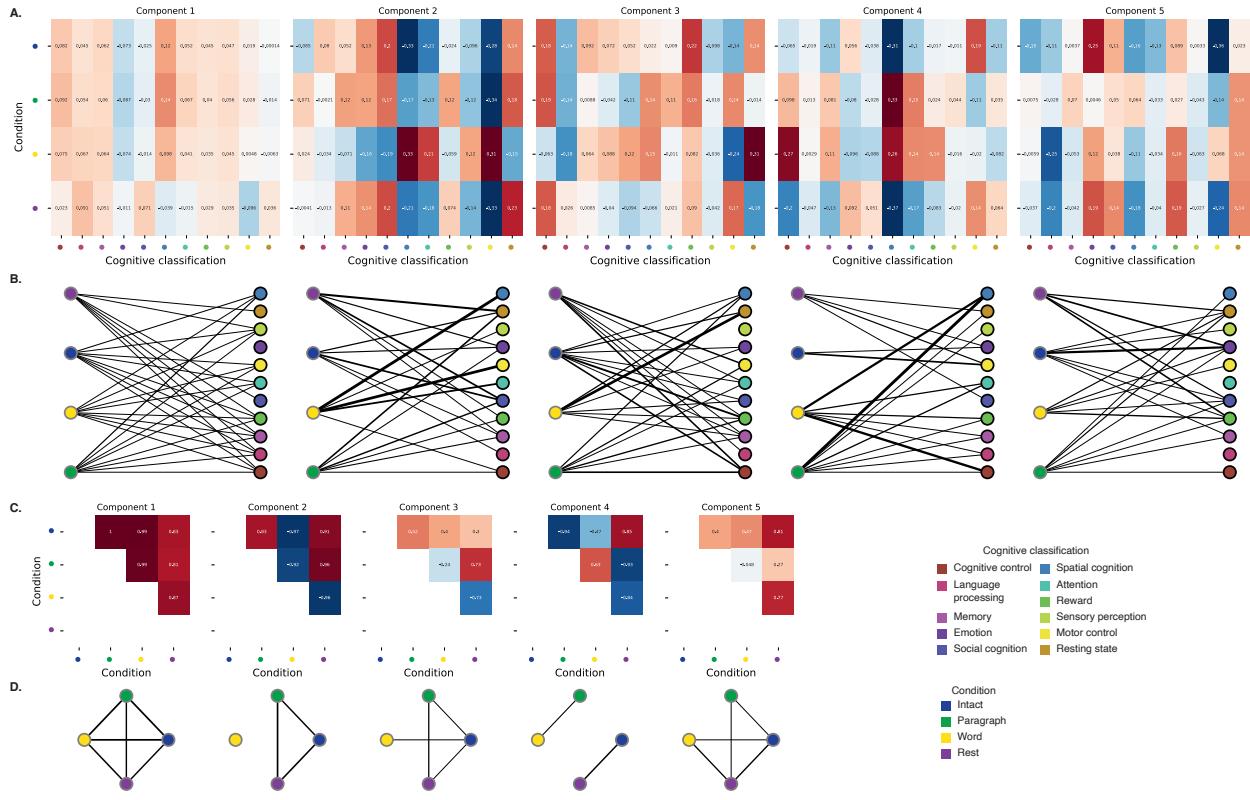


Figure S5: Functions associated with top-weighted components by condition. A. Top-weighted topics by condition. Here we display per-condition (rows, indicated by colored dots) topic correlations, averaged across topics that pertain to each of several broad cognitive functions (columns within each sub-panel, indicated by colored dots). Each sub-panel reflects correlations for the components indicated in the panel titles. A legend for the condition and cognitive function classifications is displayed in the lower right of the figure. Table S1 provides a list of each topic's top-weighted terms, along with each topic's manually labeled cognitive classification. A full list of the topics most highly associated with each component may be found in Figure S2. **B. Associations between per-condition components and cognitive functions.** The network plots denote positive average correlations between the component images for each condition (gray-outlined dots on the left sides of each network; colors denote conditions) and topic-specific brain maps associated with each indicated cognitive function (black-outlined dots on the right sides of each network; colors denote cognitive functions). The line thicknesses are proportional to the correlation values (correlation coefficients are noted in the heatmaps in Panel A). **C. Correlations between each principal component, by condition.** The heatmaps display the correlations between the brain maps (Fig. S3) for each principal component (sub-panel), across each pair of conditions (rows and columns of each sub-panel's matrix, indicated by colored dots). **D. Associations between per-condition topic weights, by component.** Each sub-panel's network plot summarizes the pattern of correlations between the topic correlations from each of the n^{th} top-weighted principal components (sub-panel), for each experimental condition (gray-outlined dots). The line thicknesses are proportional to the correlation values (correlation coefficients are noted in the heatmaps in Panel C).