

Supplemental materials for: High-level 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	facial	
Facial and voice recognition	Sensory perception	recognition	context	familiar	unfamiliar	voiced	fg	interactions	voices	partner	
Social interaction and contextual behavior	Social cognition	semantic	game	human	interaction	ppti	time	fluency	agency	phonological	
Language processing and semantic knowledge	Language processing	semantic	words	word	lexical	verbal	event	events	naming	times	
Experimental design and behavioral performance	-	trials	stimulus	responses	trial	reaction	cont	cont	target	rs	
Genetic polymorphisms and risk factors	-	carriers	allele	gene	genotype	met	val	val	target	execution	
Sensorimotor integration and movement control	Motor control	motor	movement	movements	sensorimotor	primary	imagery	imagery	sensory	heroin	
Drug addiction and substance abuse	-	cocaine	users	drug	ppi	controls	craving	craving	dependent	singing	
Music perception and auditory processing	Sensory perception	music	musical	pitch	auditory	musicians	rhythm	listening	beat	folicular	
Musical cycle and hormonal regulation	-	phase	women	cycle	phases	menstrual	expression	sex	luteal	follicular	
Cognitive functions and role playing	Cognitive control	role	play	humans	plays	cognitive	critical	distinct	key	female	
Inhibition and gender differences	-	inhibition	women	inhibitory	sex	evidence	males	stop	male	sensory	
Somatosensory stimulation and motor control	Motor control	stimulation	stimulus	inhibitory	genotype	gender	motor	rins	transcranial	metabolic	
Sensory perception and cognition	Sensory perception	auditory	sound	inhibitory	finger	genetic	sound	stimulus	primary	abnormal	
Social cognition	-	social	experience	inhibitory	cannabis	sequences	interruption	individuals	attachment	empathic	
Attention	-	target	targets	inhibitory	hf	hif	grasp	writing	distractor	location	
Reward	-	design	blocks	blocks	phases	critical	exposure	metabolism	blocked	runs	
Alcohol cue reactivity	-	design	block	alcohol	plays	anticipation	metabolic	metabolic	key	preparatory	
Neuroimaging and metabolism	-	pet	cue	emission	sex	glucose	metabolic	metabolic	receptor	schizophrenic	
Abnormalities in schizophrenia	Schizophrenia	food	tongue	emission	genotype	deficits	reward	reward	target	schizophrenic	
Eating and body weight	-	sleep	controls	reduced	abnormalities	symptoms	obese	obese	spontaneous	wake	
Sleep and olfactory processing	-	sleep	taste	body	weight	eating	rem	right	atrophy	atrophic	
Alzheimer's disease and mild cognitive impairment	-	ad	olfactory	odor	sd	deprivation	rem	night	cognitive	intentional	
Working memory and executive function	Memory	memory	disease	olfactory	sd	cognitive	impairment	night	reduced	representation	
Moral decision making and phobias	-	memor	load	task	alzheimer	maintenance	impaired	controls	located	target	
Language processing	Language processing	language	phobia	alzheimer	verb	spider	performance	orienting	is	people	
Attention	Attention	attention	asymmetry	phobic	ec	dominance	ca	control	person	reduced	
Resting-state brain activity in smokers	Resting state	reho	attentive	organization	human	asymmetries	anticipatory	judgment	responses	reduced	
Social cognition/judgment	Social cognition	social	smokers	visual	spatial	selective	control	control	magnitude	lower	
Reward and decision making	Reward	reward	judgments	resting	smoking	nicotine	neuronal	visuo	visuo	position	
ADHD and attention deficits	Attention	adhd	decisions	mind	mental	theory	visuospatial	mindfulness	mindfulness	induced	
Neurobiological variability and individual diff...	-	individual	disorder	drugs	outcomes	rewards	improvement	dimension	dimension	conjunction	
Spatial cognition	Spatial cognition	spatial	relationship	attention	dependent	children	sd	multiple	multiple	spontaneous	
Therapeutic interventions and deception	-	training	space	local	locations	nicotine	density	density	density	people	
Color perception and deception	Sensory perception	color	acupuncture	location	locations	hypercactivity	global	global	global	reduced	
Neurodegenerative diseases and disorders	-	disease	search	therapy	cr	virtual	virtual	virtual	virtual	reduced	
Cognitive control and inference	Cognitive control	-	disease	feature	deception	trained	improvement	improvement	improvement	reduced	
Structural MRI and brain volume analysis	-	conflict	pd	feature	atrophy	responses	responses	responses	responses	reduced	
ADHD and attention deficits	-	volume	control	pd	strop	motor	motor	motor	motor	reduced	
Emotion	-	gray	gray	vocal	gm	selection	grey	grey	selection	reduced	
Memory	Memory	learning	fear	switching	gm	extinction	extinction	extinction	extinction	reduced	
Skill learning and extinction	Emotion	learning	fear	practice	sequence	navigation	training	training	training	conditioned	
PTSD and trauma	PTSD and trauma	ptsd	learning	stress	disorder	traumatic	traumatic	traumatic	traumatic	motor	
Neural oscillations and electrophysiology	-	frequency	trauma	alpha	amplitude	gamma	gamma	gamma	gamma	artificial	
Temporal dynamics of stimulus processing	Sensory perception	time	source	duration	onset	stage	stage	stage	stage	reduced	
Tinnitus and hearing loss	Sensory perception	tinnitus	sustained	hearing	period	subjective	subjective	subjective	subjective	reduced	
Abstract categories and representations	Language processing	category	lost	representations	driving	abstract	abstract	abstract	abstract	reduced	
Pain perception and sensory stimulation	Sensory perception	pain	adaptation	stimulation	categories	congenital	congenital	congenital	congenital	reduced	
Body and primates	-	body	painful	humans	monkeys	unaffected	unaffected	unaffected	unaffected	reduced	
Phonological processing in reading	Language processing	phonological	complexity	phonological	language	primates	unaffected	unaffected	unaffected	reduced	
Cognitive control and inference	Cognitive control	rule	autism	size	force	readers	readers	readers	readers	reduced	
Social cognition	-	asd	ndd	size	status	grip	grip	grip	grip	reduced	
Emotion	-	ndd	adaptation	hearing	status	disorders	disorders	disorders	disorders	reduced	
Sensory perception	Sensory perception	blind	visual	adaptation	category	stuttering	stuttering	stuttering	stuttering	reduced	
Conditioning and extinction	-	blind	visual	stimulation	monkeys	stuttering	stuttering	stuttering	stuttering	reduced	
Skull training and extinction	Conditioning	risk	genetic	genetic	monkeys	stuttering	stuttering	stuttering	stuttering	reduced	
Action observation and imitation	Action	action	actions	actions	visual	stuttering	stuttering	stuttering	stuttering	reduced	
Autism Spectrum Disorder (ASD) and social impair...	Cognitive control	disorder	cognitive	cognitive	motor	stuttering	stuttering	stuttering	stuttering	reduced	
Major depression disorder and emotions	-	placebo	ocd	ocd	memory	stuttering	stuttering	stuttering	stuttering	reduced	
Blindsight and vision	Sensory perception	anxiety	dopamine	dopamine	memory	stuttering	stuttering	stuttering	stuttering	reduced	
Pain perception and sensory stimulation	-	mental	personality	personality	memory	stuttering	stuttering	stuttering	stuttering	reduced	
Deafness and sign language	Language processing	genetic	image	image	memory	stuttering	stuttering	stuttering	stuttering	reduced	
Genetic risk and familial factors in psychosis	-	genetic	repetition	repetition	memory	stuttering	stuttering	stuttering	stuttering	reduced	
Rule-based performance and complexity	Language processing	action	observation	observation	memory	stuttering	stuttering	stuttering	stuttering	reduced	
Memory and error monitoring	Cognitive control	disorder	control	control	memory	stuttering	stuttering	stuttering	stuttering	reduced	
Pharmacological effects of placebo and drug adm...	-	placebo	bipolar	bipolar	memory	stuttering	stuttering	stuttering	stuttering	reduced	
Personality and anxiety	Social cognition	anxiety	effect	effect	memory	stuttering	stuttering	stuttering	stuttering	reduced	
Mental illness and math abilities	Cognitive control	mental	trait	trait	memory	stuttering	stuttering	stuttering	stuttering	reduced	
Memory	Memory	priming	numerical	numerical	memory	stuttering	stuttering	stuttering	stuttering	reduced	
Language processing	-	wm	suppression	suppression	memory	stuttering	stuttering	stuttering	stuttering	reduced	
Resting state networks and syntax	Language processing	sentences	observation	observation	memory	stuttering	stuttering	stuttering	stuttering	reduced	
Resting state	Memory	network	control	control	memory	stuttering	stuttering	stuttering	stuttering	reduced	
Memory	Memory	memory	control	control	memory	stuttering	stuttering	stuttering	stuttering	reduced	
Sensory perception	Sensory perception	object	encoding	encoding	memory	stuttering	stuttering	stuttering	stuttering	reduced	
Deafness and sign language	-	visual	visual	visual	memory	stuttering	stuttering	stuttering	stuttering	reduced	
Priming and repetition effect	Conditioning	negative	negative	negative	memory	stuttering	stuttering	stuttering	stuttering	reduced	
Working memory and error monitoring	Conditioning	positive	positive	positive	memory	stuttering	stuttering	stuttering	stuttering	reduced	
Sentence comprehension and syntax	-	autobiographical	events	events	memory	stuttering	stuttering	stuttering	stuttering	reduced	
Episodic memory encoding and retrieval	Episodic memory	episodic	future	future	memory	stuttering	stuttering	stuttering	stuttering	reduced	
Effective causal modeling of neural networks	Effective causal modeling	stroke	feedback	feedback	memory	stuttering	stuttering	stuttering	stuttering	reduced	
Relationship reasoning and fluid intelligence	Relationship reasoning	positive	future	future	memory	stuttering	stuttering	stuttering	stuttering	reduced	
Affective valence and fluid intelligence	-	negative	events	events	memory	stuttering	stuttering	stuttering	stuttering	reduced	
Autobiographical memory in epilepsy	Memory	autobiographical	provide	provide	memory	stuttering	stuttering	stuttering	stuttering	reduced	
Evidence and effect in behavioral studies	-	evidence	provide	provide	understanding	stuttering	stuttering	stuttering	stuttering	reduced	

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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). *ChatGPT*. <https://chat.openai.com>.
- 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.

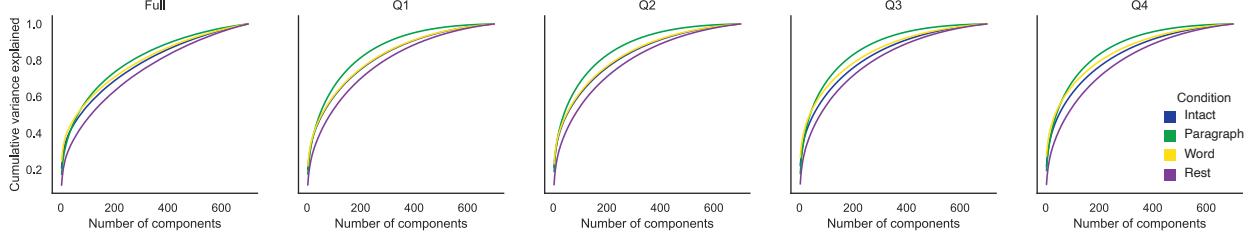


Figure S1: Cumulative variance explained by component, condition, and part. Each panel displays the cumulative variance explained in the neuroimaging data as a function of the number of principal components. Colors denote experimental conditions. The left panel displays results for all data, and the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

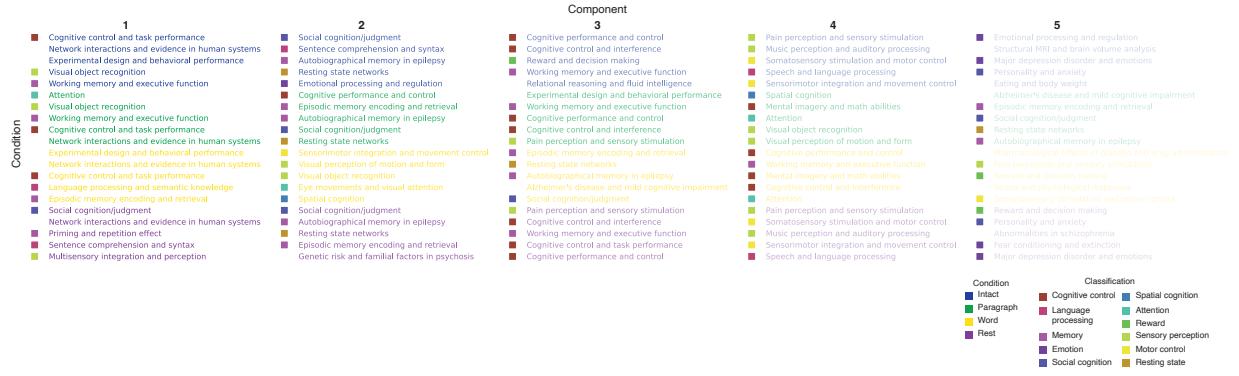


Figure S2: Highest-weighted topics associated with the highest-weighted components by condition, broken down by story segment. Each group of five rows corresponds to an experimental condition (denoted by color, as indicated in the legend in the lower right), and the columns and shading correspond to 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).

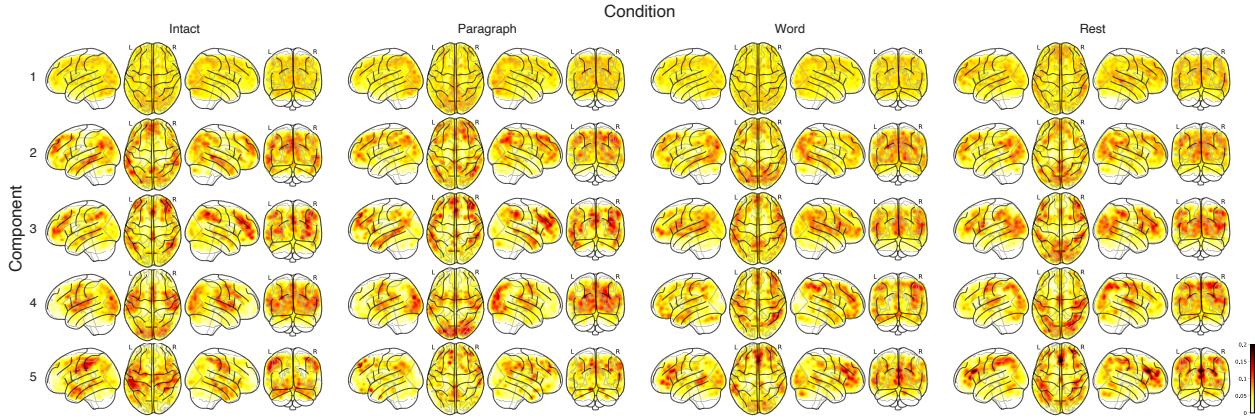


Figure S3: Brain maps by component and condition. For the top five highest-weighted principal components (rows), from each experimental condition (columns), the components' brain maps are projected onto four views: left sagittal, axial, right sagittal, and coronal. The color scale is the same for all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

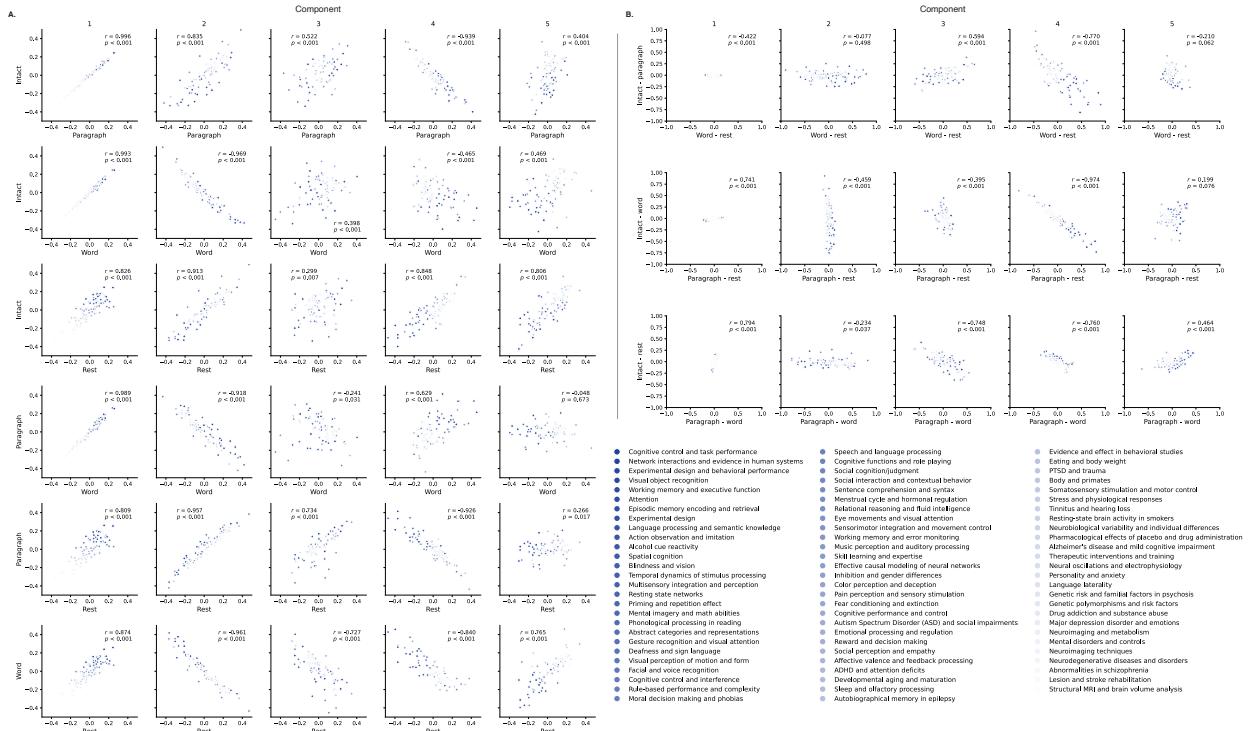


Figure S4: Comparisons between per-component topic correlations across conditions. Each sub-panel displays a scatterplot comparing the per-topic correlations for two or more experimental conditions. Each dot denotes the correlations for a single topic (indicated by the legend on the right). The topics 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.

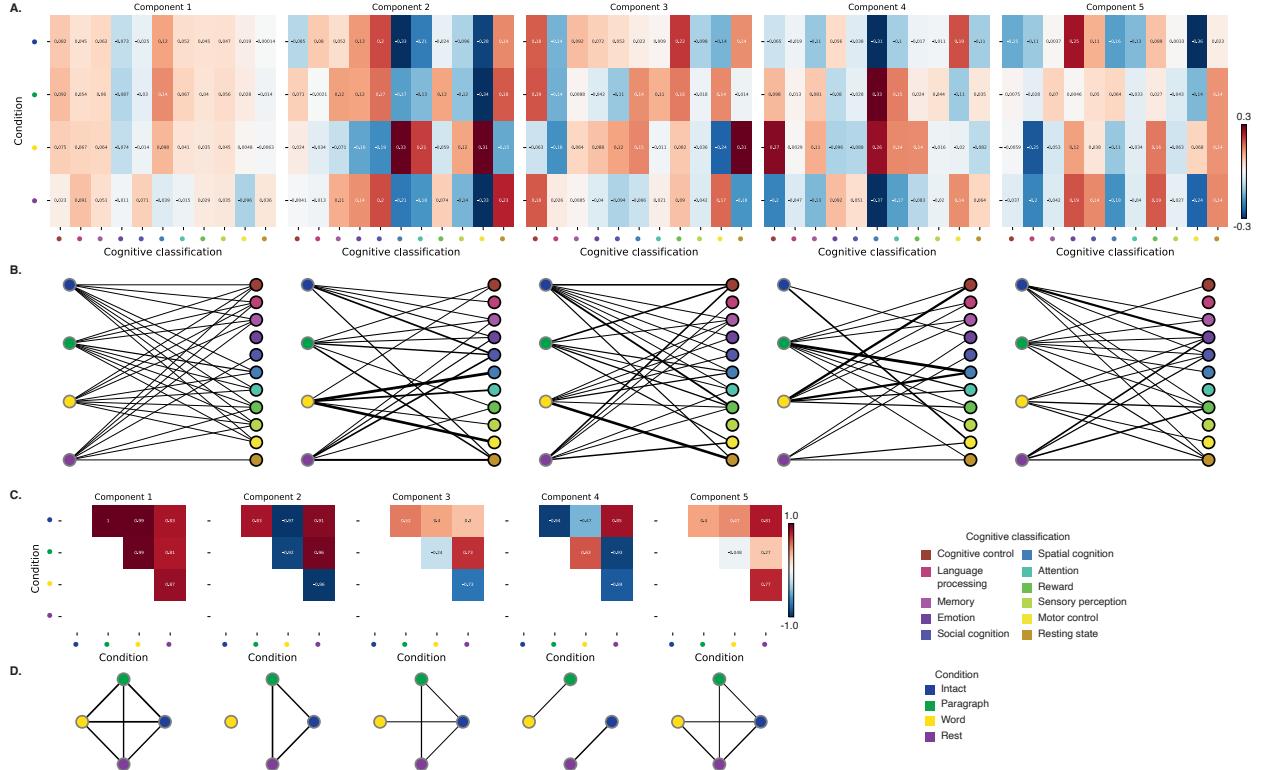


Figure S5: Functions associated with top-weighted components by condition. **A. Top-weighted topics by condition.** Here we display per-condition (rows, indicated by colored dots) topic correlations, averaged across topics that pertain to each of several broad cognitive functions (columns within each 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 heat maps in Panel A). **C. Correlations between each principal component, by condition.** The heat maps 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 heat maps in Panel C).