Supporting Information (SI)

SI Materials and method

TMS-specific recruitment parameters

As in our prior repetitive transcranial magnetic stimulation (rTMS) study (1), participants were excluded from participation if they might be pregnant, had a current or previous neuropsychiatric or neurological illness, were taking any psychoactive medications, had a prior head injury that required hospitalization, had a history of concussions, had experienced frequent or severe headaches, had a prior experience of a seizure, had a diagnosis or family history of epilepsy, or were diabetic. Before participating in each continuous theta-burst (cTBS) session, participants self-reported to not have consumed alcohol in the last 24h and not to have consumed caffeinated drinks in the last 2h.

Object stimuli and task presentation

Experimental materials comprised 162 object cue words denoting common, everyday objects drawn from prior related studies (e.g., 2-4). The cues were divided into 18 lists (i.e., 3 cTBS sessions (no-cTBS, vertex, or AG) by 3 tasks (episodic simulation, divergent thinking, non-episodic control) by 2 runs). As in our prior rTMS study (1), cue lists were counterbalanced as a function of cTBS site and task. All stimuli were shown on a black screen in white 25-point Arial font. Stimuli were present using the Cogent software package (http://vislab.ucl.ac.uk/cogent.php) as implemented in MATLAB (The MathWorks, Natick, MA, USA).

Post-scan subjective ratings

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For each simulation trial, participants rated the similarity of the event to a prior experience (5-point scale: 'never anything similar' to 'this event exactly'), its plausibility (5-point scale: 'not at all' to 'extremely'), and whether it was within the next 1-5 years (binary response: 'yes' or 'no'). For each divergent thinking trial, participants rated the similarity of the uses generated to prior experiences (5-point scale: 'not at all' to 'extremely') and how creative (original and novel) they thought their uses were on average (5-point scale: 'not at all' to 'extremely'). For each control trial, participants rated the familiarity of the objects generated on average (5-point scale: 'not at all' to 'extremely') and the typicality (semantically and thematically related) of them (5-point scale: 'not at all' to 'extremely'). At the end of the session, participants also viewed each use generated for the AUT and rated each as either 'old' or 'new', with an old idea being a previous memory or thought before the study and a new idea being a thought that came to mind for the first time during the study (see also refs. 2-3, 5-6). These data were collected for exploratory purposes outside the current study's scope (note also that due to trial numbers, an analysis of old vs. new ideas would be statistically underpowered).

Post-scan interview scoring

Each future event was segmented into internal and external details. Internal or episodic details refer to those of the main event that are specific in both time and place (i.e., the who, what, when, and where details of the central event). External or non-episodic details include factual, off-topic, metacognitive, or repetitive information (for other examples of this scoring approach, see refs. 1, 7-10). Internal details for the control task refer to those of the object definitions (including the two associated objects

generated for each trial) that are on-task and meaningful. External details refer to details that are off-topic, repetitive, not meaningful, or commentary. Quantitative measures included fluency (i.e., total appropriate uses generated excluding repetitions), flexibility (i.e., the number of distinct categories that appropriate uses could be classified under), and elaboration (i.e., a rating of the level of detail associated ranging from 0 to 2; see ref. 11). A single qualitative measure was computed as originality (i.e., a rating of the perceived novelty and appropriateness of each use, ranging from 1 to 4, with scores of 3 and 4 given to only a few uses per participant; 6). For each measure, the scores were averaged across trials to create a standardized measure of performance.

fMRI acquisition, preprocessing, and analysis parameters

For task-based scanning, functional images were acquired with a multiband echo-planar imaging sequence (University of Minnesota C2P sequence: repetition time (TR) of 2s, echo time (TE) of 30ms, matrix size of 124×124, 87 slices (3 slices acquired simultaneously), 1.7mm^3 resolution). The slices were auto-aligned to an angle 20^o toward coronal from anterior–posterior commissure alignment. Anatomic images were acquired with a magnetization-prepared rapid gradient echo sequence (1mm^3 resolution).

Task-based functional image preprocessing in SPM12 included slice-time correction, two-pass spatial realignment, and normalization into Montreal Neurological Institute (MNI) space (images were not resampled). Functional images were smoothed with a 3mm full-width half-maximum (FWHM) Gaussian kernel. Anatomic images were normalized into MNI space using an analogous procedure to that employed for the functional images.

For resting-state scanning, images were acquired with a multiband echo-planar imaging sequence (TR of 650ms, TE 34.80ms, matrix size of 90x90, 64 slices (8 slices acquired simultaneously), 2.3mm^3 resolution). The slices were auto-aligned to an angle 20^o toward coronal from anterior–posterior commissure alignment. Note the acquisition parameters differed from the functional data to maximize scanner capabilities. The first four TRs of each resting-state scan were removed to minimize T1-saturation. The data were realigned, spatially normalized to the MNI template, and resampled to 2 mm^3. Resting-state specific preprocessing steps were conducted in FSL 4.1.7 (FMRIB) and SPM12 (12). Data were smoothed with a 4mm Gaussian kernel and filtered to retain frequencies below 0.08Hz. Partial regression was used to create a series of regressors reflecting variance of non-neural sources (i.e., noise). These regressors included 6 motion parameters, the averaged signal within cerebrospinal fluid, an ROI within deep white matter, and an ROI comprising the whole brain (i.e., global signal regression; 13). We also included each regressor's first temporal derivative to correct for potential temporal shifts in BOLD signal.

We also conducted an analysis to test for the specificity of the effect of cTBS on connectivity between the hippocampal seed and AG target site (i.e., we compared the hippocampus-to-AG connectivity to connectivity to other 'control' locations). Specifically, we examined whether cTBS to the AG relative to the vertex also changed connectivity between the hippocampal seed and two other known resting-state fMRI networks. On an individual participant basis, we extracted the connectivity values for regions belonging to the frontoparietal control network (FPCN) and the visual attention network (VAN) using the functional-anatomic characterization reported by Vincent et al. (2008;

see Table 2 in (14) for coordinates). The FPCN regions included the anterior cingulate, right and left dorsolateral prefrontal cortex, left and right anterior insula, and left and right anterior inferior parietal lobule (7 regions). The VAN regions included left and right frontal eye fields, and left and right superior parietal lobule (4 regions). Connectivity values were averaged across regions within a given network (mean hippocampus-to-FPCN connectivity (± 1 standard error) following vertex cTBS and AG cTBS was -0.005±0.02 and -0.04±0.02, respectively, and mean hippocampus-to-VAN connectivity following vertex cTBS and AG cTBS was -0.066 ±0.02 and -0.08±0.01, respectively. We adopted an ROI approach relative to a whole-brain connectivity analysis to directly compare the originally reported seed-to-target connectivity analysis to the connectivity in regions of the FPCN and VAN.

We also performed a parametric modulation analysis in SPM by including regressors in the first-level models (for similar procedures, see 2, 10). Although we employed fMRI-guided cTBS to specifically manipulate episodic relative to non-episodic processing, this additional analysis was carried out to further relate the behavioral and neural data. We entered, on a trial specific basis, a behavioral score for each imagined event, divergent thinking, and non-episodic control trial as a covariate of interest (i.e., regressor for each trial/detail type). The detail scored was modeled linearly, represented the orthogonal contribution of detail in the absence of any other covariates, and was mean-centered according to SPM algorithms. At the second level, parameter estimates for the six covariates of interest (i.e., behavioral scores for the construction-related activity for each of the three tasks and two cTBS sites) and for each participant were entered into a repeated-measures ANOVA. We then conducted the identical interaction

contrast as the main analysis (i.e., the vertex > AG contrast for the episodic simulation + divergent thinking > non-episodic control). This parametric modulation analysis identifies those voxels that during construction demonstrate differential activity following the cTBS to the AG vs. vertex as modulated by an index of detail for imagined events and divergent thinking over the non-episodic control task.

cTBS protocol for TMS manipulation

The cTBS protocol was composed of 50Hz triplets (three single pulses separated by 20msec) repeated at a frequency of 5Hz (every 200msec) for a duration of 40sec (or 600 pulses) using parameters from ref. 15 (for other studies employing this protocol, see refs. 16-18). This TMS protocol was assumed to be inhibitory and impair performance. This assumption is based on prior studies demonstrating that cTBS reduces cortical excitability (15), univariate fMRI activity (19), and has been shown to disrupt behavioral performance during episodic memory (16) and in autobiographical memory tasks (18, 20) akin to those employed in the current study. cTBS intensity was determined from the participant-specific motor threshold. In this procedure (e.g., 21), the left motor cortex was identified on each participant's anatomic image and motor threshold was defined as the lowest single-pulse TMS intensity that produced 5 out of 10 motor responses in the right hand (i.e., visual detection of a finger twitch in the right hand; motor threshold was set at 70% of stimulator output if no twitch was evident at this intensity). Once identified, cTBS intensity was set at 90% of the resting motor threshold. Mean cTBS intensity was 54.66±2.13% (i.e., resting motor threshold of 60.73). Relative to our previous TMS study which employed rTMS (i.e., 1Hz for 10min), here we employed cTBS for the specific purpose of being able to acquire fMRI data. In

contrast to rTMS, cTBS disrupts neural activity with shorter TMS durations (i.e., 40s relative to 60min of 1Hz TMS which would produce roughly equivalent durations of inhibitory TMS effects). Therefore, for reasons of participant comfort and overall feasibility, we adopted a cTBS as opposed to rTMS protocol.

Brainsight neuronavigation to implement TMS

To apply the cTBS and implement real-time tracking of the TMS coil and anatomic image on a participant-to-participant basis with Brainsight neuronavigation, three landmarks were identified on the participant-specific anatomic image (nasion, left preauricular, and right preauricular) and then coregistered. Reflective markers were also attached to the TMS coil which emitted signals picked up by an infrared camera. The coil was positioned perpendicular to the cTBS site and maintained at an angle 45^{o} away from the midline (see also refs. 1, 22-23). The TMS coil was initially placed at the target location. The coil was held in place by experimenter, with the TMS coil kept within 1-2mm from the target location during the TMS application.

SI Results

Subjective ratings

Behavioral variables collected in the scanner for the three tasks did not vary as a function of cTBS site (i.e., task difficulty or vividness rating; $Fs(2,34)<1.40$, $ps>0.26$; see Table S1). Consistent with prior findings, participants experienced the divergent thinking task as greatest in difficulty and the episodic simulation task as greatest in vividness relative to the other two tasks, respectively (2-3). Analyses of the post-scan ratings also revealed null effects of cTBS site ($ts(17)<1.47$, $ps>0.16$; see Table S2). In general,

future episodes were rated as plausible and not very similar to past experiences, and non-episodic control trials involved very familiar and typical objects. For the divergent thinking task, post-scan ratings indicated that generated uses were dissimilar to previous experiences, and creative. Taken together, these in-scan and post-scan ratings verify overall task compliance and confirm that participants performed the tasks adequately.

Divergent thinking metrics

Uses generated were scored as 'somewhat detailed' and 'somewhat creative', with these average elaboration and originality ratings not significantly differing as a function of cTBS site (0.99±0.08 and 1.75±0.06, respectively; $ts(17)<2.00$, $ps>0.06$).

Table S1

	Episodic simulation		Divergent thinking		Non-episodic control	
Rating	***Vertex***	***AG***	***Vertex***	***AG***	***Vertex***	***AG***
Difficulty	1.15 (0.12)	1.08 (0.11)	2.03 (0.14)	1.82 (0.15)	1.35 (0.12)	1.35 (0.14)
Vividness	2.39 (0.11)	2.5 (0.10)	1.91 (0.13)	1.89 (0.12)	2.03 (0.12)	2.02 (0.13)

1. Mean difficulty and vividness (± 1 standard error of the mean) for each task (episodic simulation, divergent thinking, and non-episodic control) and stimulation site (vertex and AG). Both ratings were made on a 5-point scale with lower ratings reflecting reduced vividness and difficulty.

2. As reported in the main text, for either the in-scan vividness or difficulty rating there was no interaction as a function of cTBS site. For either rating there were also no main effects of cTBS site (Fs, 1, 17) < 2.09, ps > 0.17), but the main effects of Task were significant (Fs(2, 34) > 15.60, ps < 0.001, partial η^2s > 0.48). Follow-up t-tests revealed that the episodic simulation task was experienced as greater in vividness than both the divergent thinking and control tasks (ts(17) > 3.77, ps < 0.002, ds > 0.89), with no other comparisons significant (t(17) = 1.28, p = 0.22). In addition, the divergent thinking task was experienced as greater in difficulty than both the episodic simulation and non-episodic control task (ts(17) > 5.31, ps < 0.001, ds > 1.25), with no other comparison significant (t(17) = 2.00, p = 0.06).

Table S2

Episodic simulation		
Rating	***Vertex***	***AG***
Similarity to a past event	2.51 (0.19)	2.52 (0.18)
Plausibility of the event	2.71 (0.18)	2.92 (0.16)
Divergent thinking		
Rating	***Vertex***	***AG***
Self-rated creativity	3.05 (0.14)	3.01 (0.13)
Similarity of uses to prior experience	2.33 (0.15)	2.32 (0.16)
Non-episodic control		
Rating	***Vertex***	***AG***
Familiarity of objects generated	4.15 (0.10)	4.17 (0.10)
Typicality of objects generated	4.18 (0.11)	4.15 (0.10)

1. Mean post-scan ratings made on a 5-point scale ranging from least to most (± 1 standard error of the mean) for each task (episodic simulation, divergent thinking, and non-episodic control) and stimulation site (vertex and AG).

2. As reported in the main text, no significant differences emerged when comparing each post-scan rating as a function of cTBS site.

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