Supplementary Information for:

Stimulus-specific enhancement of fear extinction during slow-wave sleep

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Supplementary Table 1. **Regions exhibiting increased fMRI signal for CS+ versus CS- cues (parametrically modulated by SCR) during pre-sleep conditioning.**

Region	L/R	Volume	*x*	*y*	*z*	Peak *Z*	*P* value
Middle frontal gyrus	R	22	48	42	10	3.268	0.0005
Cerebellum	L	13	-18	-60	-40	3.128	0.0009
Insula	R	23	46	18	8	3.127	0.0009
Orbitofrontal cortex	R	20	16	42	-12	3.015	0.0013
Anterior cingulate cortex	R	27	8	48	10	3.011	0.0013
Hippocampus	R	10	38	-22	-16	2.996	0.0014

Trial-specific SCR was used to estimate fMRI time-courses of conditioning, on a subject-by-subject basis. Volume in mm^3. L, left hemisphere; R, right hemisphere.

Supplementary Table 2. **Regions exhibiting decreased fMRI signal from pre- to post-sleep in response to tgCS+ versus ntCS+ (adjusted for CS- baselines)**.

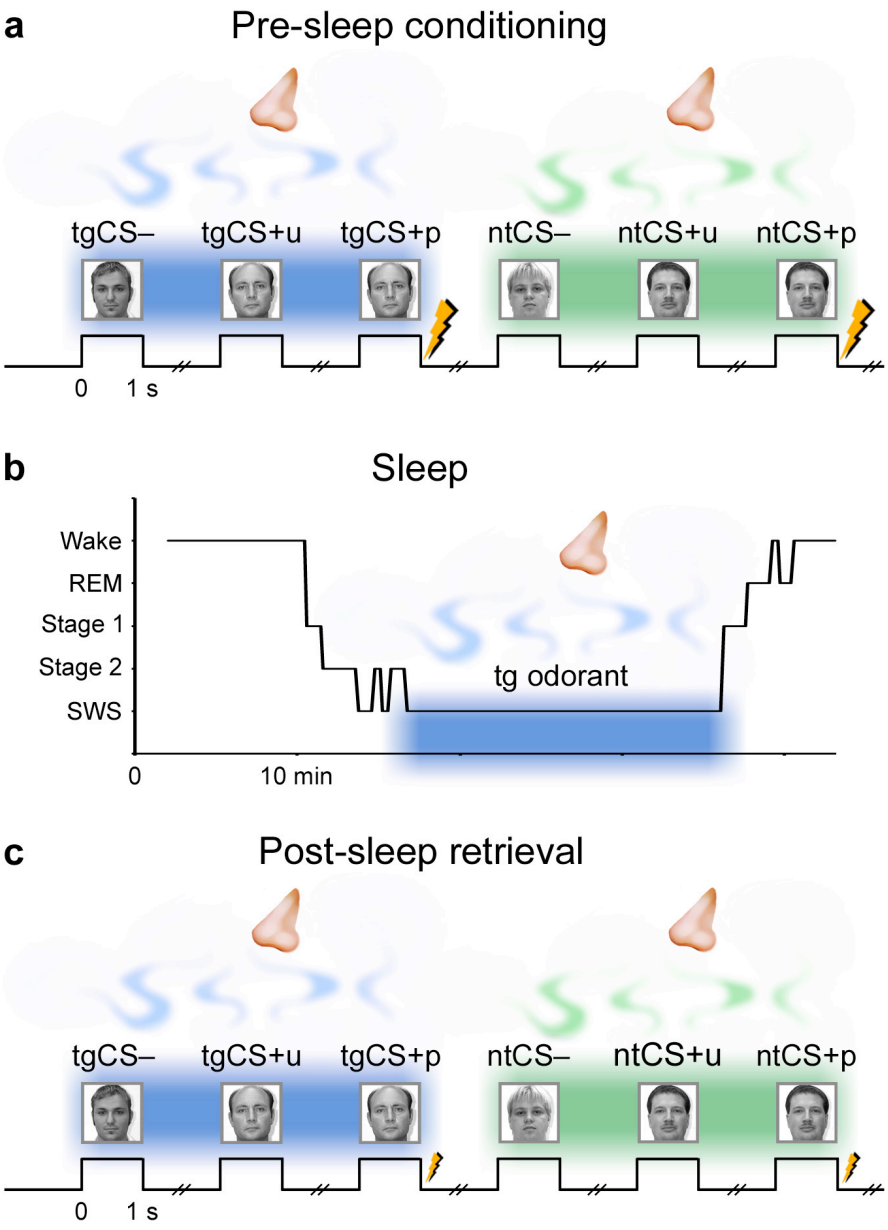
Region	L/R	Volume	*x*	*y*	*z*	Peak *Z*	*P* value
Dorsolateral PFC	L	120	-42	36	24	4.034	0.00003
Hippocampus	R	40	38	-8	-24	3.849	0.00006
Anterior cingulate	R	40	18	28	20	3.498	0.00023
Insula	R	48	36	18	14	3.239	0.00060

Volume in mm^3. L, left hemisphere; R, right hemisphere. PFC, prefrontal cortex. All regions survived a cross-validation analysis based on an iterative jackknife approach followed by small-volume correction (as described in Online Methods). Clusters passing a corrected threshold of $P < 0.05$ are reported (*P* values for the peak voxels within each cluster are reported here). Adjustment for CS- baselines was performed by subtracting stimulus-evoked responses to tgCS- and ntCS- from responses to tgCS+ and ntCS+, respectively.

Supplementary Table 3. **Duration of wakefulness and sleep stages during the sleep phase of the study, averaged across all subjects (*N*=15).**

	Wake	Stage 1	Stage 2	SWS	REM
Minutes	17.1 (3.8)	16.2 (2.7)	12.0 (2.4)	18.9 (3.1)	9.2 (2.1)
Percent time	21.9 (4.3)	21.3 (3.1)	16.4 (3.6)	28.7 (4.2)	11.8 (2.7)

Values shown are *M* (*SE)*. SWS, slow-wave sleep; REM, rapid eye-movement sleep.



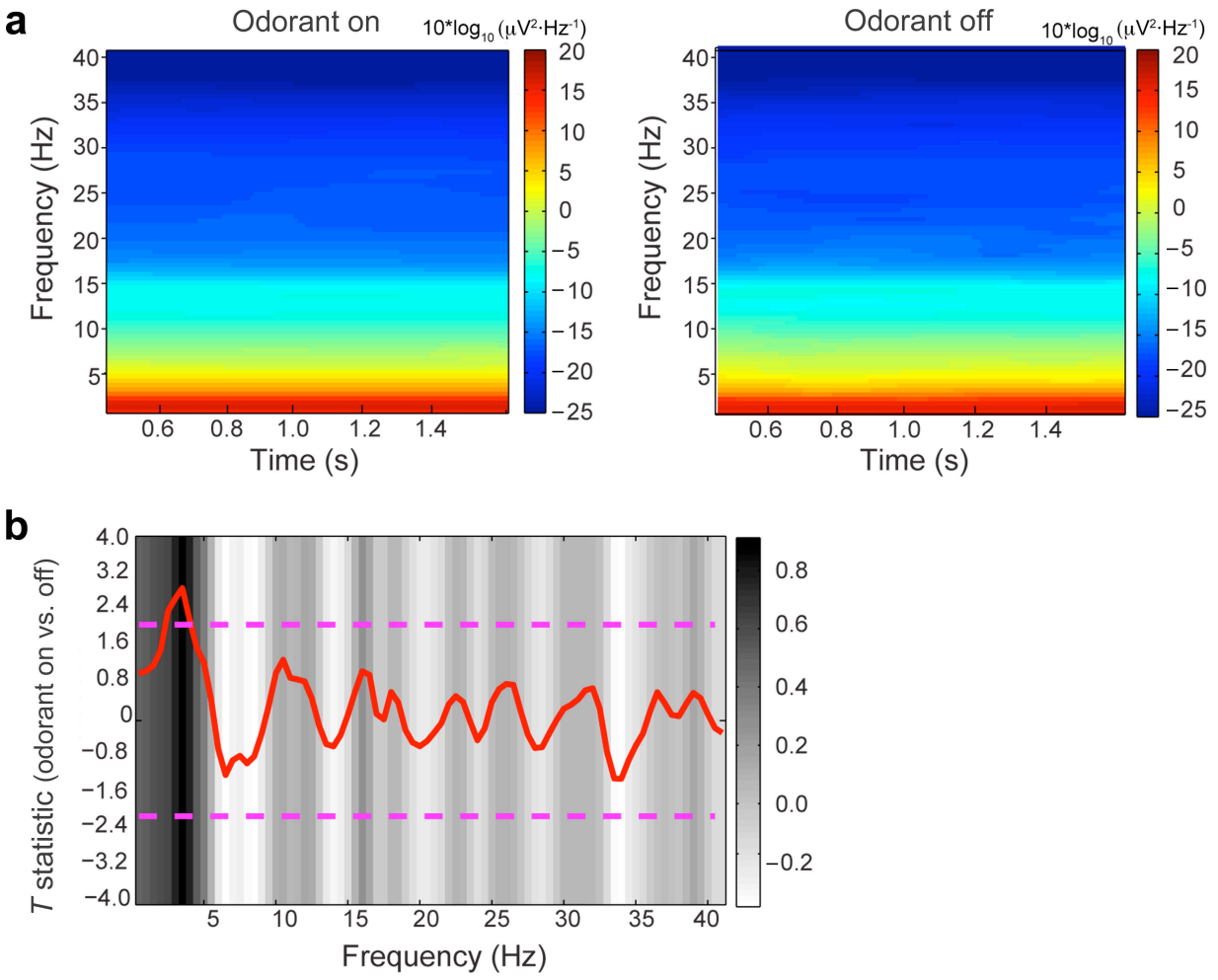
Supplementary Figure 1. Experimental paradigm.

(a) Contextual fear conditioning was completed in the MRI scanner. "Target" (blue) and "non-target" (green) odorants served as background contexts in alternating trial blocks. Two conditioned stimuli (face images) were presented within the target context (tgCS+, tgCS-), and two within the non-target context (ntCS+, ntCS-). Both tgCS+ and ntCS+ were paired with the

US (mild electric shock) on 50% of trials (tgCS+p, ntCS+p) and were unpaired on the remaining 50% of trials (tgCS+u, ntCS+u). Control stimuli (tgCS-, ntCS-) were never paired with shock. Stimuli were presented in 8 blocks (4 target, 4 non-target), in pseudo-randomized order.

(b) Subjects in slow-wave sleep (SWS) underwent repeated re-exposure to the target odorant (in 30s on-off intervals), outside of the MRI scanner. The hypnogram illustrates sleep-staging data for a representative subject (for group averages, see Supplementary Table 3).

(c) Upon awakening, subjects completed a retrieval task in the MRI scanner. This task was identical to the pre-sleep conditioning task, apart from a 12.5% partial-reinforcement schedule, following prior methods (reference 21, main text).



Supplementary Figure 2. EEG spectral power analysis during sleep.

(a) Mean spectrograms from central electrodes C3 and C4 for odorant-on blocks (left) and odorant-off blocks (right) during slow-wave sleep (n=14).

(b) Mean EEG power for odorant-on and odorant-off blocks did not significantly differ for the following frequency bands: delta (0–4Hz; t[13]=1.77, P=0.09), theta (4–8Hz; t[13]=0.81, P=0.42), alpha (8–12Hz; t[13]=0.67, P=0.51), beta (12–30Hz; t[13]=0.18, P=0.85) and gamma (30–40Hz; t[13]=-0.03, P=0.96). A fine-grained analysis over the full range of frequencies (1–41 Hz, no averaging across bands) revealed significantly increased power during odorant-on versus

odorant-off blocks in the low frequency range of 2.5–4 Hz (and not in alpha frequencies, as would be indicative of awakening). Specifically, significant differences were found for 2.5 Hz (t[13]=2.37, P=0.03), 3 Hz (t[13]=2.64, P=0.02), 3.5 Hz (t[13]=2.87, P=0.01), and 4 Hz (t[13]=2.19, P=0.04). The gray-scale image reflects the difference in total power at a given frequency for odorant-on versus odorant-off blocks ([odorant on] – [odorant off]). T-statistic values (two-tailed) are represented by the red line (n=14). The threshold of statistical significance (P=0.05) is represented by the pink dashed line.