

# **Modulating dream experience: Noninvasive brain stimulation over the sensorimotor cortex reduces dream movement**

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## **SUPPLEMENTARY MATERIAL**

## Supplementary content analysis of movement sensations in verbal dream reports

Movements were reported in 49.8% (SEM=10) of dreams following sham-stimulation and 54.9% (SEM=10.9) of dreams following tDCS. Repetitive actions were the most common type of movement, followed by single actions, with passive movements being the least common (see Tables 2 and S1), replicating the pattern observed in the BED Questionnaire data. However, there were no significant differences between the sham-stimulation and tDCS conditions (see Table S1), in contrast to the effects observed in the questionnaire data (see Table 1). The discrepancy could be due to a considerably smaller proportion of explicitly expressed movements in free dream reports compared to the BED Questionnaire answers, i.e. participants tended to omit explicit descriptions of movements from the spontaneous verbal reports.

Nevertheless, the proportion of repetitive actions correlated strongly between the free dream reports and the BED Questionnaire answers in the sham-stimulation condition (Spearman rank order correlation:  $\rho=0.81$ ,  $p_{B-g}=0.033$ ), indicating a strong convergence between these two types of measurement. Interestingly, this association did not hold in the tDCS condition ( $\rho=-0.19$ ,  $p_{B-g}=1$ ). No other correlations were significant.

**Supplementary Table S1.** Dream content analysis: Percentage of dream reports containing movement sensations following sham-stimulation and tDCS during REM sleep

	<i>Sham</i>	<i>tDCS</i>	<i>Statistical test</i>	
	<i>M (SEM)</i>	<i>M (SEM)</i>	<i>t/Z</i>	<i>p</i>
<i>Movement</i>	49.8 (10)	54.9 (10.9)	$t(9) = 0.31$	0.77
<i>Movement sub-scales</i>				
Single actions	21.6 (10.5)	24.9 (8.6)	$t(9) = 0.19$	0.85
Repetitive actions	38.2 (12.7)	43.2 (9.4)	$Z = 0.54$	0.59
Passive movements	16.6 (7)	8.3 (5.7)	$Z = 0.76$	0.45

*Note.* t: paired samples t test; Z: Wilcoxon signed-rank test. Uncorrected p values.

### **Control analysis of the time of night effect on the presence of bodily experiences in dreams**

To control the possible effect of the time of night on the frequency of bodily experiences reported in the BED Questionnaire upon awakening, we compared the answers to the five main questions regarding the presence of different types of bodily experiences (tactile-somatosensory, vestibular-balance, movement, movement alterations, body scheme alterations) between the first and the last reports of each night, separately for the sham-stimulation and tDCS conditions. Cases in which a given experience was present in the first but not in the last set of questionnaire responses from the same night were coded as -1. Cases in which a given experience was either present or absent in both the first and the last set of questionnaire responses from the same night were coded as 0, indicating no change during night. Finally, cases in which a given experience was absent in the first but present in the last set of questionnaire responses from the same night were coded as 1. We observed no systematic difference between the first and the last set of questionnaire responses from the same night, excluding cumulative effects over night (see Supplementary Table S1).

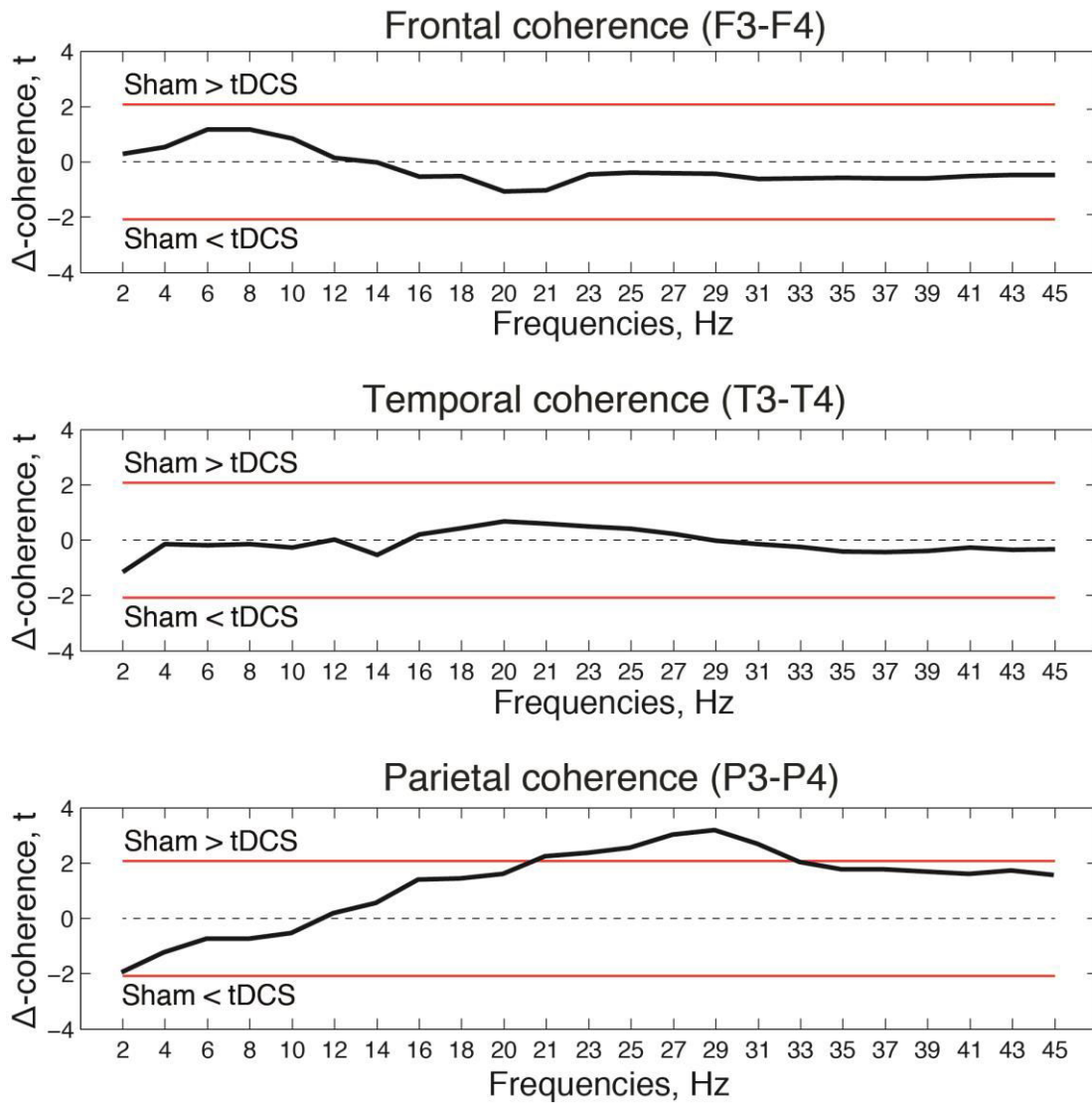
**Supplementary Table S2.** Relative values on a Likert scale comparing answers to the BED Questionnaire between the first and the last report within the same night

<i>Participant ID</i>	<i>5. Tactile-somatosensory</i>		<i>11. Vestibular-balance</i>		<i>14. Movement</i>		<i>18. Movement alterations</i>		<i>26. Body scheme alterations</i>	
	<i>Sham</i>	<i>tDCS</i>	<i>Sham</i>	<i>tDCS</i>	<i>Sham</i>	<i>tDCS</i>	<i>Sham</i>	<i>tDCS</i>	<i>Sham</i>	<i>tDCS</i>
1	-1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	1	1	0	0	0	0
3	0	1	0	0	0	0	0	1	0	0
4	-1	0	0	0	0	0	-1	0	0	0
5	-1	0	-1	0	0	0	0	0	0	0
6	1	-1	0	0	0	1	1	0	0	0
7	0	1	0	0	0	-1	0	0	0	0
8	0	1	0	0	-1	0	-1	0	-1	0
9	0	0	0	0	0	-1	0	0	0	0
10	0	0	-1	0	0	0	0	0	0	0

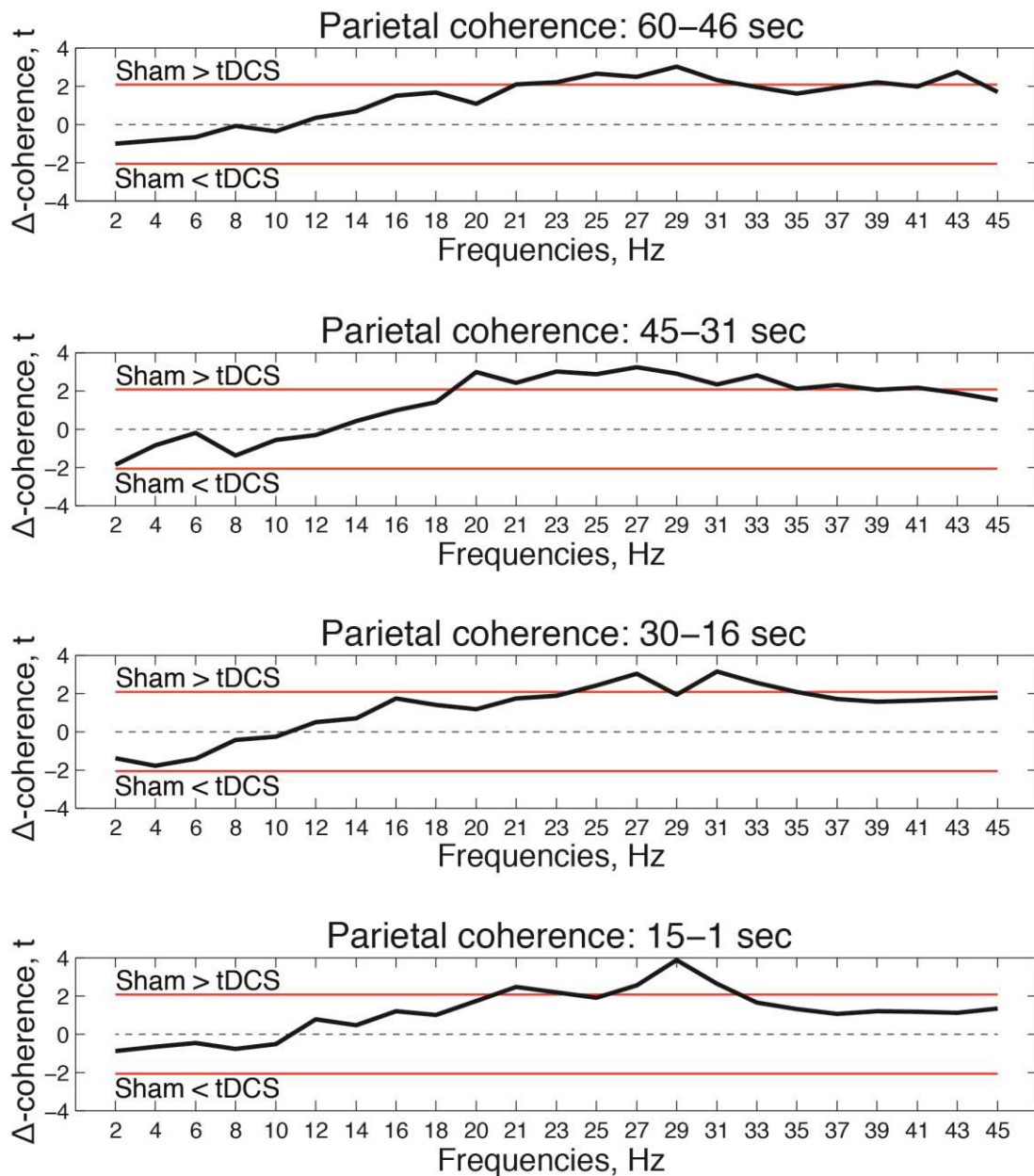
## **tDCS modulation of EEG coherence: Exploratory analysis of individual frequencies**

While hypothesis-based analysis was carried out by averaging EEG beta coherence over 15-30 Hz frequency range, exploratory pairwise comparisons across a wider range of frequencies (2-45 Hz) indicated that the tDCS effect was maximal between parietal electrodes P3 and P4 in the high beta range (21-31 Hz) ( $t(9)$  range=[2.29 3.23],  $p$  range=[0.01 0.048] (uncorrected), Cohen's  $d$  range=[0.84 0.93]) (see Fig. S1). Contrary to this, there were no tDCS effects in the delta, theta, alpha and gamma frequency ranges (see Fig. S1). Likewise, tDCS did not produce a significant modulation of inter-hemispheric coherence between the pairs of frontal (min/max  $t(9)$ =1.18,  $p$ =0.27 (uncorrected), Cohen's  $d$ =0.52) or temporal (min/max  $t(9)$ =-1.16,  $p$ =0.28 (uncorrected), Cohen's  $d$ =0.52) electrodes adjacent to the stimulation site (see Fig. S1)..

A more fine-grained analysis of four 15 sec time windows between the termination of stimulation and controlled awakenings indicated a short-lasting decrease of parietal coherence in the low gamma frequency range (37-43 Hz) immediately following tDCS, i.e. from -60 to -31 sec before awakenings (min/max  $t(9)$ =2.72,  $p$ =0.024 (uncorrected), Cohen's  $d$ =1.18; see Fig. S2).



**Figure S1 | Exploratory analysis of inter-hemispheric EEG coherence.** Inter-hemispheric EEG coherence between frontal (top), temporal (middle), and parietal (bottom) electrodes surrounding the tDCS site, expressed on the y axis as t statistic of a contrast between sham-stimulation and tDCS conditions ( $\Delta$ -coherence). A separate paired samples t test was carried out for each individual frequency from 1.95 Hz to 44.92 Hz separated in steps of 1.95 Hz, calculated over the whole 60 sec period from the termination of stimulation to the controlled awakenings. Individual frequencies are represented on the x axis. Red lines depict the significance threshold (uncorrected  $p < 0.05$ ). Positive t values indicate higher coherence in the sham-stimulation condition, whereas negative t values indicate higher coherence in the tDCS condition.



**Figure S2 | Exploratory analysis of inter-hemispheric parietal EEG coherence one minute before the awakenings.** Inter-hemispheric EEG coherence between parietal electrodes P3 and P4 located posterior to the tDCS site is depicted on the y axis as t statistic of a contrast between sham-stimulation and tDCS conditions ( $\Delta$ -coherence).  $\Delta$ -coherence is plotted separately in four stimulation-free time intervals preceding controlled awakenings from REM sleep. A separate paired samples t test was carried out for each individual frequency from 1.95 Hz to 44.92 Hz separated in steps of 1.95 Hz, which are represented on the x axis. Red lines depict the significance threshold (uncorrected  $p < 0.05$ ). Positive t values indicate higher coherence in the sham-stimulation condition, whereas negative t values indicate higher coherence in the tDCS condition.





For each sensation, mark the duration, whole body / body part and intensity. If you mark "never", jump to the next sensation.

9) Did you experience any of the following sensations? \*

	never	..2..	..3..	..4..	..5..	..6..	..7..	..8..	through out	whole body	right hand	left hand	right side of face	left side of face	other body part	low intensity	..2..	..3..	..4..	..5..	..6..	..7..	..8..	high intensity
pain *	€	€	€	€	€	€	€	€	€	€	€	€	€	€	€	€	€	€	€	€	€	€	€	€
pressure *	€	€	€	€	€	€	€	€	€	€	€	€	€	€	€	€	€	€	€	€	€	€	€	€
itching *	€	€	€	€	€	€	€	€	€	€	€	€	€	€	€	€	€	€	€	€	€	€	€	€

10) If you experienced other sensations and/or marked "other body part", please specify which sensation, which body part and on which side of the body (right / left / both)!

11) Did you experience any vestibular or balance sensations in your dream? \*

(for instance falling, floating, flying, spinning, or strange movement trajectories)

yes  no

12) Please specify the duration of vestibular and balance sensations in your dream! \*

	never	..2..	..3..	..4..	..5..	..6..	..7..	..8..	throughout
*	€	€	€	€	€	€	€	€	€

13) Did you experience any of the following vestibular sensations in your dream? \*

Please only mark one option in each horizontal line!

	never	..2..	..3..	..4..	..5..	..6..	..7..	..8..	throughout
falling *	€	€	€	€	€	€	€	€	€
floating *	€	€	€	€	€	€	€	€	€
flying *	€	€	€	€	€	€	€	€	€
spinning *	€	€	€	€	€	€	€	€	€
strange movement trajectories (back and forth, curvilinear) *	€	€	€	€	€	€	€	€	€

14) Did you move in your dream (including active as well as passive movements (for instance in a vehicle) of the whole body or body parts)?

yes  no

15) How frequently did you move in your dream (including active as well as passive movements (for instance in a vehicle) of the whole body or body parts)?

	never	..2..	..3..	..4..	..5..	..6..	..7..	..8..	throughout
*	€	€	€	€	€	€	€	€	€

16) How frequently did you perform the following types of movements in your dream?

	never	..2..	..3..	..4..	..5..	..6..	..7..	..8..	through out	whole body	right hand	left hand	right side of face	left side of face	other body part
single actions (e.g. placing a book on the table) *	€	€	€	€	€	€	€	€	€	€	€	€	€	€	€
repetitive actions (e.g. running) *	€	€	€	€	€	€	€	€	€	€	€	€	€	€	€
passive movements (e.g. going by car) *	€	€	€	€	€	€	€	€	€	€	€	€	€	€	€

17) If you marked "other body part", please specify which body part and on which side of the body (right / left / both)!







39) Is there anything else that you would like to remark about your dream? Did you remember more about your dream than you initially reported in your free dream report? If so, please report these things below!

40) Did you omit, censor, or change certain parts of your dream in your answers to these questions? \*

yes

no

41) Please try to estimate the duration of your dream. How long did your dream seem to last, according to subjective experience (in minutes)? \*

€ I want to submit my answers