Changes in brain network states while switching tasks after abrupt awakening

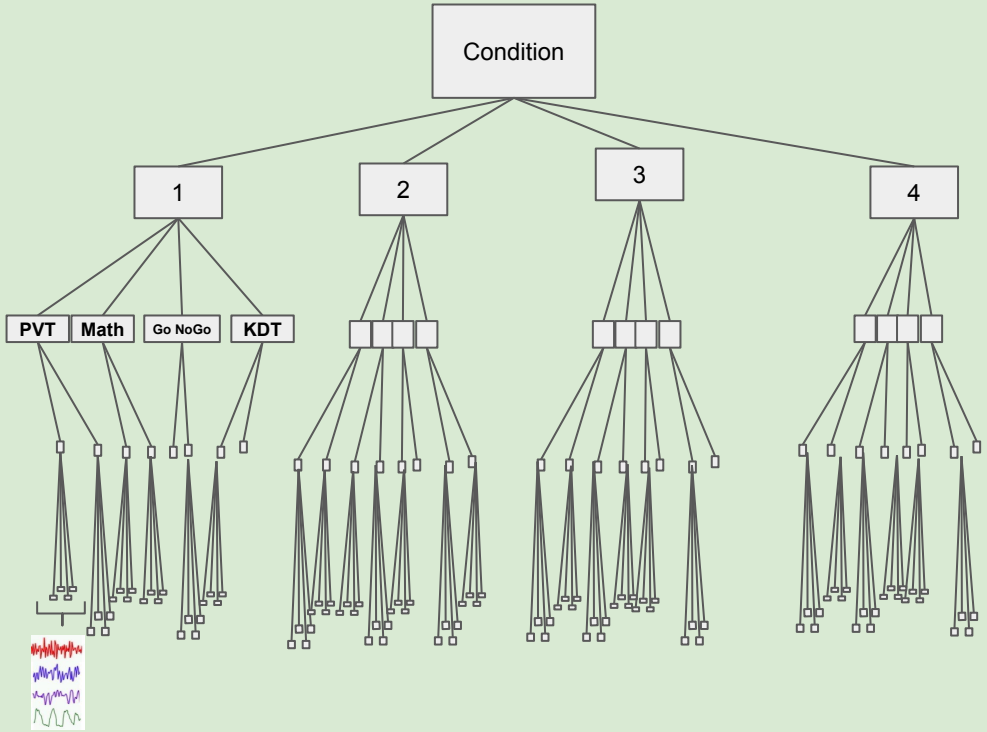
Variables

Experimental/ Manipulated Variables

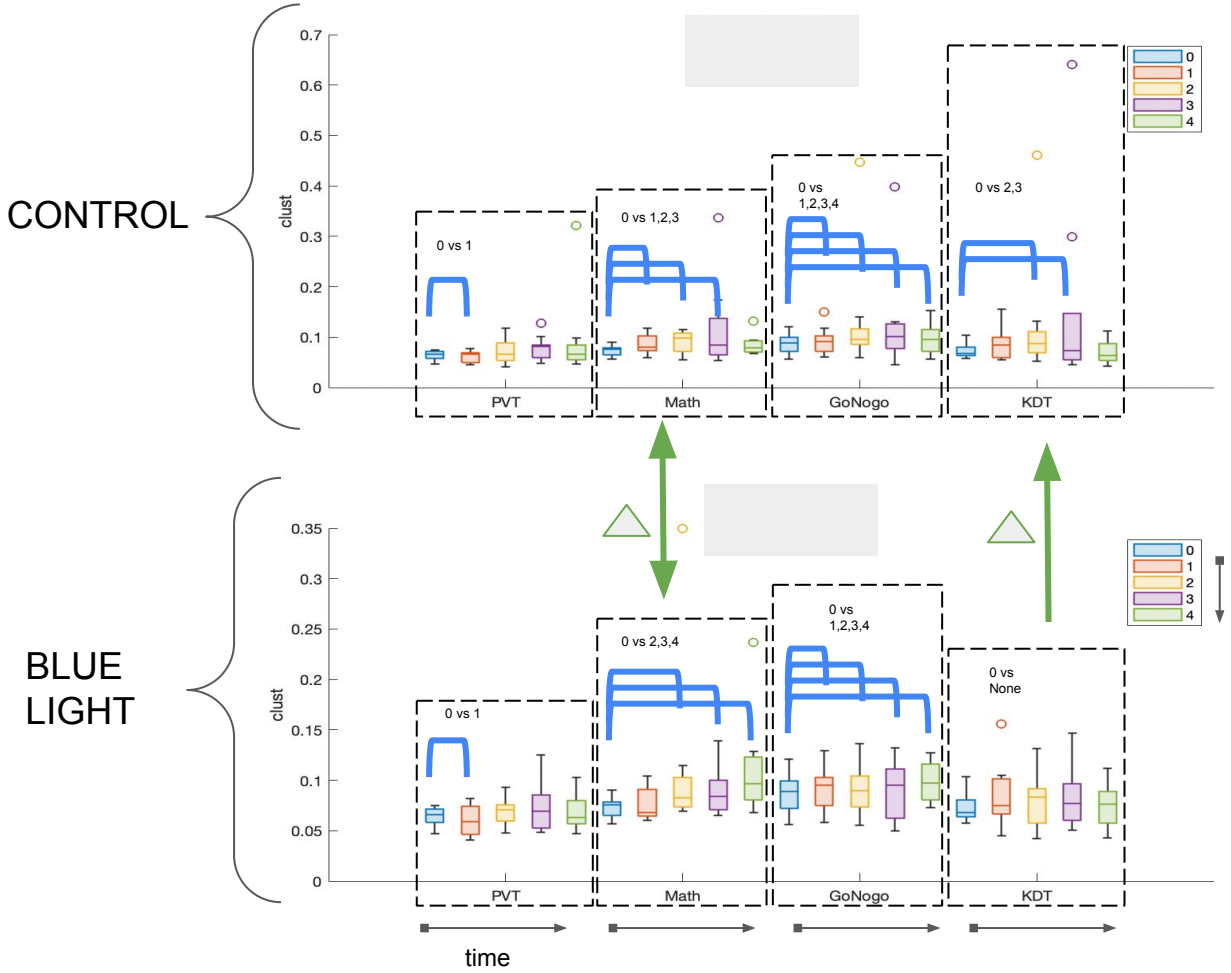
- 3 Conditions (Pre-sleep, control, blue light)
- 4 Test Bouts (time: 1,2,3,4)
- 4 Tasks (PV, Math, GoNogo, KDT)

Dependent /measured Variables

- Multiple Network Properties (Power, Clustering, Path Length)
- 4 frequency bands (delta, theta, alpha, beta)



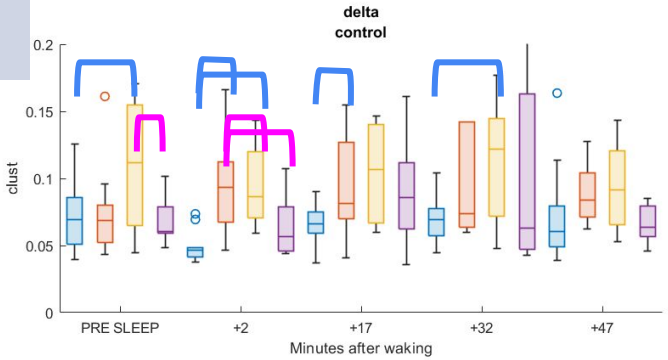
Clustering coefficient



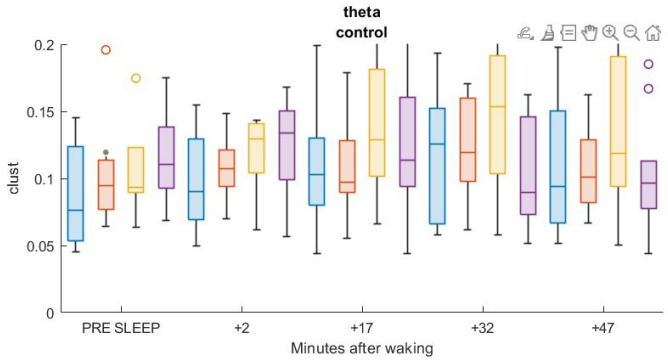
Pre- sleep is the comparison group

Clustering coefficient within bands during control

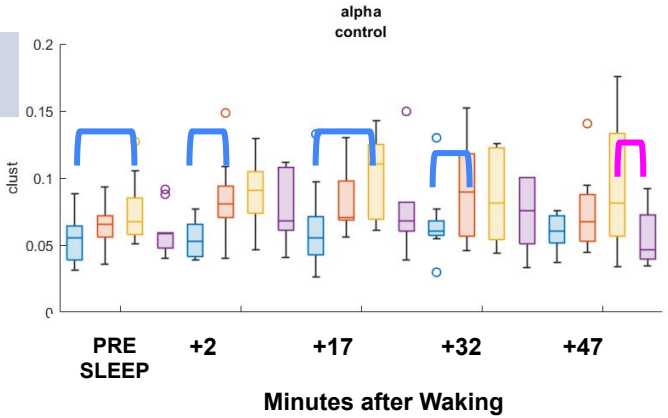
delta



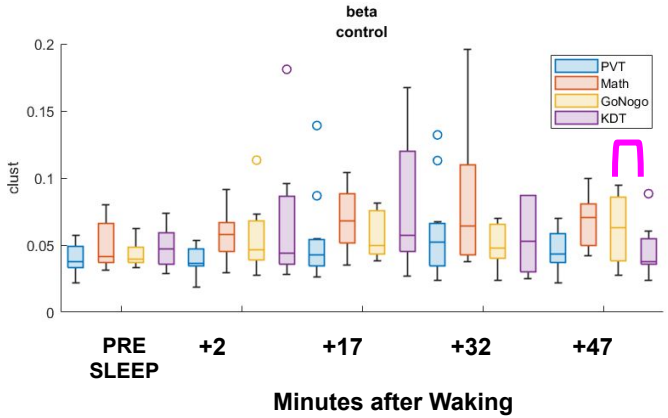
theta



Alpha

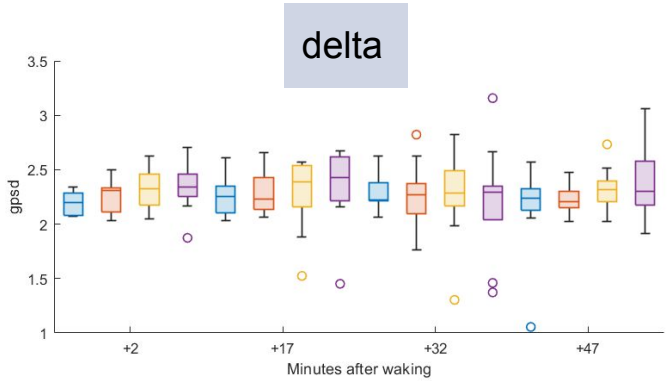


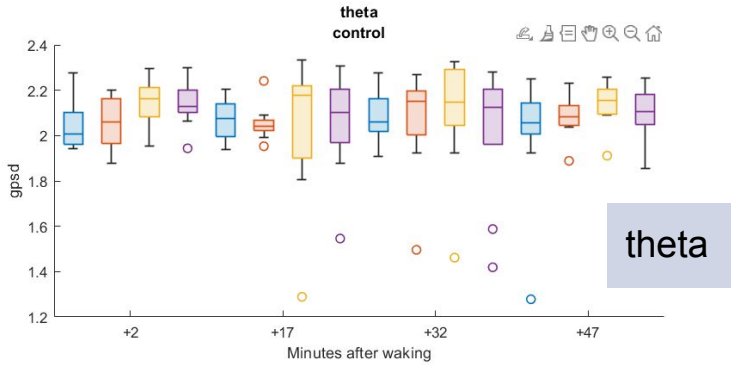
Beta

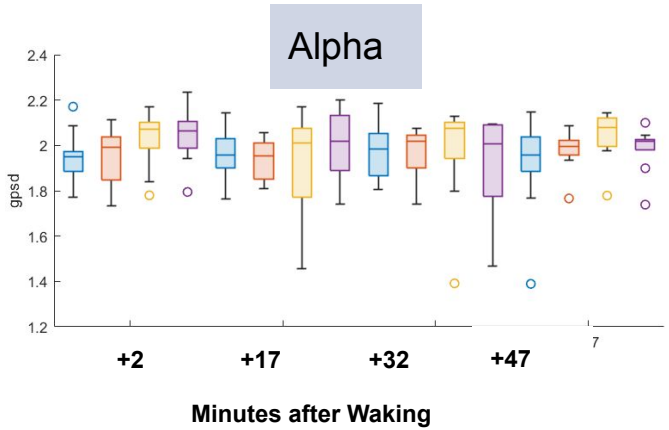


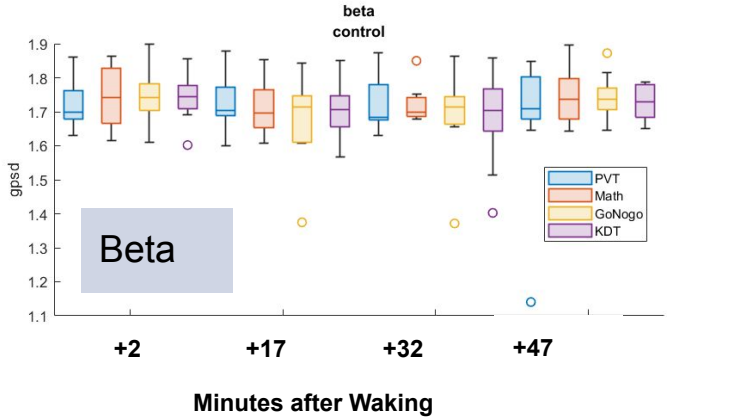
Global power within bands during control (no effects)

Global power

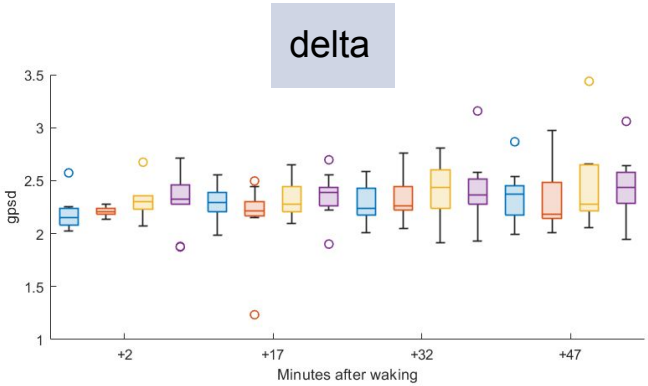


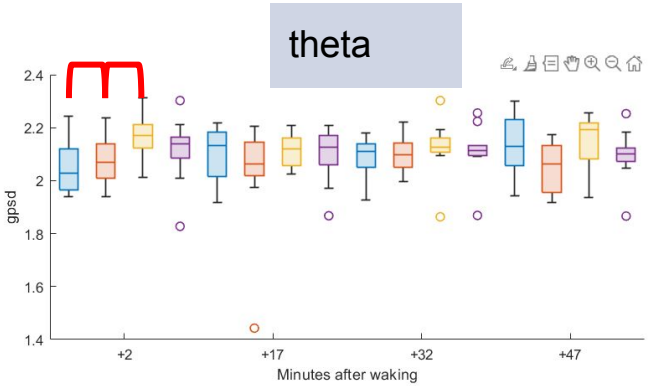


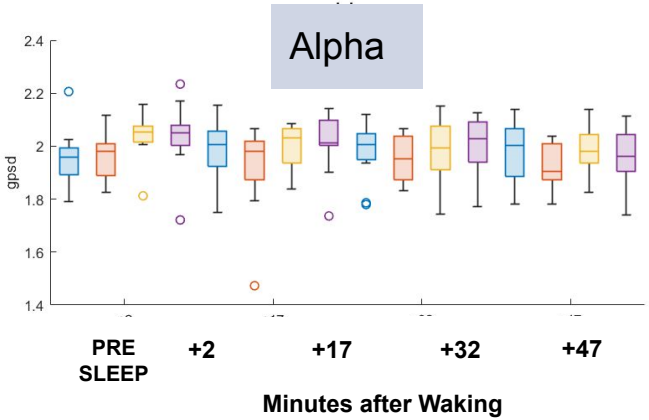


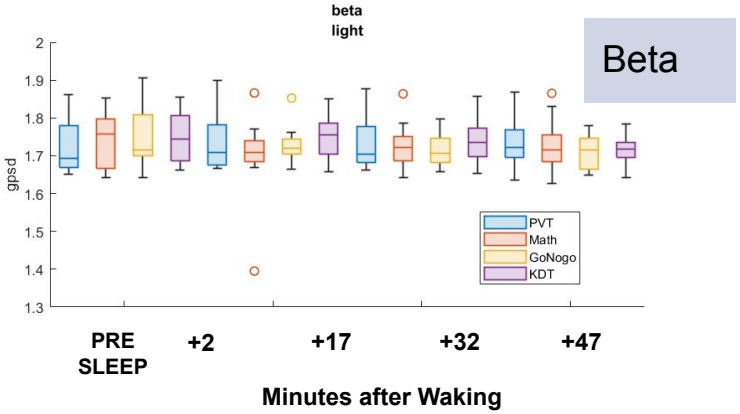


Global power within bands with blue light



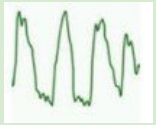






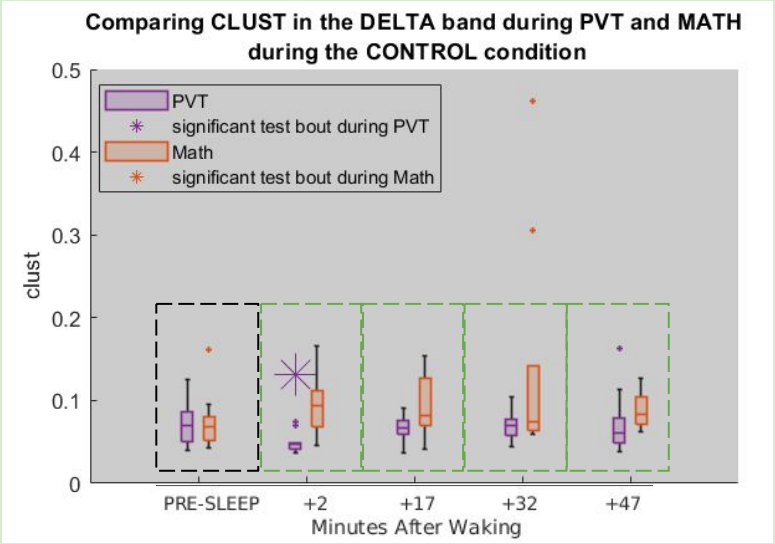
Note: Analysis of the control only

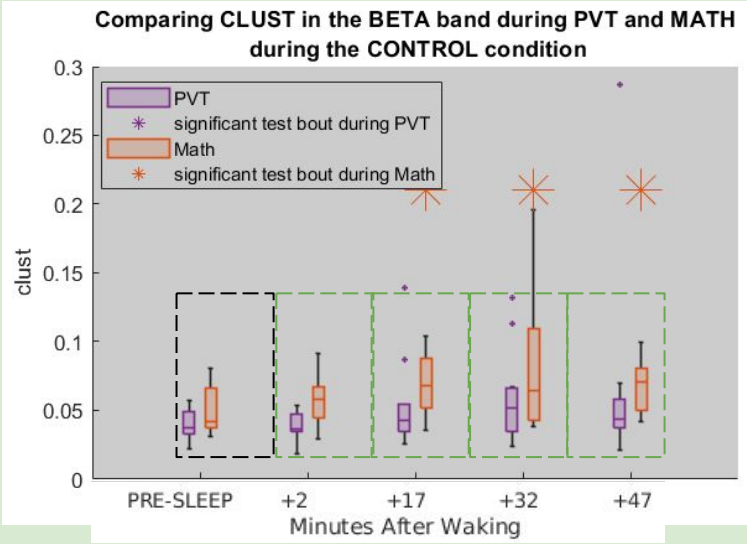
Onset and duration of clustering changes in different tasks and bands



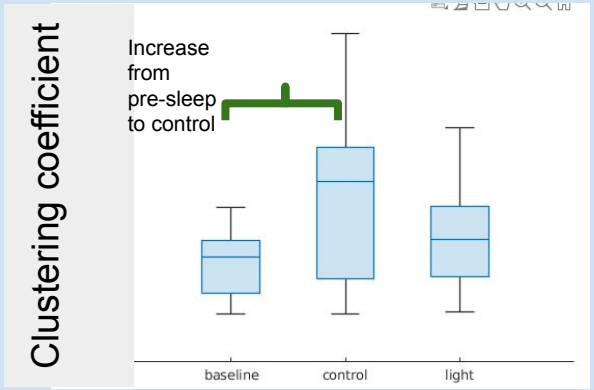
Task: PV task (PVT)
Band: delta/lower
Onset: early
Duration: short

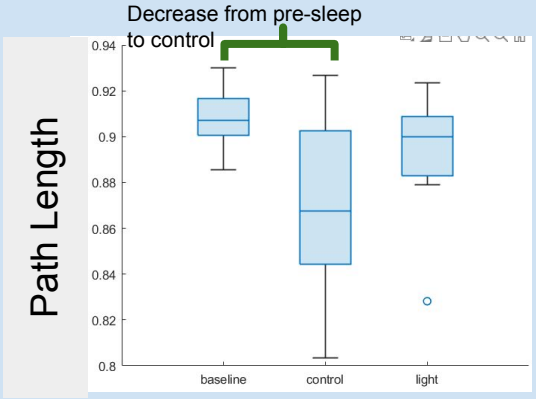
Task: Math task (orange)
Band: beta/higher
Onset: late
Duration: long

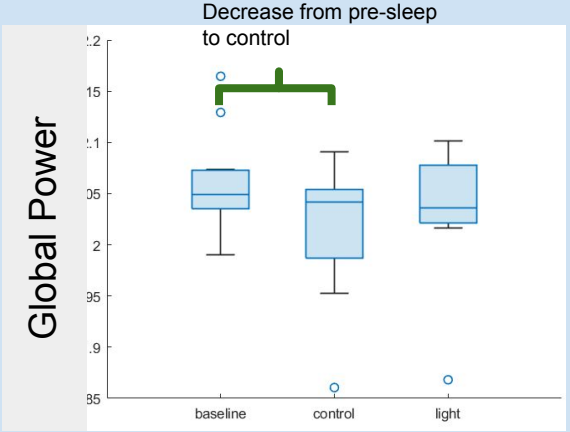




How networks change after abrupt awakening with and without blue light exposure







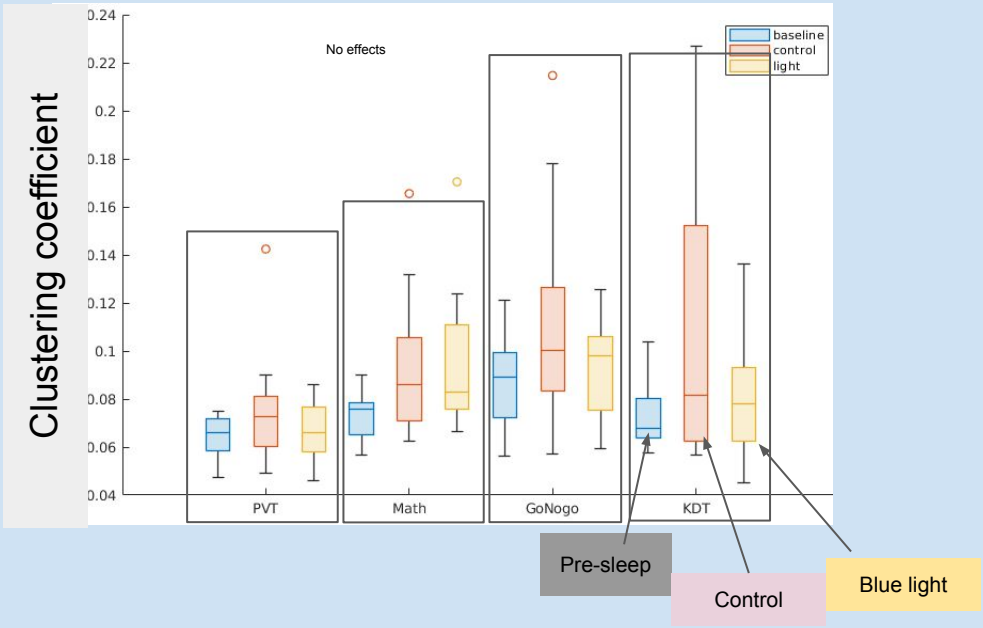
Pre-sleep

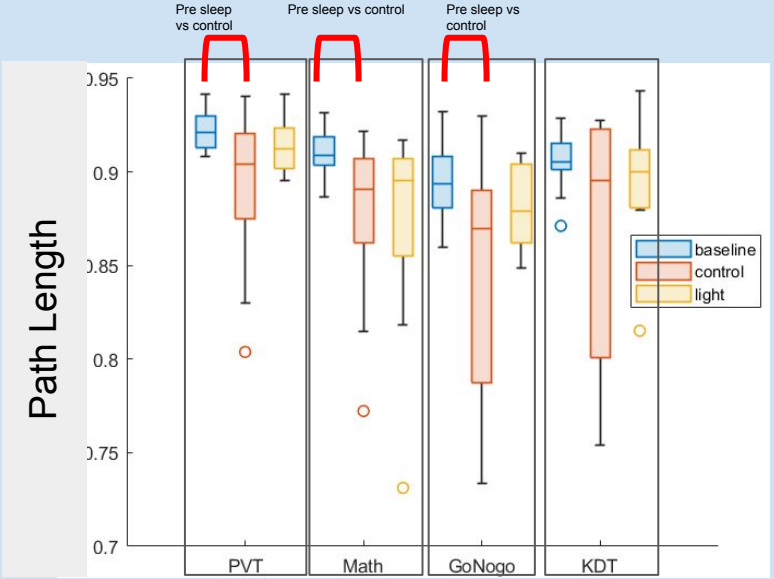
Control

Exposure to blue light

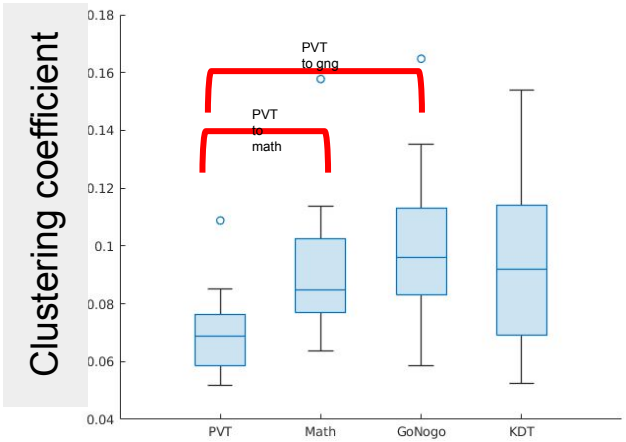
Effects of task switching within each condition

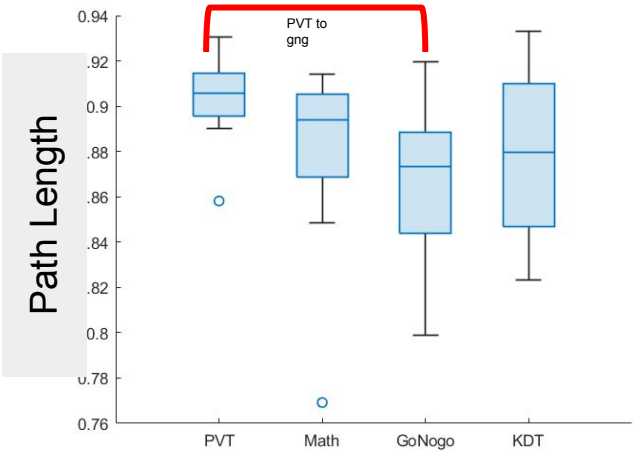
How does the network change while engaging in one task during pre-sleep and after abrupt awakening?





Effects of task switching

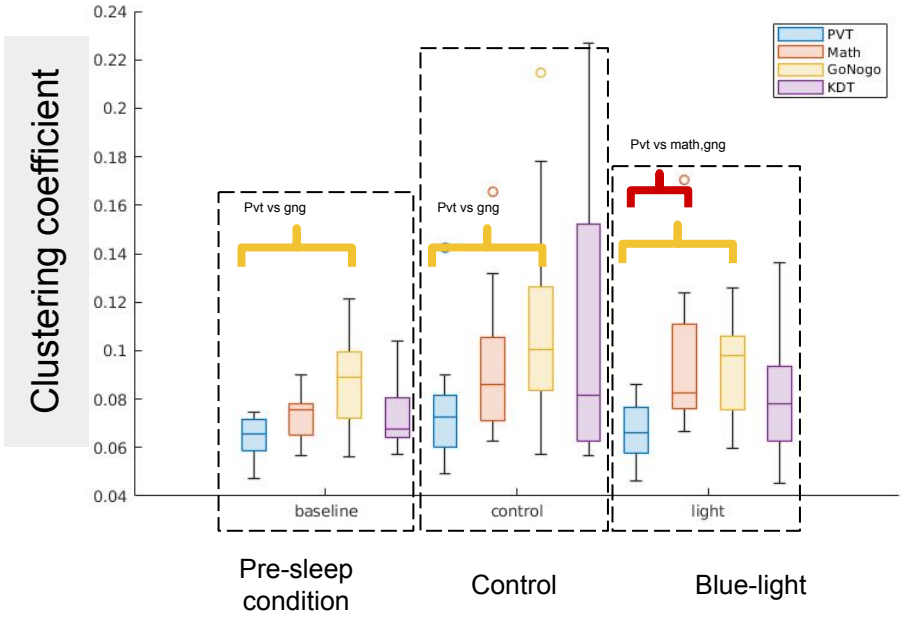




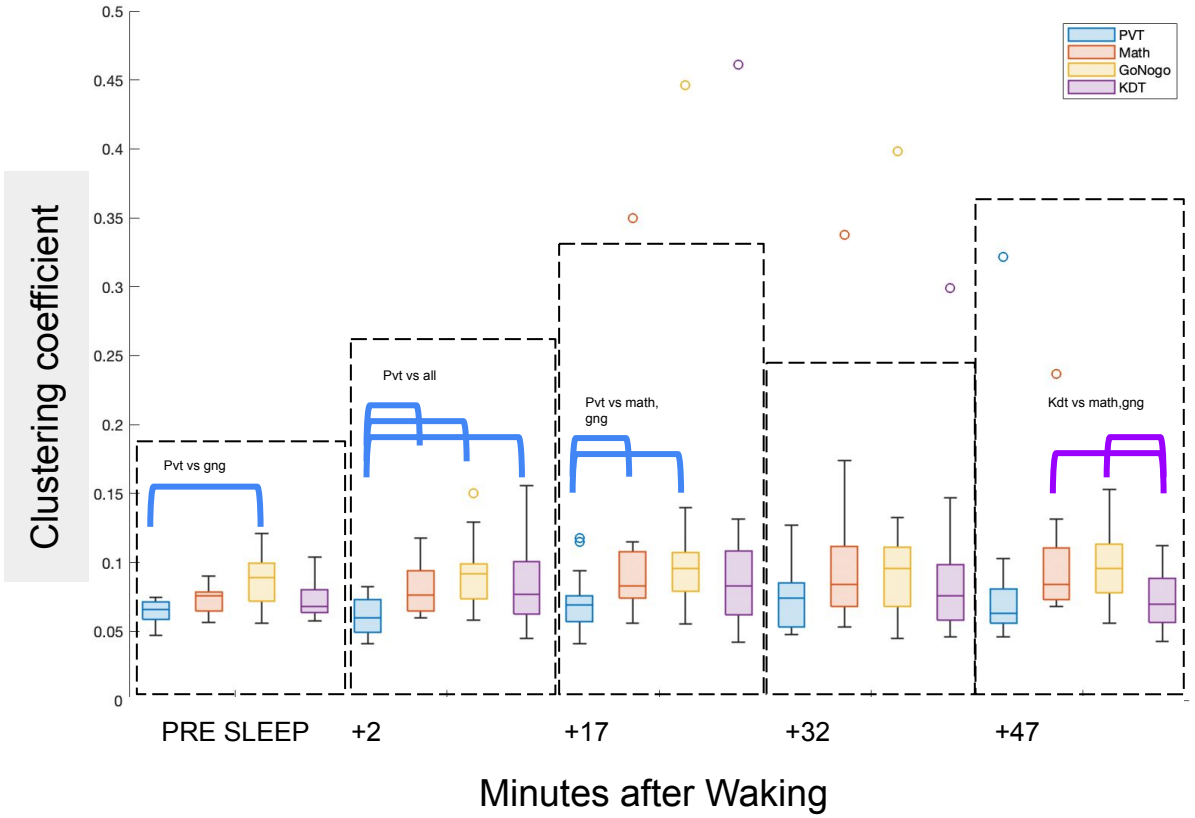
Effects of task switching within each condition

How does SWITCHING tasks, within the same condition, impact the network?

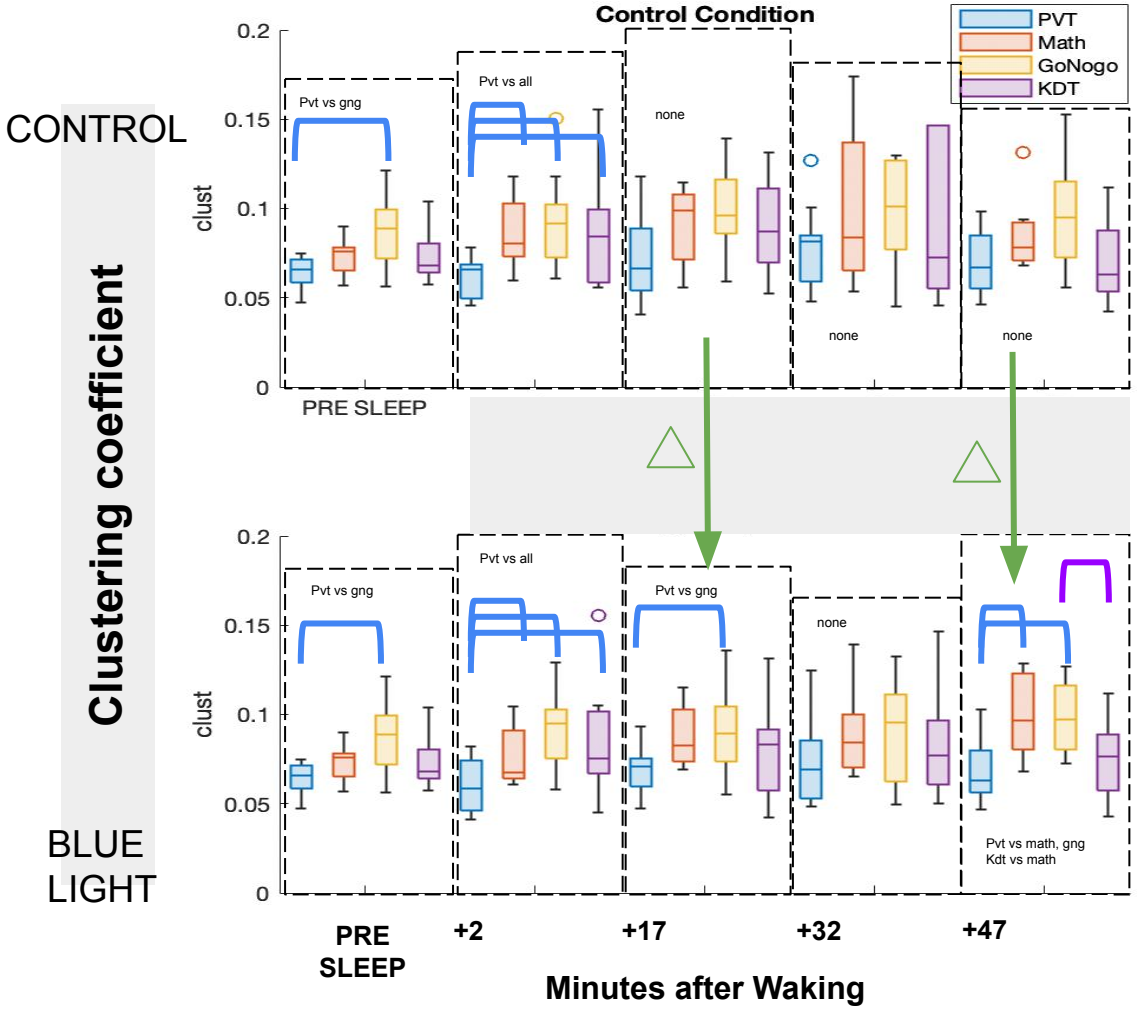
Here we average across time and frequency bands



Effects of task switching within each test bout



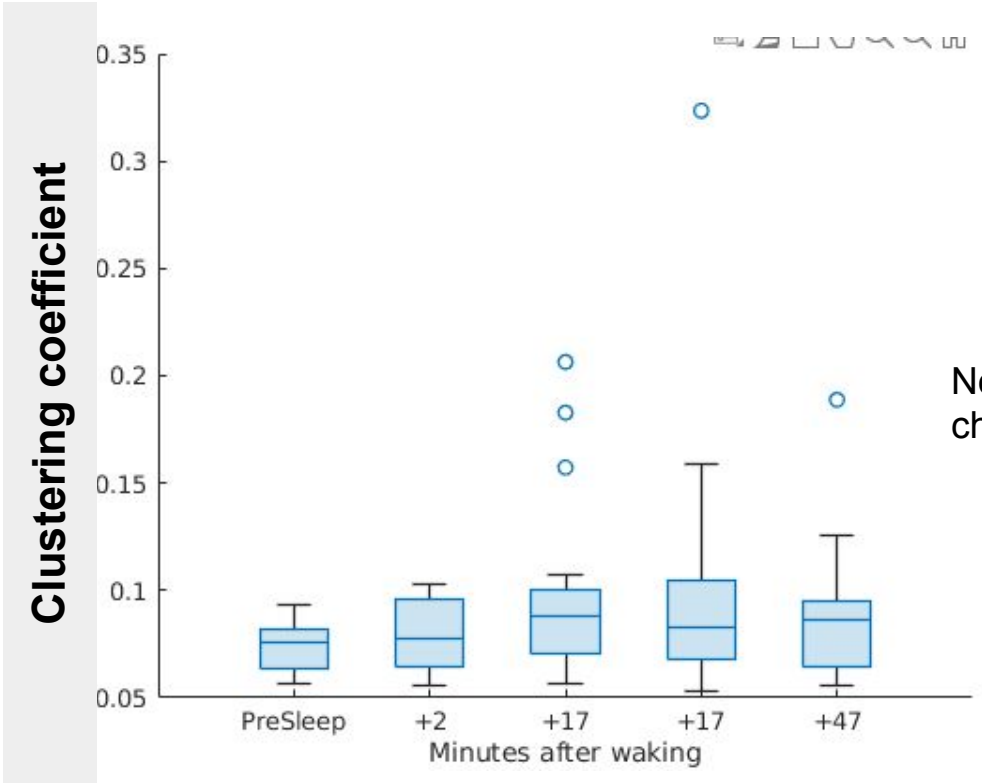
Effects of task switching within each test bout and within each condition



Effects of time

How does the network change across time?

Average across conditions, tasks, and frequency bands

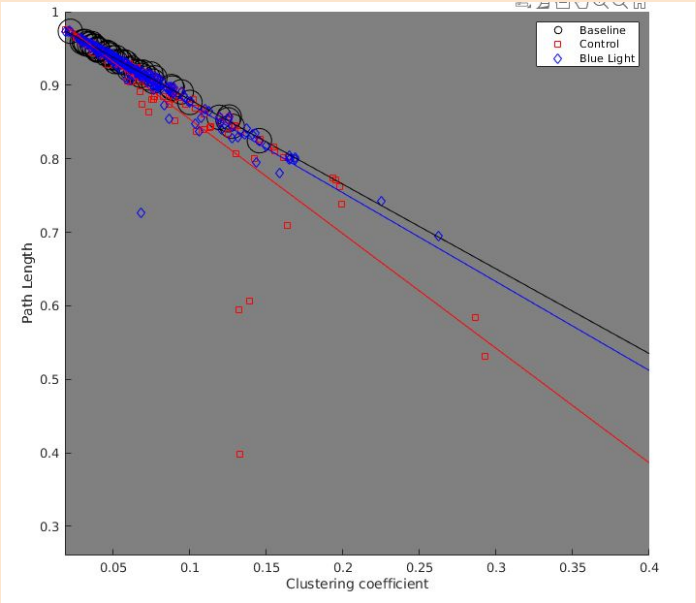


No changes

Clustering coefficient Vs Path-Length

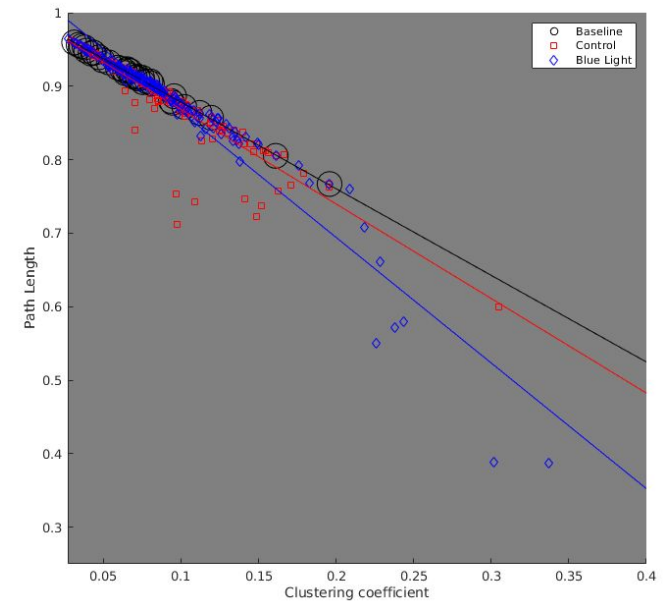
Slopes are the same as pre-sleep slopes with and without blue light

PV Task



Math Task

Slope returns to pre-sleep slope when exposed to blue light



IGNORE ALL SLIDES BELOW

End

KDT Task still needs analysis
Channel by channel analysis
Other network properties need to be assessed

Data Set (private)
https://drive.google.com/drive/folders/1FWJkyVSYTuJRY8v8M3hCf841RlFpys6A?usp=sharing

Git repo (private)
https://github.com/luisjexp/prjSleepinertia

ntwprop	cogtest	condition	band	sbj	run	value
clust	PVT	baseline	alpha	2952	0	0.032
clust	PVT	baseline	alpha	2954	0	0.055156
clust	PVT	baseline	alpha	2956	0	0.064947
clust	PVT	baseline	alpha	2957	0	0.06048
clust	PVT	baseline	alpha	2958	0	0.051711
clust	PVT	baseline	alpha	2959	0	0.046943
clust	PVT	baseline	alpha	2961	0	0.072821
clust	PVT	baseline	alpha	2963	0	0.036614
clust	PVT	baseline	alpha	2967	0	0.031018
clust	PVT	baseline	alpha	2968	0	0.088051
clust	PVT	baseline	alpha	2969	0	0.061889
clust	PVT	baseline	beta	2952	0	0.035964
clust	PVT	baseline	beta	2954	0	0.02988
clust	PVT	baseline	beta	2956	0	0.034642
clust	PVT	baseline	beta	2957	0	0.0398
clust	PVT	baseline	beta	2958	0	0.032383
clust	PVT	baseline	beta	2959	0	0.056985
clust	PVT	baseline	beta	2961	0	0.054517
clust	PVT	baseline	beta	2963	0	0.039619
clust	PVT	baseline	beta	2967	0	0.037796
clust	PVT	baseline	beta	2968	0	0.022082
clust	PVT	baseline	beta	2969	0	0.052067
clust	PVT	baseline	delta	2952	0	0.045968
clust	PVT	baseline	delta	2954	0	0.0585
clust	PVT	baseline	delta	2956	0	0.069479
clust	PVT	baseline	delta	2957	0	0.12578
:	:	:	:	:	:	:
gpsd	GoNogo	light	beta	2954	4	1.7437
gpsd	GoNogo	light	beta	2956	4	1.7582
gpsd	GoNogo	light	beta	2957	4	1.6914
gpsd	GoNogo	light	beta	2959	4	1.6487
gpsd	GoNogo	light	beta	2963	4	1.6519
gpsd	GoNogo	light	beta	2967	4	1.715
gpsd	GoNogo	light	beta	2968	4	1.7339
gpsd	GoNogo	light	beta	2969	4	1.7801
gpsd	GoNogo	light	delta	2952	4	2.6581
gpsd	GoNogo	light	delta	2954	4	2.0586
gpsd	GoNogo	light	delta	2956	4	2.2246
gpsd	GoNogo	light	delta	2957	4	2.643
gpsd	GoNogo	light	delta	2959	4	3.4381
gpsd	GoNogo	light	delta	2963	4	2.1921
gpsd	GoNogo	light	delta	2967	4	2.2811
gpsd	GoNogo	light	delta	2968	4	2.2496
gpsd	GoNogo	light	delta	2969	4	2.2812
gpsd	GoNogo	light	theta	2952	4	2.2105
gpsd	GoNogo	light	theta	2954	4	1.935
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gpsd	GoNogo	light	theta	2963	4	2.0555
gpsd	GoNogo	light	theta	2967	4	2.2456
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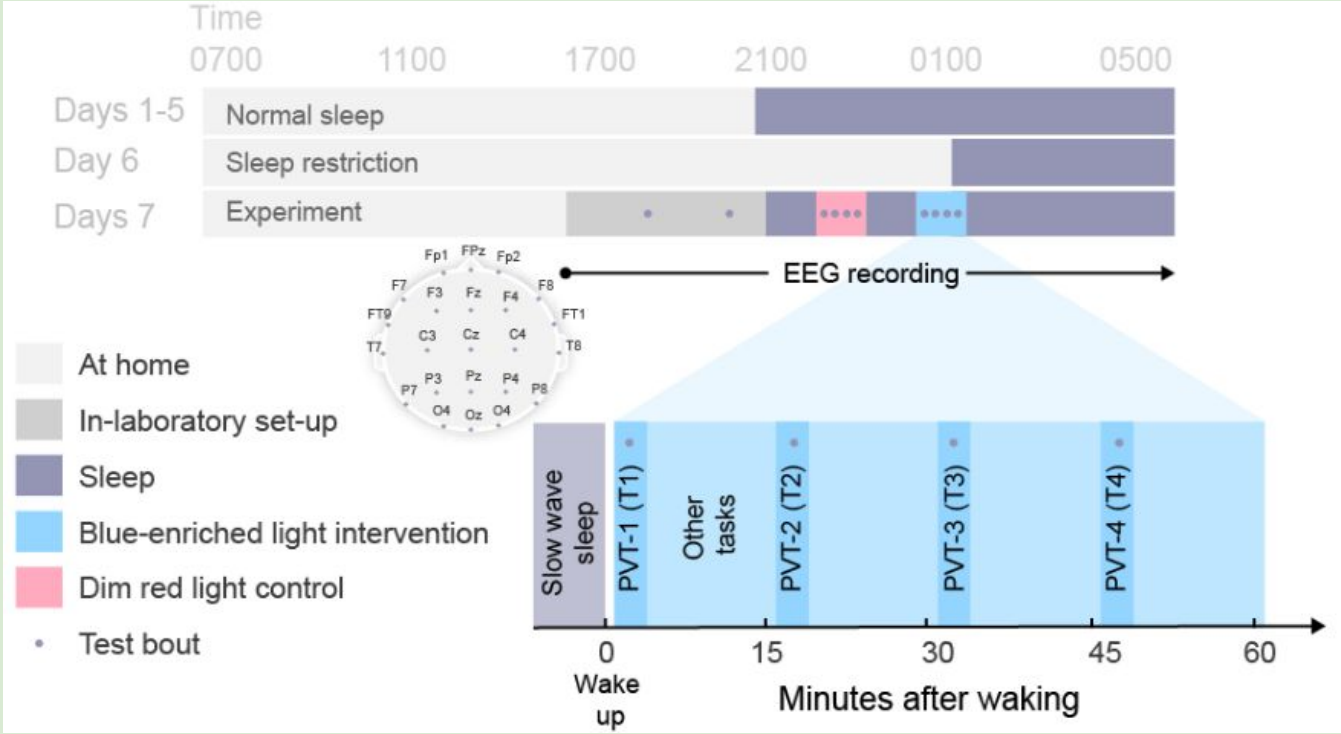
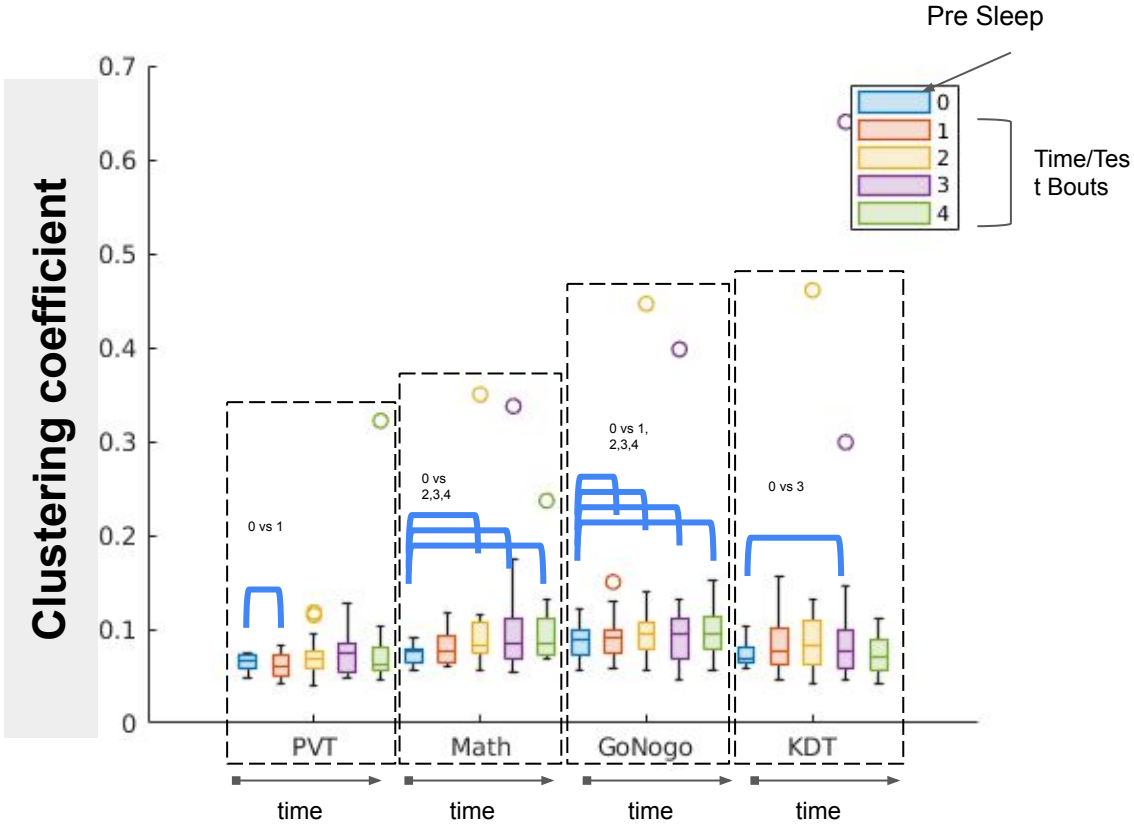
Experimental Procedure



Effects of time while performing one task

How does the network change across time during each task?



Presleep is the comparison group

Tasks

PVT

- Psychomotor vigilance task

Math

-

GoNogo

- Measures response inhibition by presenting a target stimulus “x” and a distractor “o.” Examinee must respond as quickly as possible to the target and inhibit response to the distractor

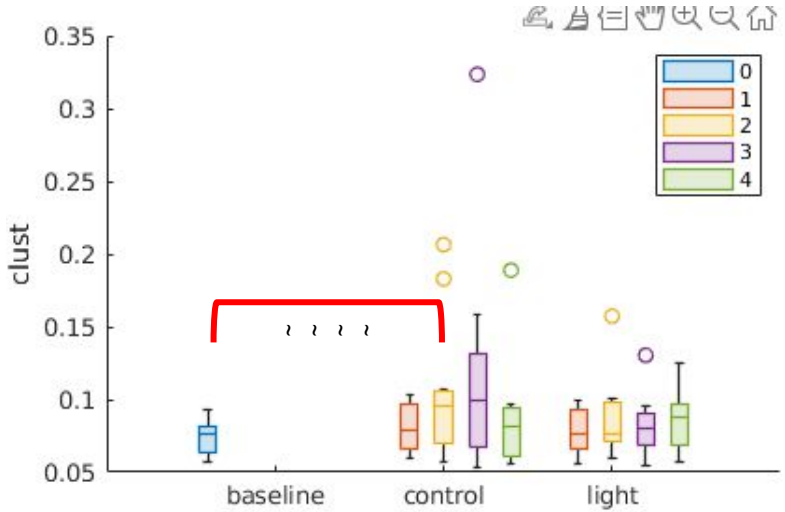
KDT

- stare at a dot for 3 minutes and try to limit blinking and movement. It is designed to produce a relatively artifact-free EEG recording.

EFFECTS OF TIME

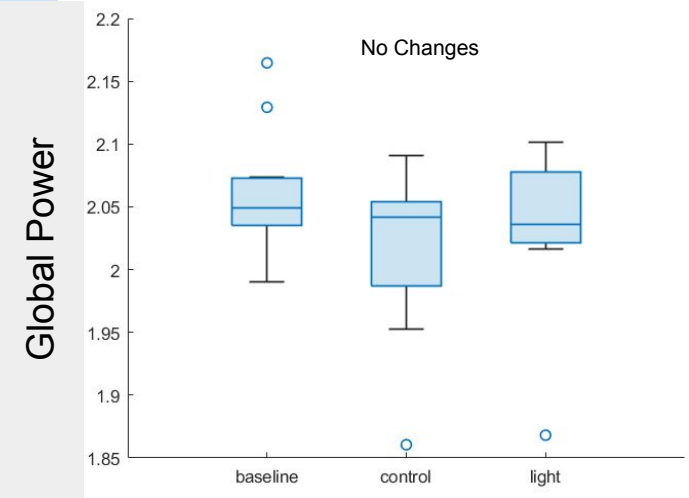
How does the network change across time within a condition?

Ignore, tasks and bands



How about other properties?

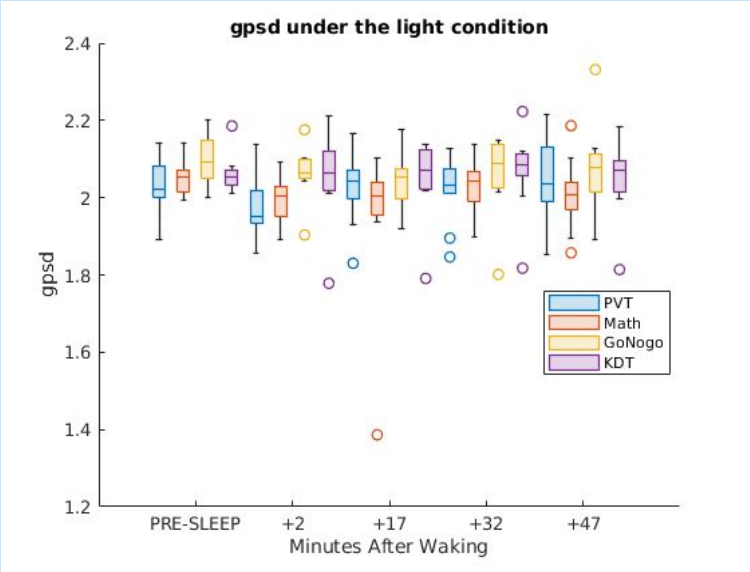
after averaging across all tasks, runs, and frequency bands

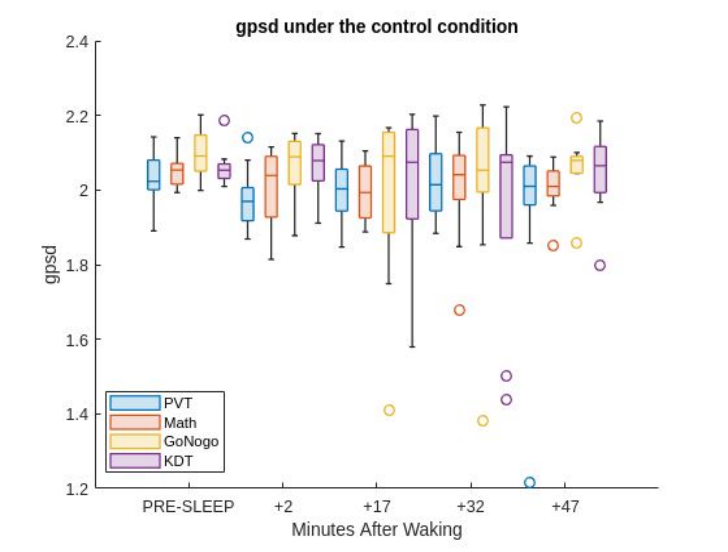


Assessing Relationships between variables

ntwprop	cogtest	condition	band	sbj	run	value
clust	PVT	baseline	alpha	2952	0	0.032
clust	PVT	baseline	alpha	2954	0	0.055156
clust	PVT	baseline	alpha	2956	0	0.064947
clust	PVT	baseline	alpha	2957	0	0.06048
clust	PVT	baseline	alpha	2958	0	0.051711
clust	PVT	baseline	alpha	2959	0	0.046943
clust	PVT	baseline	alpha	2961	0	0.072821
clust	PVT	baseline	alpha	2963	0	0.036614
clust	PVT	baseline	alpha	2967	0	0.031018
clust	PVT	baseline	alpha	2968	0	0.088051
clust	PVT	baseline	alpha	2969	0	0.061889
clust	PVT	baseline	beta	2952	0	0.035964
clust	PVT	baseline	beta	2954	0	0.02988
clust	PVT	baseline	beta	2956	0	0.034642
clust	PVT	baseline	beta	2957	0	0.0398
clust	PVT	baseline	beta	2958	0	0.032383
clust	PVT	baseline	beta	2959	0	0.056985
clust	PVT	baseline	beta	2961	0	0.054517
clust	PVT	baseline	beta	2963	0	0.039619
clust	PVT	baseline	beta	2967	0	0.037796
clust	PVT	baseline	beta	2968	0	0.022082
clust	PVT	baseline	beta	2969	0	0.052067
clust	PVT	baseline	delta	2952	0	0.045968
clust	PVT	baseline	delta	2954	0	0.0585
clust	PVT	baseline	delta	2956	0	0.069479
clust	PVT	baseline	delta	2957	0	0.12578
:	:	:	:	:	:	:
gpsd	GoNogo	light	beta	2954	4	1.7437
gpsd	GoNogo	light	beta	2956	4	1.7582
gpsd	GoNogo	light	beta	2957	4	1.6914
gpsd	GoNogo	light	beta	2959	4	1.6487
gpsd	GoNogo	light	beta	2963	4	1.6519
gpsd	GoNogo	light	beta	2967	4	1.715
gpsd	GoNogo	light	beta	2968	4	1.7339
gpsd	GoNogo	light	beta	2969	4	1.7801
gpsd	GoNogo	light	delta	2952	4	2.6581
gpsd	GoNogo	light	delta	2954	4	2.0586
gpsd	GoNogo	light	delta	2956	4	2.2246
gpsd	GoNogo	light	delta	2957	4	2.643
gpsd	GoNogo	light	delta	2959	4	3.4381
gpsd	GoNogo	light	delta	2963	4	2.1921
gpsd	GoNogo	light	delta	2967	4	2.2811
gpsd	GoNogo	light	delta	2968	4	2.2496
gpsd	GoNogo	light	delta	2969	4	2.2812
gpsd	GoNogo	light	theta	2952	4	2.2105
gpsd	GoNogo	light	theta	2954	4	1.935
gpsd	GoNogo	light	theta	2956	4	2.2
gpsd	GoNogo	light	theta	2957	4	2.1705
gpsd	GoNogo	light	theta	2959	4	2.2571
gpsd	GoNogo	light	theta	2963	4	2.0555
gpsd	GoNogo	light	theta	2967	4	2.2456
gpsd	GoNogo	light	theta	2968	4	2.1931
gpsd	GoNogo	light	theta	2969	4	2.0892

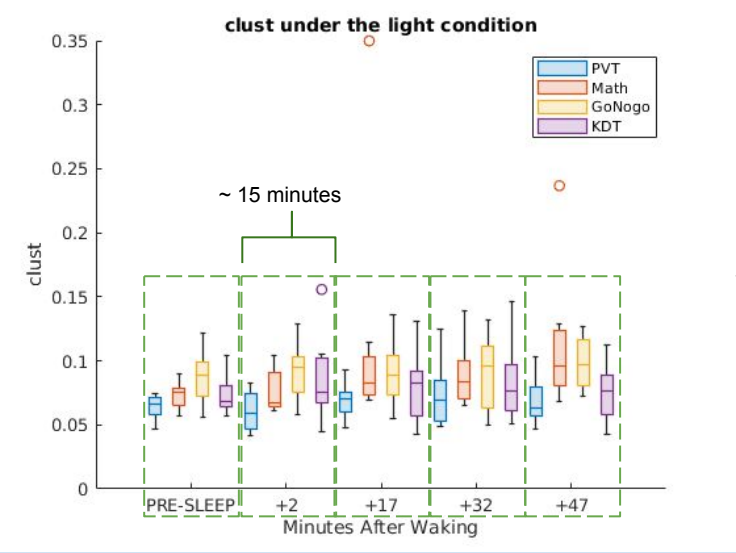
How does global power change during each task?

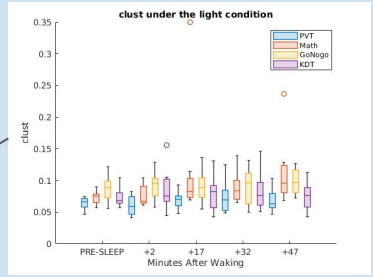


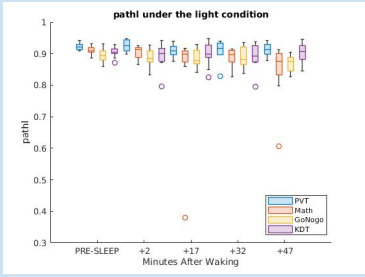


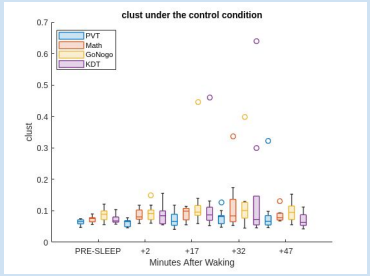
Measuring network properties while engaging in different tasks

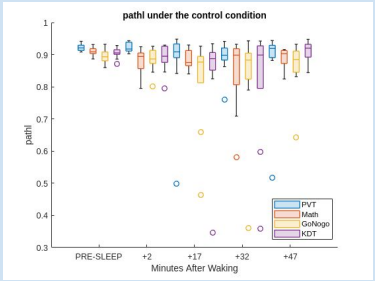
Batteries of Cognitive Tests



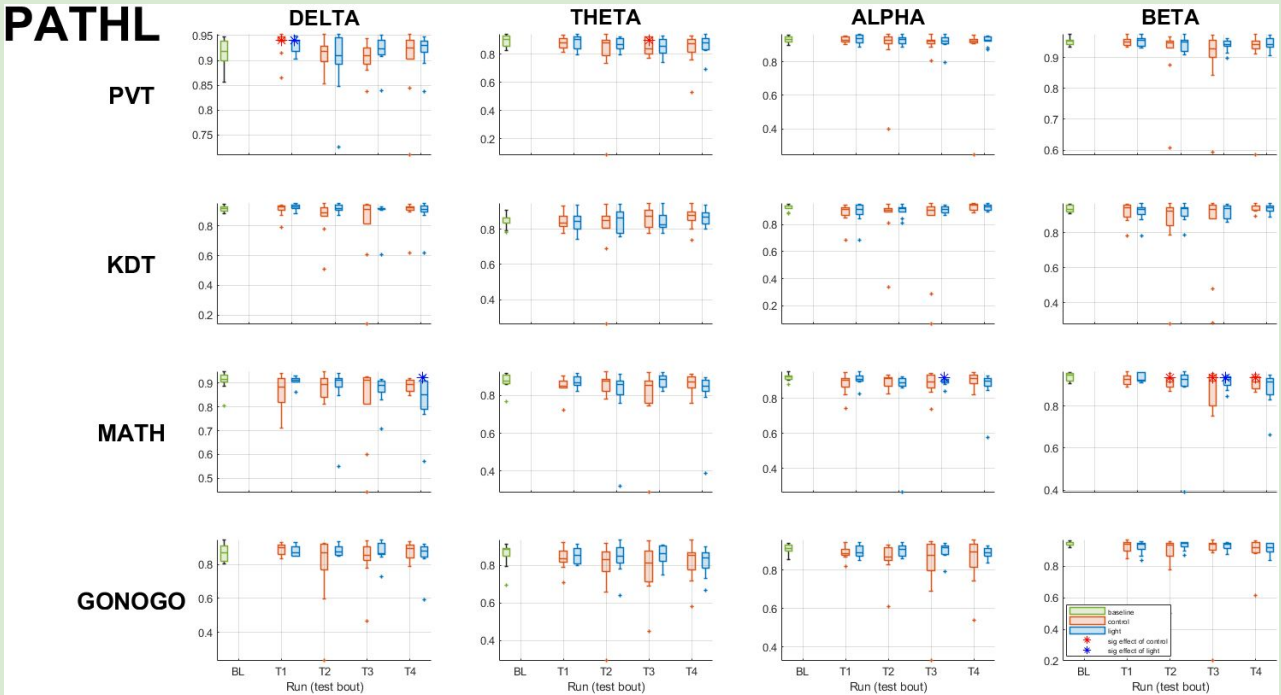




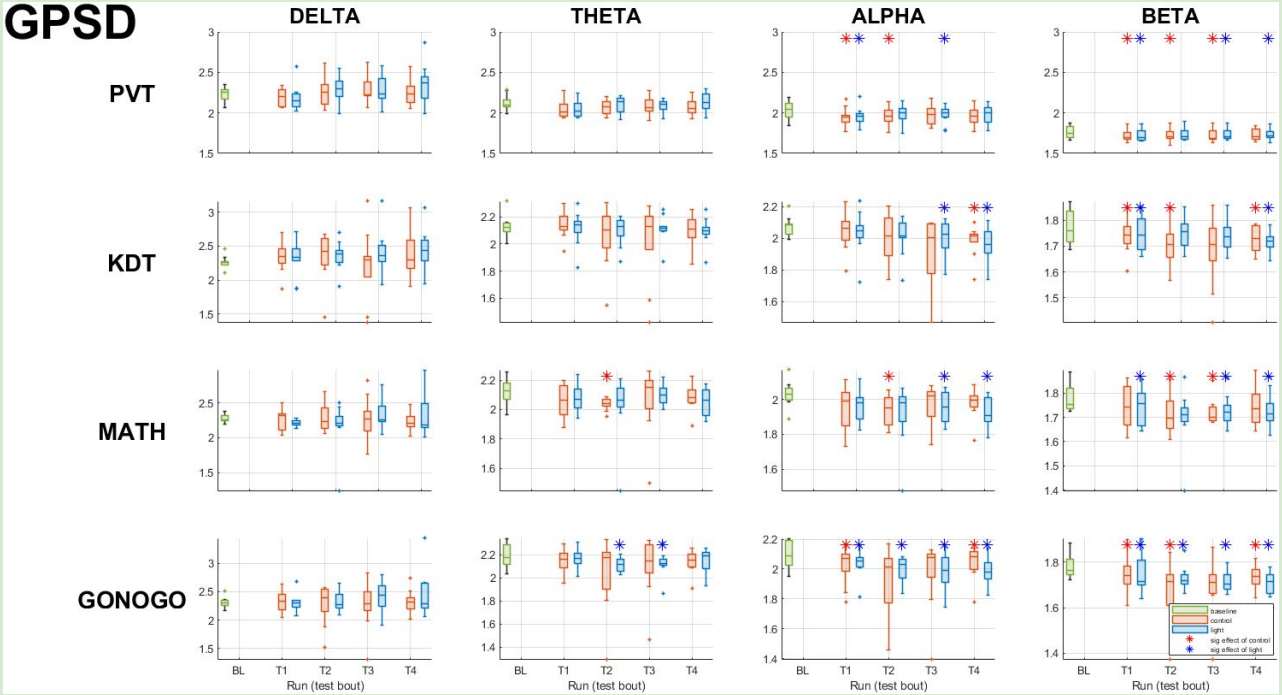




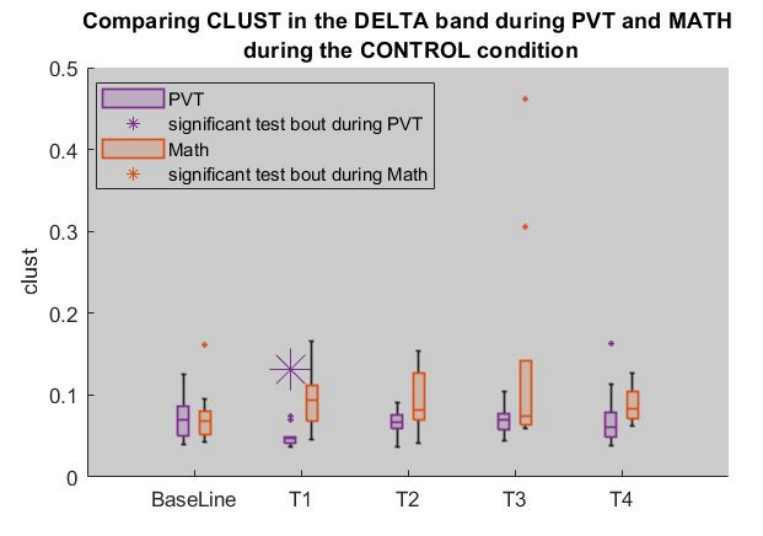
Asses how cognitive tasks impact frequency bands after abrupt awakening

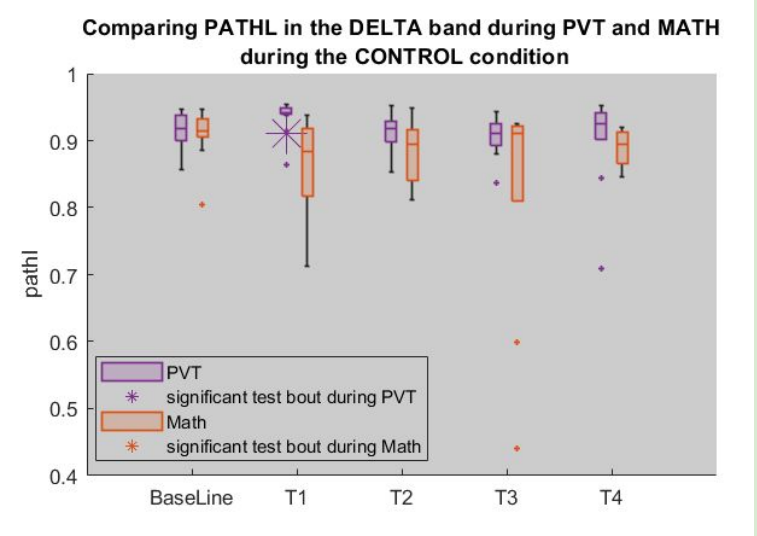


Asses how cognitive tasks impact frequency bands after abrupt awakening

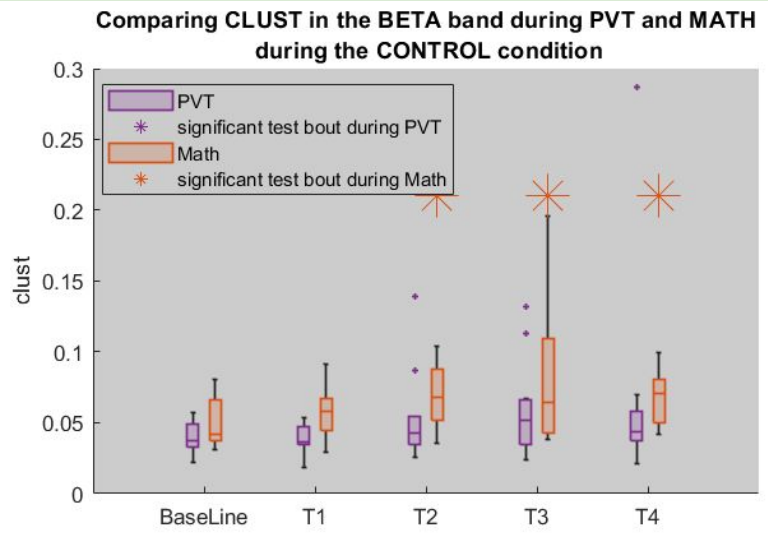


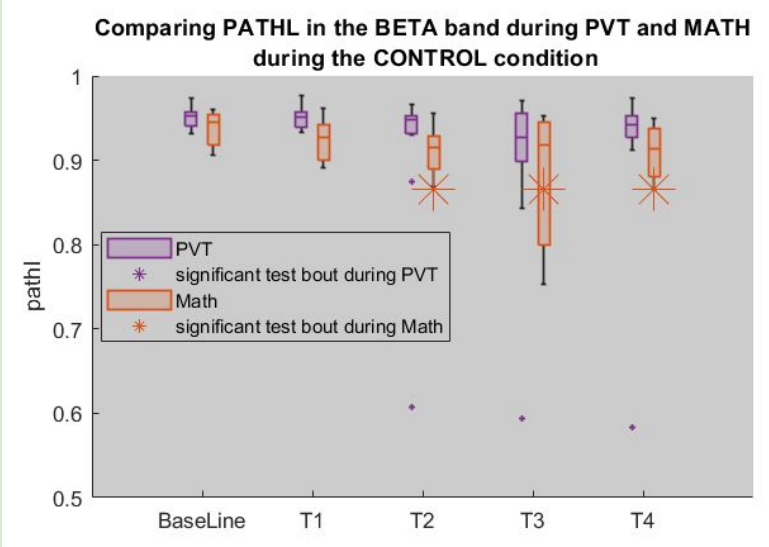
Low frequency components immediately and transiently change while engaging in PVT task, control condition only



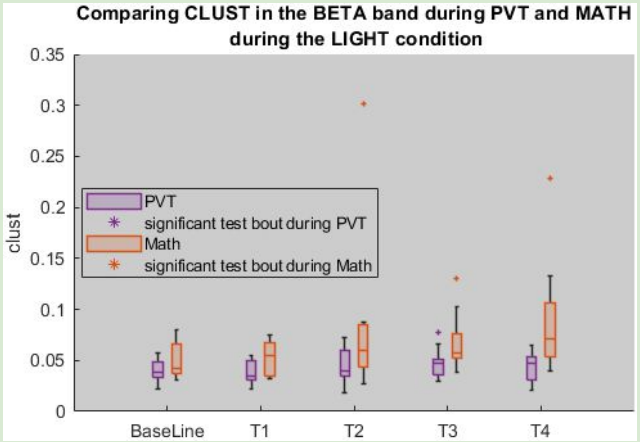


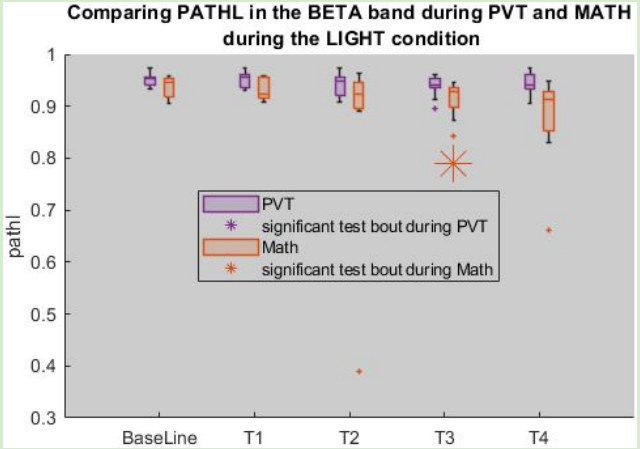
High frequency components change later and do not recover while engaging in Math task, control condition only





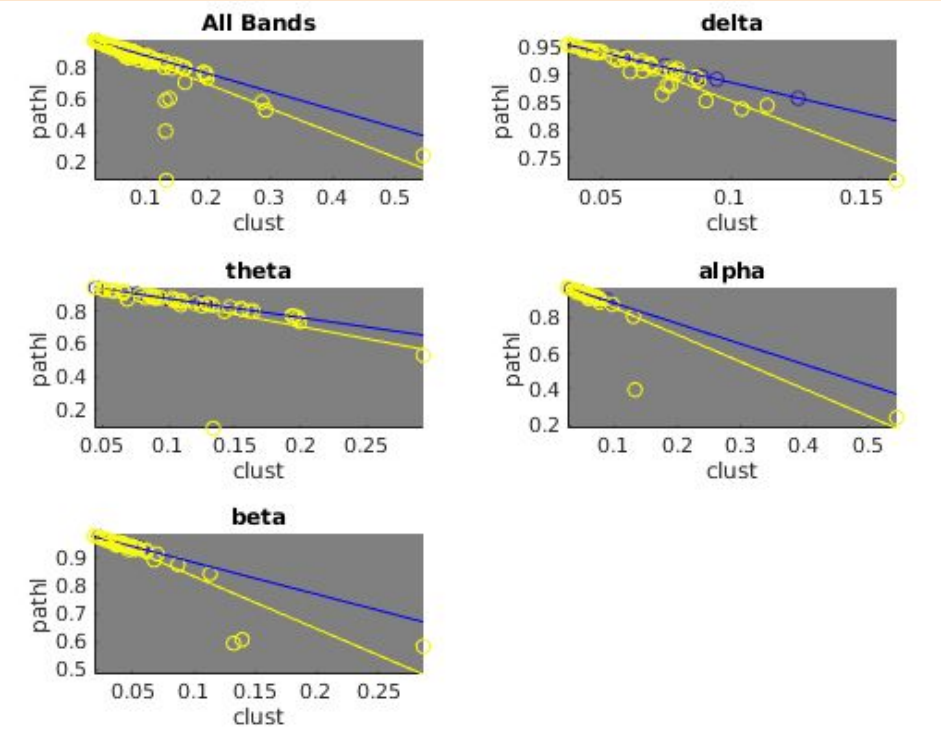
How high frequency components change during PV and Math task with blue light exposure

- 



Assessing clustering vs Path-Length with blue light exposure while engaging in the PV task

Assessing clustering vs Path-Length after abrupt waking while engaging in the PV task, in each band

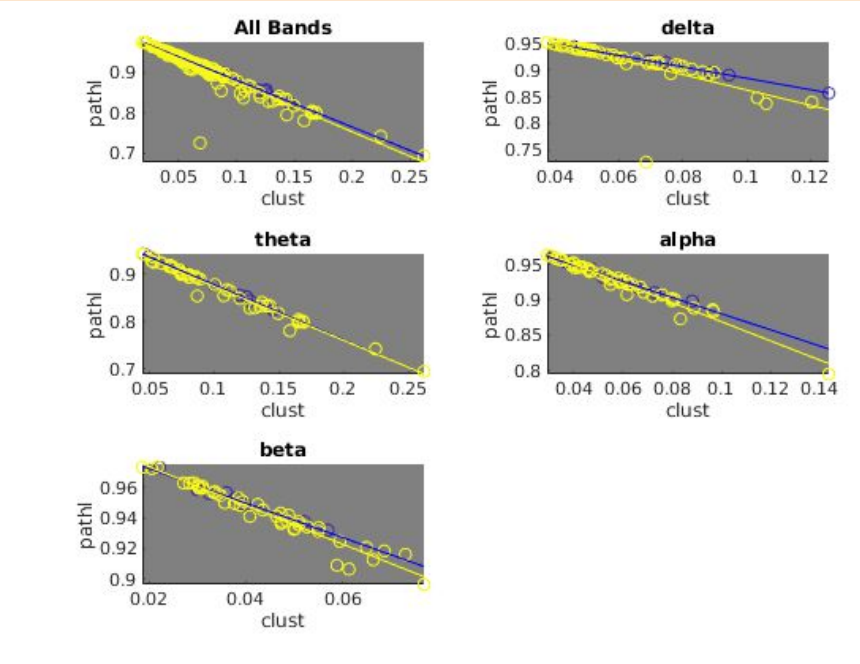


##################
Delta band

Estimated Coefficients:

	Estimate	SE	tStat	pValue
(Intercept)	0.99309	0.010868	91.381	3.3062e-58
clust	-1.0799	0.14336	-7.5327	7.8592e-10
condition_control	0.033557	0.011981	2.8009	0.0071816
clust:condition_control	**-0.66759**	**0.1609**	**-4.1492**	**0.00012659**

Assessing clustering vs Path-Length with blue light exposure while engaging in the PV task, in each band

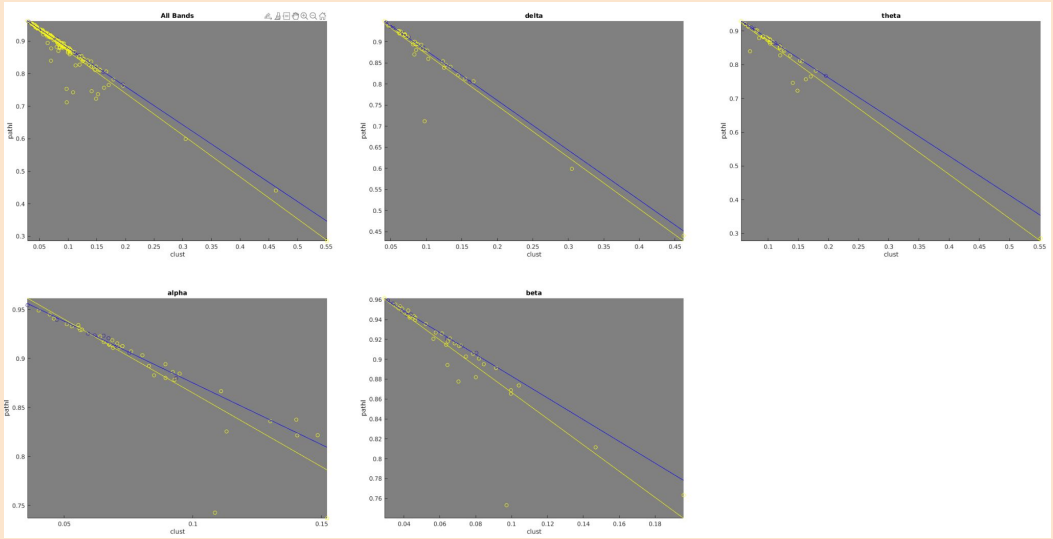


Alpha Namd

Estimated Coefficients:

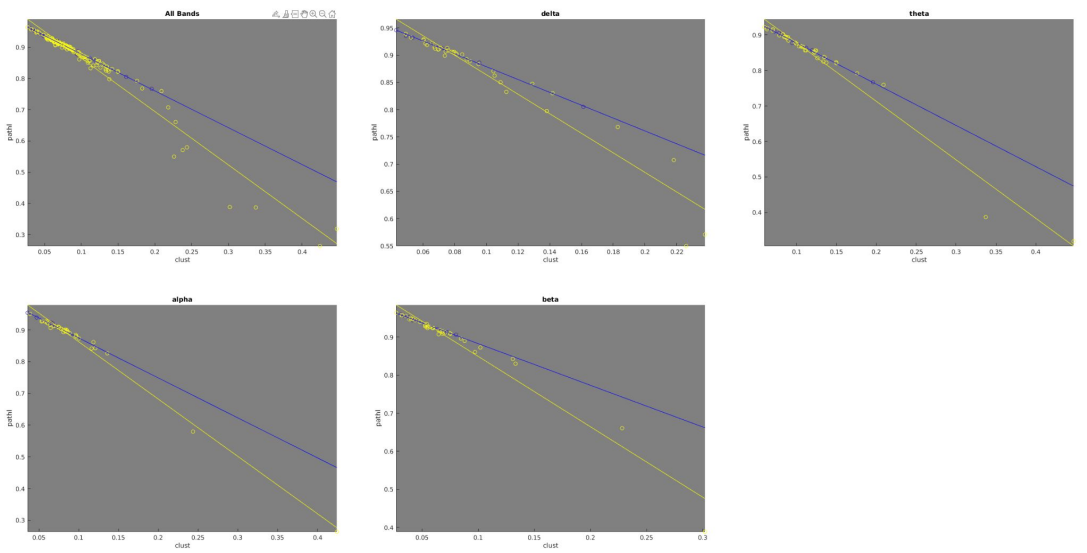
	Estimate	SE	tStat	pValue
(Intercept)	0.99428	0.0053592	185.53	7.655e-74
clust	-1.1397	0.093668	-12.168	1.0643e-16
condition_light	0.0097538	0.0057863	1.6857	0.097968
clust:condition_light	**-0.21149**	**0.10015**	**-2.1117**	**0.039629**

Assessing clustering vs Path-Length with blue light exposure while engaging in the Math task, in each band



Slopes are always the same

Assessing clustering vs Path-Length with blue light exposure while engaging in the Math task, in each band



All slopes are highly significant (beta band is moderately sig however p = .08)

Original Findings

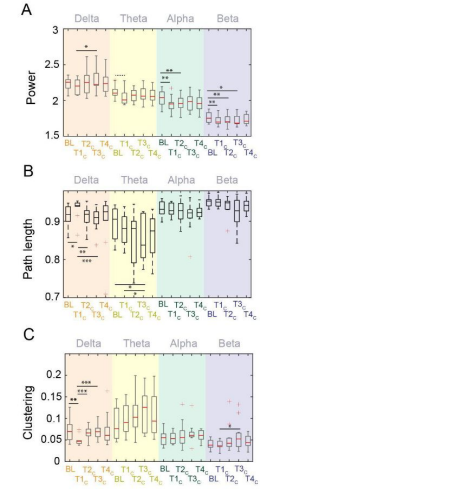


Figure 1. (A) Comparison for power, and (B) - (C) brain network properties across test bouts for each frequency band in the control condition (dim, red light). BL = baseline, T#: = Test bout # during the control condition. *$p < .05$; **$p < .01$; ***$p < .001$. Dashed line denotes marginally significant difference ($p = .053$).

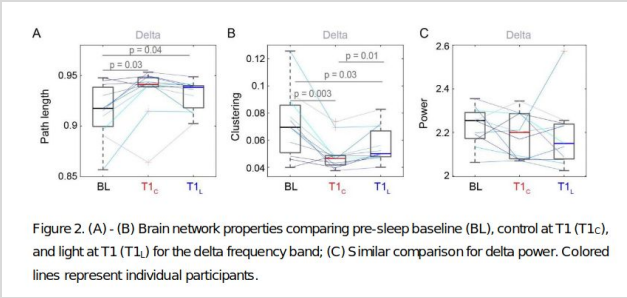


Figure 2. (A) - (B) Brain network properties comparing pre-sleep baseline (BL), control at T1 ($T1_C$), and light at T1 ($T1_L$) for the delta frequency band; (C) Similar comparison for delta power. Colored lines represent individual participants.

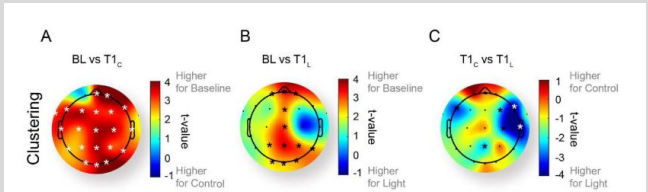
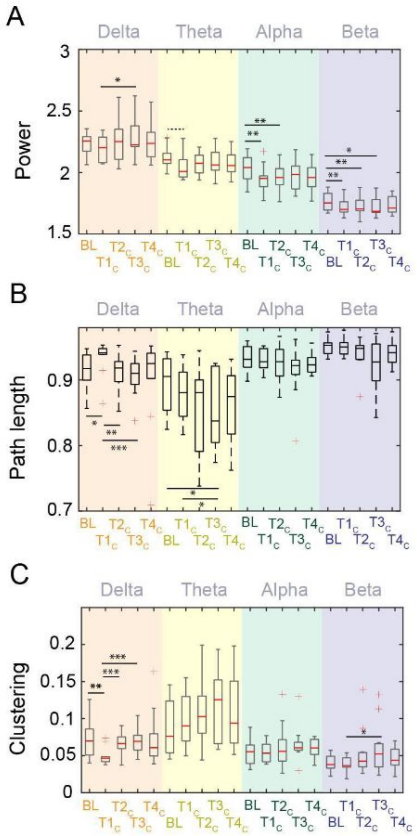


Figure 3. Change in clustering between (A) baseline (BL) and control at T1 ($T1_C$), (B) baseline and light at T1 ($T1_L$), and (C) control and light at T1 across scalp regions. White asterisks represent electrodes with significant difference on a paired-t test ($q < .05$) when corrected for multiple comparisons; black asterisks represent uncorrected significance ($p < .05$).

Original Findings



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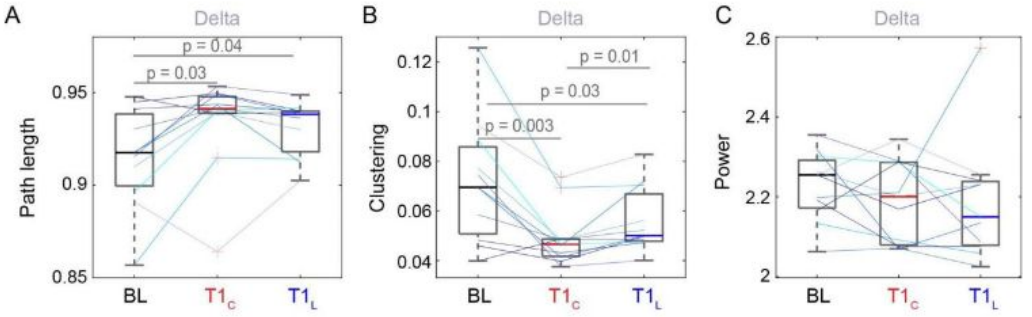
Original Findings



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Original Findings

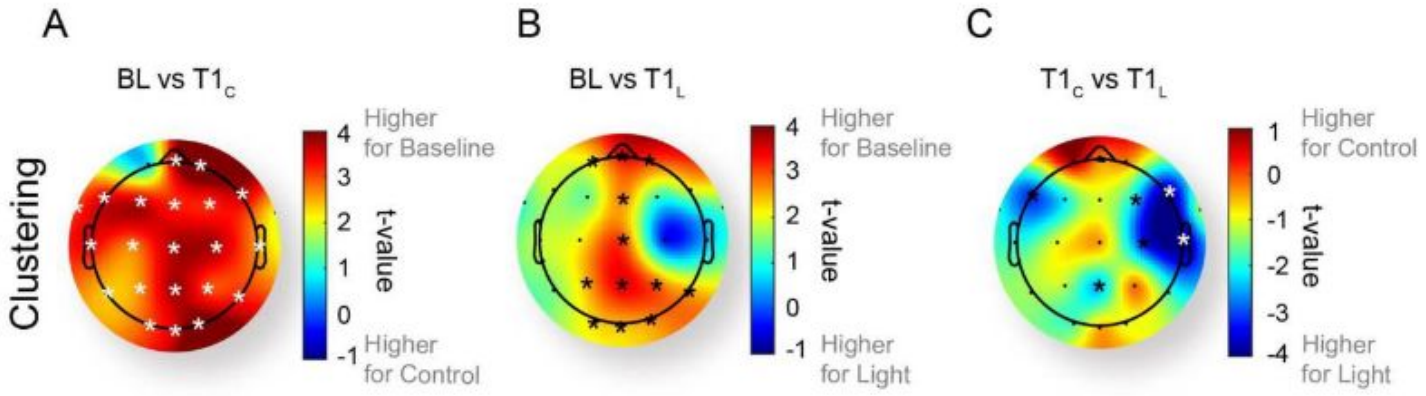

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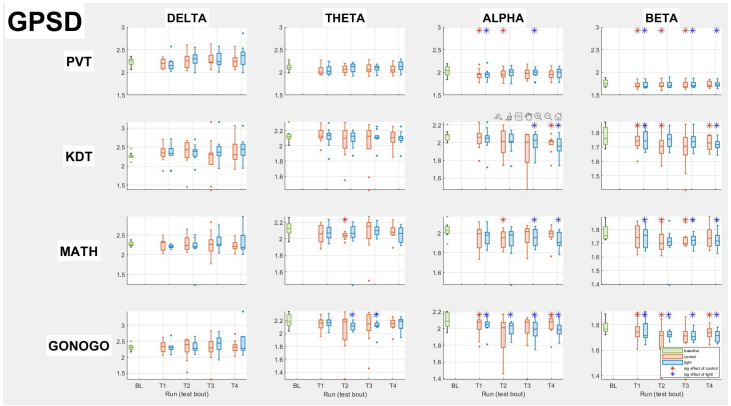
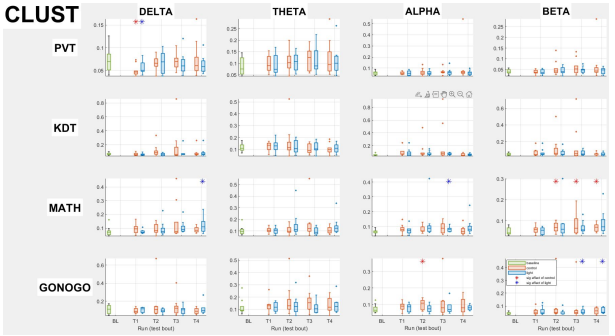
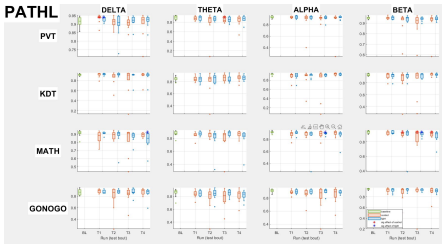
Figure 1 analysis but with for all cognitive tests







Beta 15-30 Hz

Awake, normal alert consciousness

Alpha 9-14 Hz

Relaxed, calm, meditation, creative visualisation

Theta 4-8 Hz

Deep relaxation and meditation, problem solving

Delta 1-3 Hz

Deep, dreamless sleep