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Supplemental information

Decoding human spontaneous spiking activity in medial temporal lobe from scalp EEG

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Supplemental Information

Table S1. Number of units per subject and brain area, related to STAR Methods.

	P396		P399		P402		P405		P406		P416	
	L	R	L	R	L	R	L	R	L	R	L	R
Amygdala	4	0	14	0	9	6	4	1	8	8	0	5
Hippocampus	5	2	0	13	3	2	3	5	6	8	3	16
Frontal Cortex	0	0	12 SMA	12 SMA	0	6 SMA	2 OF	7 OF	3 AC	4 AC	10 OF	0

The number of recorded units from each region. SMA – Supplementary Motor Area; OF – Orbitofrontal cortex; AC – Anterior Cingulate Cortex.

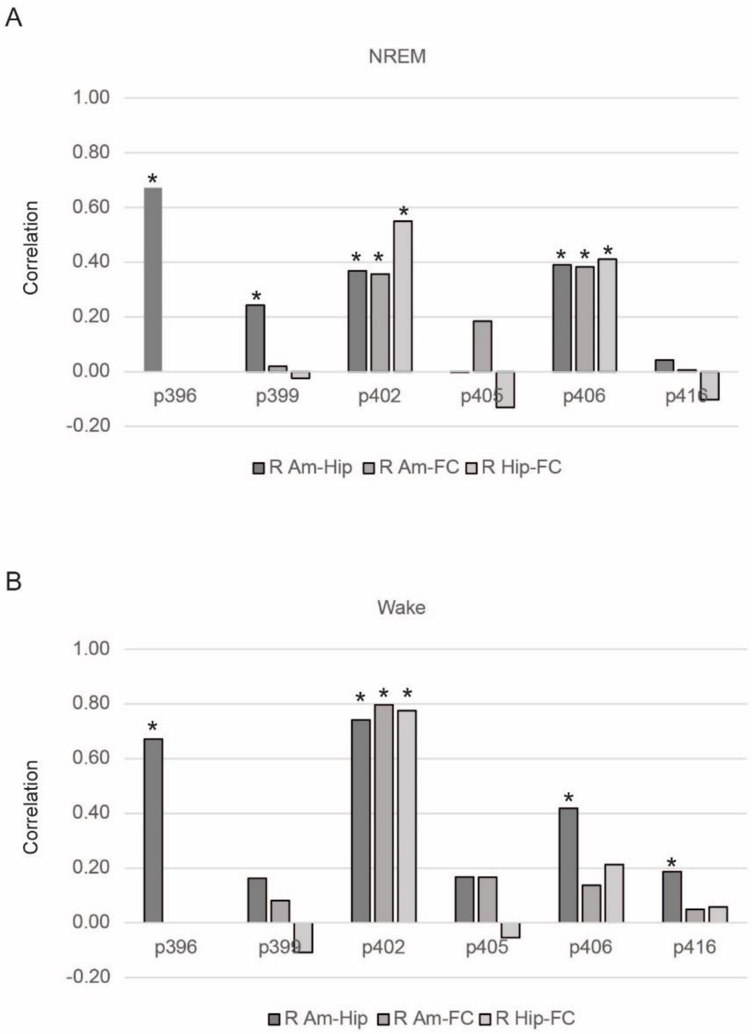

Figure S1. Correlation within MTL units, related to Figure 1. Pearson's correlation coefficient between the average neuron of the hippocampus, amygdala and frontal cortex for each subject and state (awake or NREM). * represents significant correlation after Bonferroni correction for multiple comparisons ($p<0.0003$).

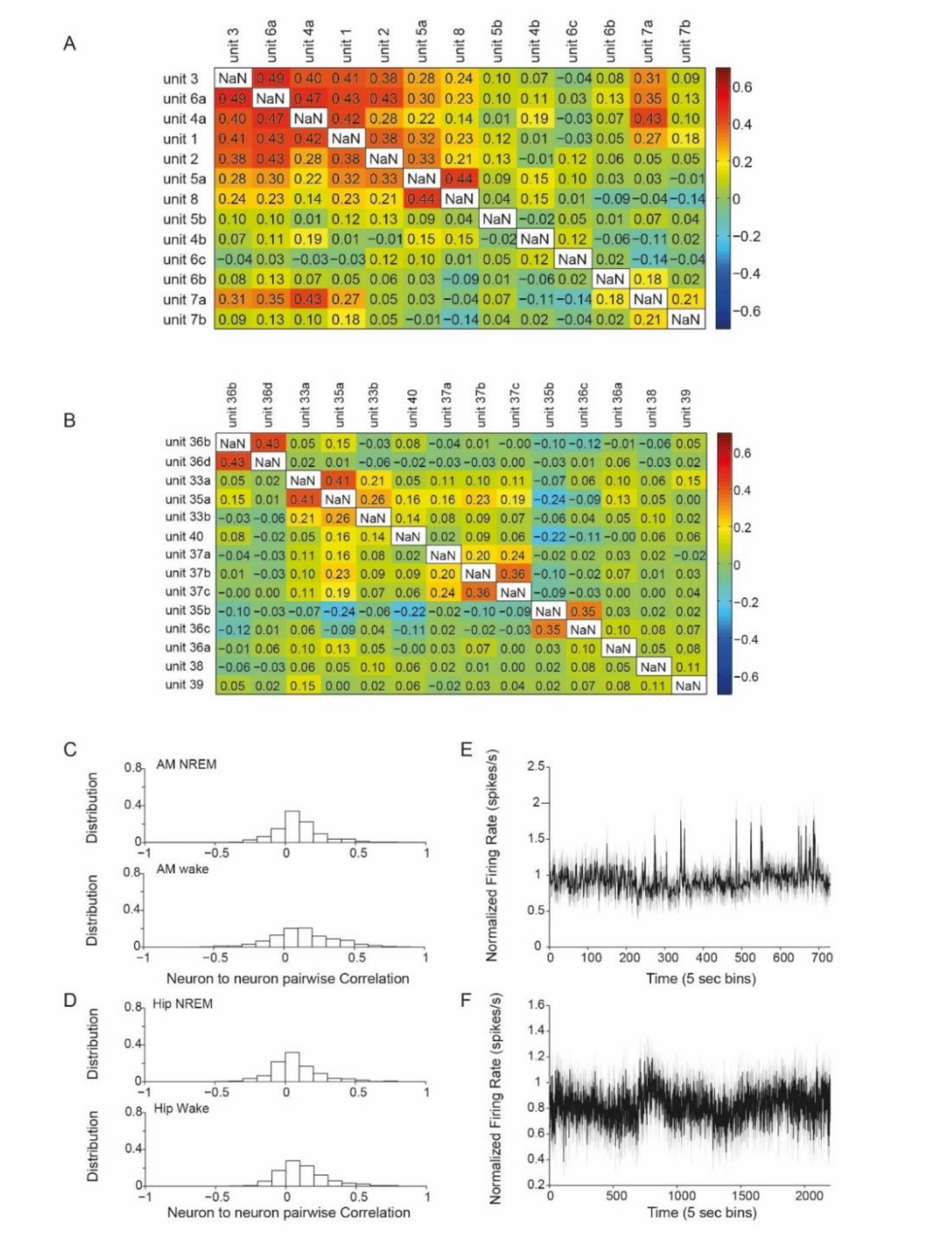

Figure S2. Representative Firing Measure, related to STAR methods

In order to find a representative firing measure, we examined the Pearson correlation coefficients between the firing rates in 5 s bins of simultaneously recorded units in each brain region during awake and non REM sleep periods. Panels A and B shows an example of a correlation matrix from the amygdala during non-REM sleep and hippocampus during wakefulness respectively in the same subject (P399). The correlations are ordered by their distance, as measured by hierarchical clustering. The figure illustrates that most of the inter-unit correlations are positive and are in the weak to moderate range, with the negative correlations usually very weak. The units do not appear to be segregated into clusters of activity (at most one cluster can be observed), whereas most of the other units' activity is idiosyncratic. Panels C and D depict the histograms of the correlations between all simultaneously recorded units from the amygdala or hippocampus during awake or non-REM sleep periods. It demonstrates the same pattern of described activity. Thus, we chose to take the sample mean of the recorded units as a representative firing measure of the region. Panels E and F show in black the average activity and in gray shade the standard error of the mean of units whose correlation are shown in Panels A and B.

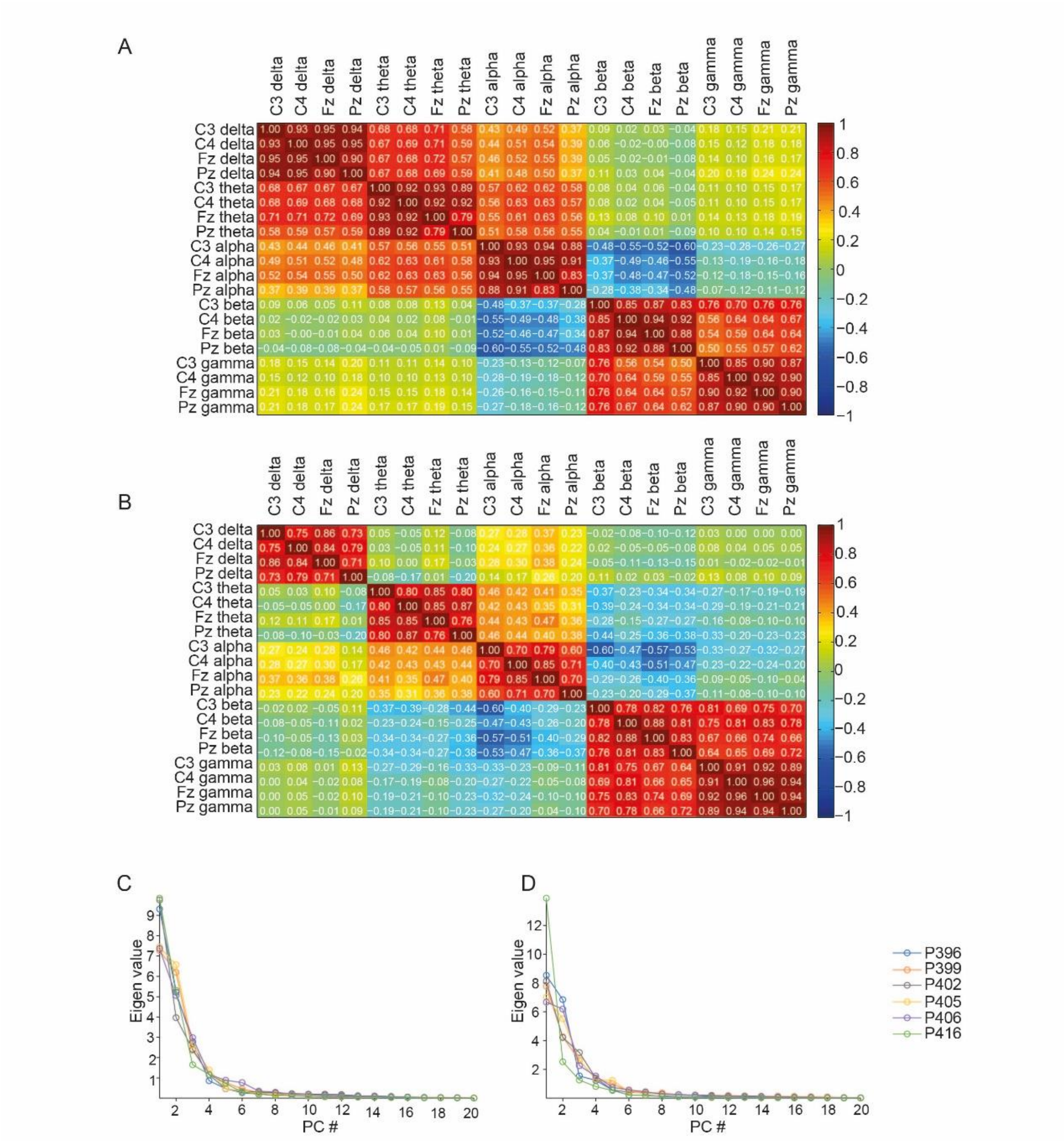

Figure S3. Multicollinearity of EEG features, related to STAR Methods. (A-B) Examples of the EEG feature correlation matrix from two subjects during wakefulness (A) and NREM sleep (B). This shows the multicollinearity of the feature matrix. Low frequencies (delta, theta and alpha) are correlated with each other across channels. The same occurs for the higher frequencies (beta and low gamma). This suggests that applying a PCA to find an uncorrelated representation of the features before applying the linear regression might be useful. (C-D) Scree plots of Eigen value vs. principal component (PC) numbers for awake (C) and NREM sleep (D) for all subjects, showing that at the 6th PC the screen plot transits from steep descent to plateau. Thus, using the projection of the feature matrix with the first 6 PCs was chosen.

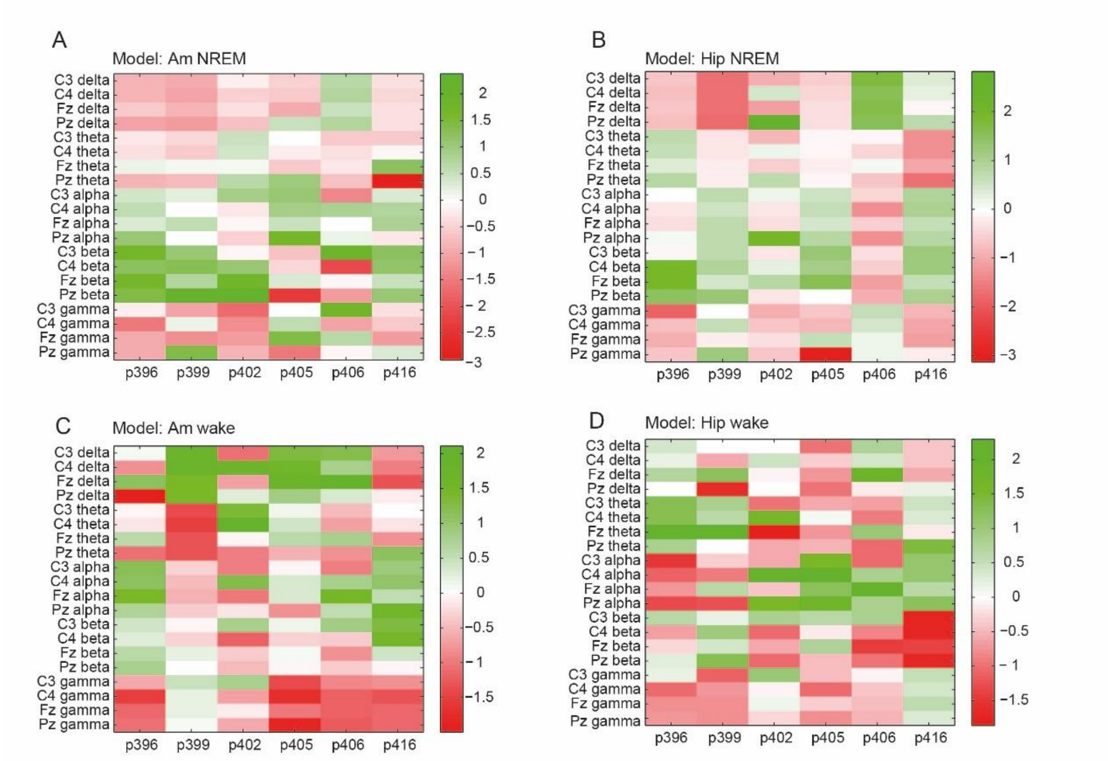

Figure S4. Model coefficients vary between subjects, related to Figure 2. (A-D) each column represents the color coding of the z scored coefficients calculated by the linear regression for the amygdala (A,C) and the hippocampus (B,D) of different subjects during NREM sleep (A,B) and wakefulness (C,D). The coefficients are of the original features, before applying PCA. The original coefficients were calculated as the multiplication of the PCA coefficients with the model coefficients.

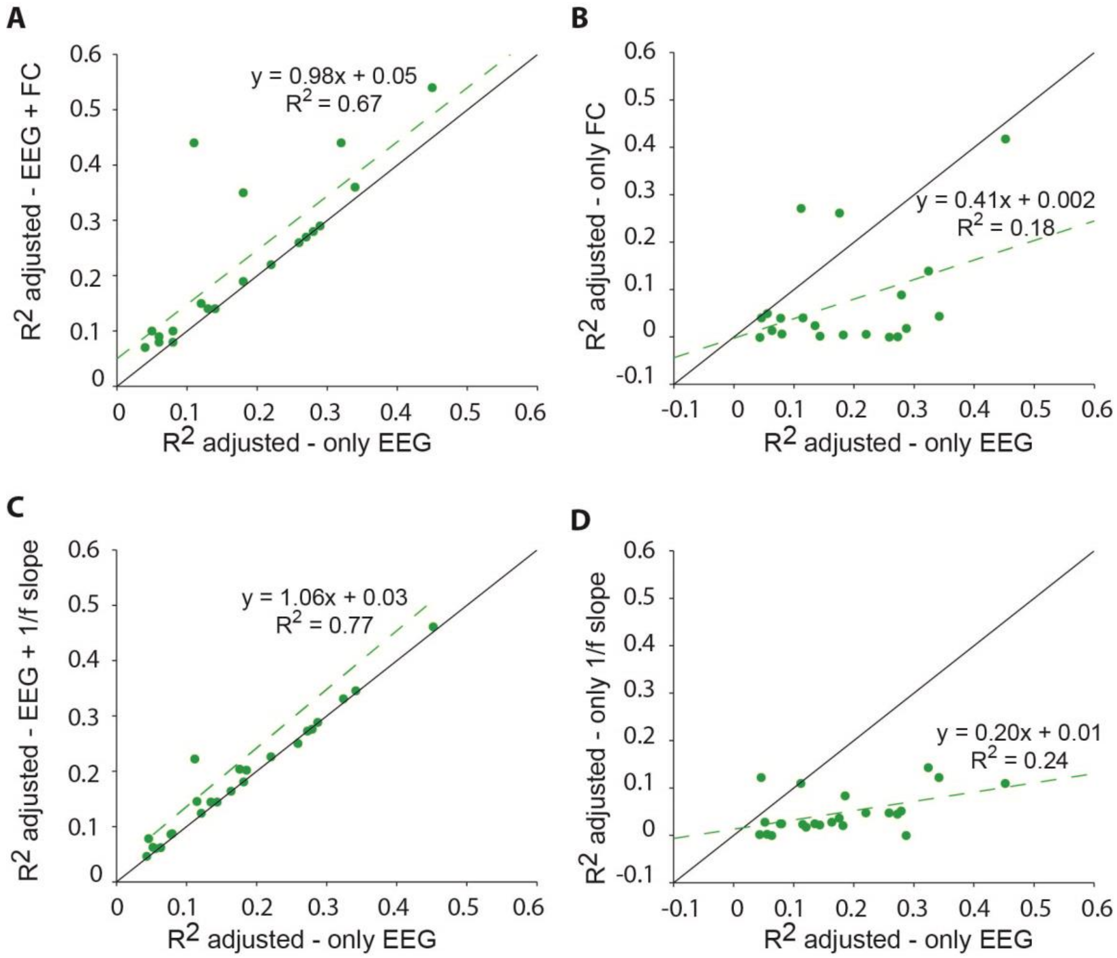

Figure S5. Minor differences between models after including Frontal Cortex unit activity or a proxy of arousal as additional information, related to Figure 3. For each model described in the manuscript, we created complementary models in which additional predictors were used either in addition to the scalp EEG spectral features or instead of them. First, we included a predictor comprised of averaged FC unit activity (**A-B**). Second, we included a proxy of arousal measured by an estimate of the 1/f slope in the frequency band 30-45Hz (**C-D**).The modeling was performed in a similar way as described in the methods for the original models. For each model and complementary model, we calculated an adjusted R^2 score considering the different number of predictors. Overall, when adding features to the models, the slope of the regression fit between the original and each complementary model predictions was ~1 (0.98 for FC activity and 1.06 for arousal) which suggest a close relationship between them. 4 of the 20 models show slight improvement in predicting MTL activity when adding FC activity. Further inspection of these models shows that FC and MTL activity was highly correlated in these cases explaining the better performance. When considering the added features alone, the prediction of the complementary models was poor, with most models deteriorating, and below our r=0.2 criterion.

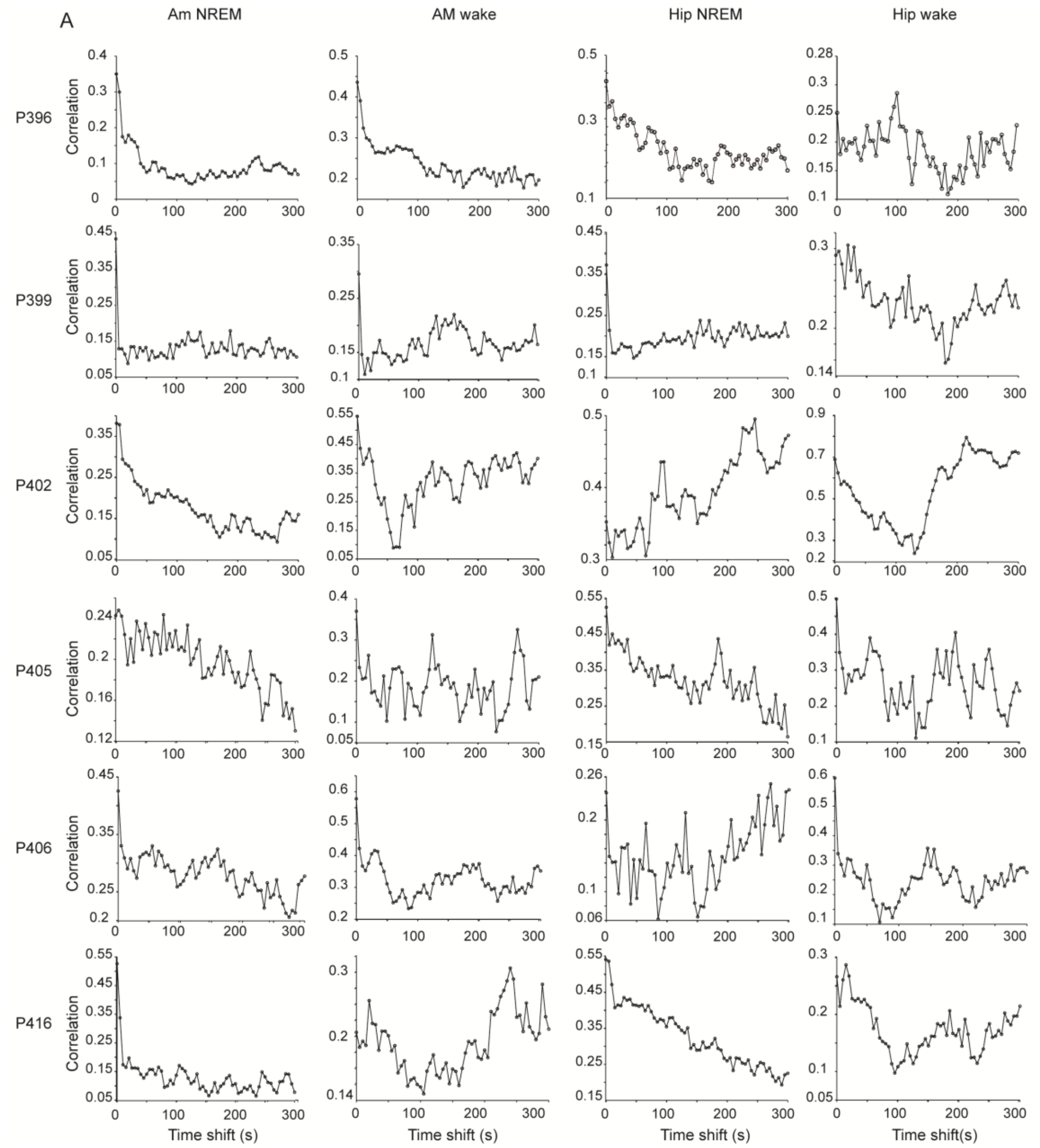

Figure S6. **Time-Shifted Models, related to Figure 3.** For most patients, shifted correlation descents rapidly and remains at the same level for all other time shifts. (A) perason's correlatin coefficient of unshifted (time 0) and shifted models for each patient (rows), area and state (columns).