Supplementary Materials

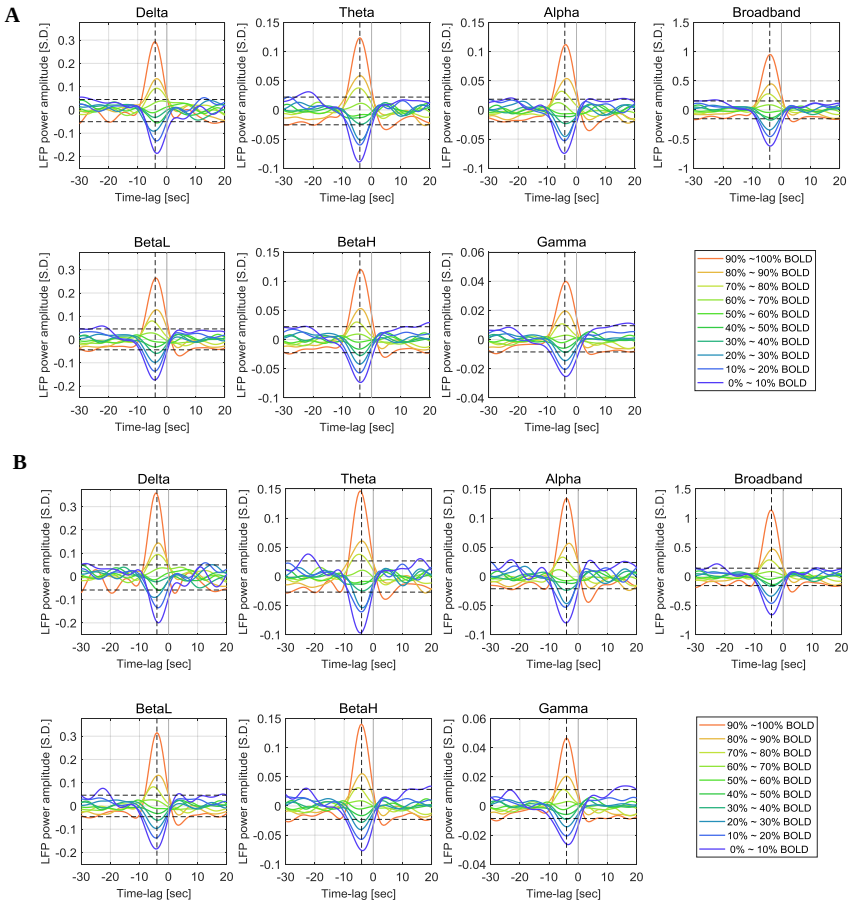

Figure S.1 Two different strategies to get BOLD triggered average yield very similar results. Panel A, the BOLD triggered average obtained when treating each individual time point as a separated trigger, which is identical to the figure 2A except the scale of y-axis. Panel B, the BOLD triggered average obtained by combining adjacent triggers into one single trigger, weighted by the duration of the event. The two methods produce very similar results, the general shapes are nearly identical despite the later method gives higher amplitudes.

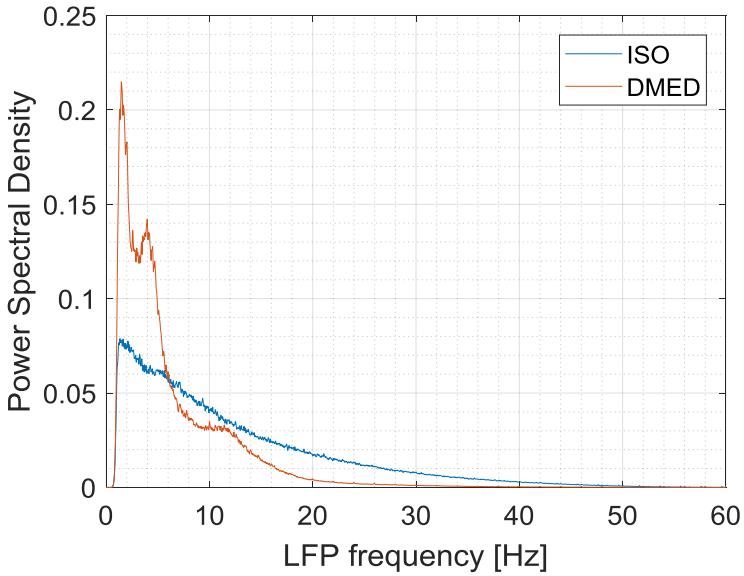

Figure S.2 LFP power distribution (ISO, n=32, DMED, n=22). Each scan session (500 sec) was z-scored and the power spectral density (PSD) function was estimated using Welch's method (50% overlap, 64 segments). Then the PSDs were averaged within ISO group and DMED group. The amount of energy distributed in delta, theta, alpha, low frequency beta, high frequency beta, gamma are 21.1%, 22.7%, 16.5%, 27.2%, 9.7% and 2.3% under ISO, respectively; and 44.4%, 28.7%, 12.9%, 11.9%, 1.3% and 0.4% under DMED, respectively. The PSD decays much faster in DMED as frequency goes higher, and the low energy in these high frequency bands makes the estimation of LFP power and therefore the BOLD-triggered average very noisy.

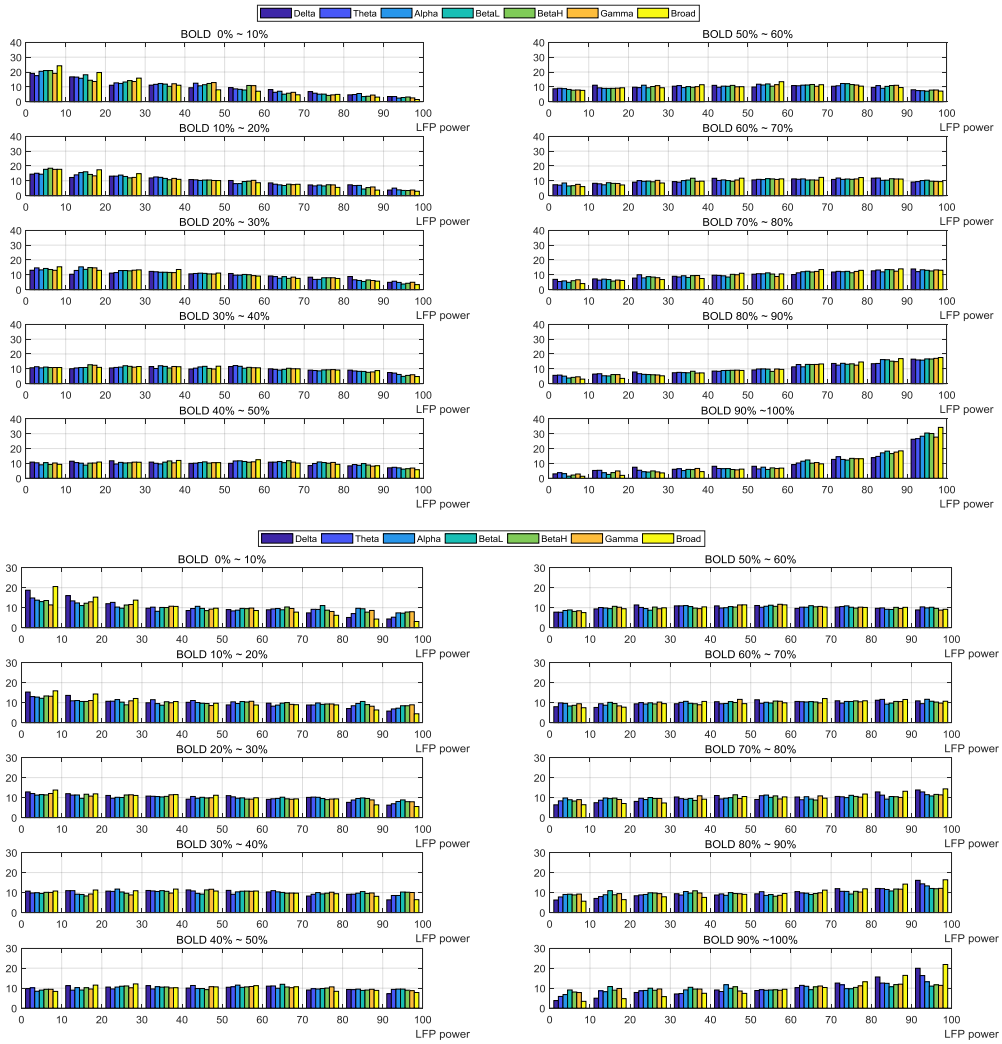

Figure S.3 Histograms of LFP power under ISO anesthesia (panel A) and DMED anesthesia (panel B) at the maximally-correlated lag given a BOLD amplitude. The different colors shows different frequency component of LFP power. Each subplot shows that, given the BOLD amplitude is within in a certain range, the relative frequency in percentages (y-axis) of having a LFP power in a particular range specified by LFP power percentiles (x-axis). Everything is measured in percentiles so that the frequency bands with different amplitudes can be comparable. For any LFP power frequency band, the sum across 10 LFP power groups within a given BOLD group or the sum across 10 BOLD groups within a given LFP group is equal to 100%. It can be seen that under many circumstances (either 30~70% BOLD or 30~70% LFP) the relative frequency is around 10%, meaning it is almost uniformly distributed and thus knowing one signal does not help predicting the other. Only in the highest or the lowest BOLD groups, the distribution of LFP becomes skewed and is significantly different from a uniform distribution, and vice versa. This skewed distribution gives rise to the BOLD-triggered averages seen in figure 2 and motivated us to hypothesize that the correlation between LFP power and BOLD is driven by the most prominent events (either the LFP surpassing-threshold events or the BOLD surpassing-threshold events).

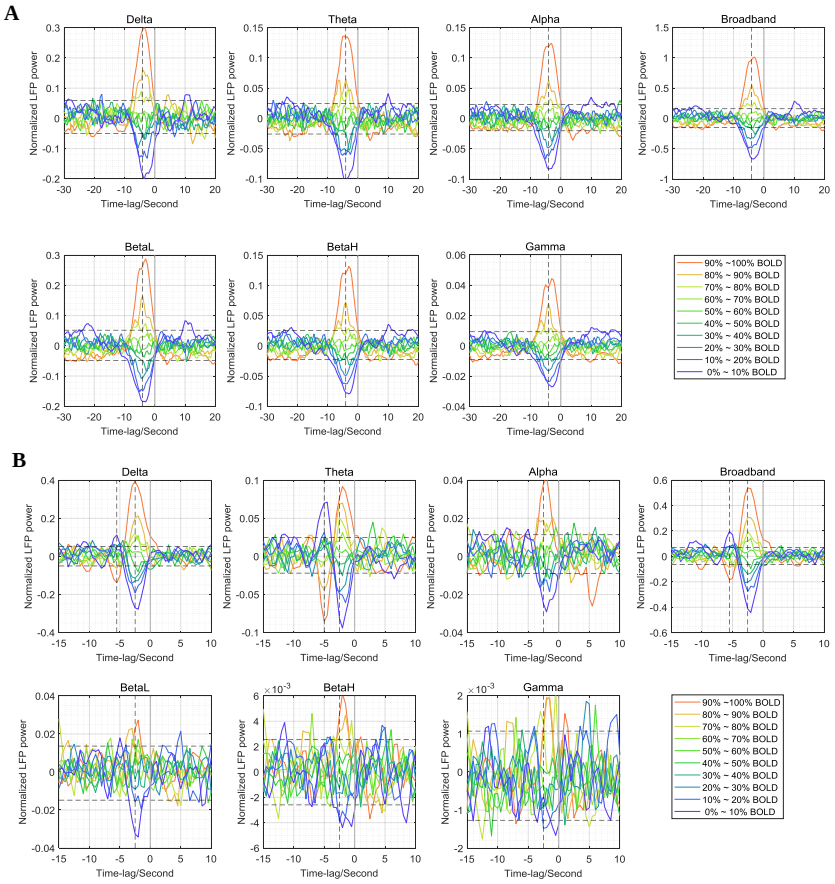

Figure S.4 Unfiltered BOLD triggered average under ISO anesthesia (panel A) and DMED anesthesia (panel B). The BOLD time course for defining the triggers was still band-pass filtered (0.01~0.1Hz for ISO and 0.01~0.25Hz for DMED). Unlike figure 2, the LFP power time courses being averaged were unfiltered. The time course was sampled with a temporal resolution of 0.5 second, meaning any frequency components lower than 1Hz can be seen in the figure. However, despite of some minor shape distortion and noise contamination, the BOLD-triggered average time course is not heavily influenced by removing the band-pass filtering.

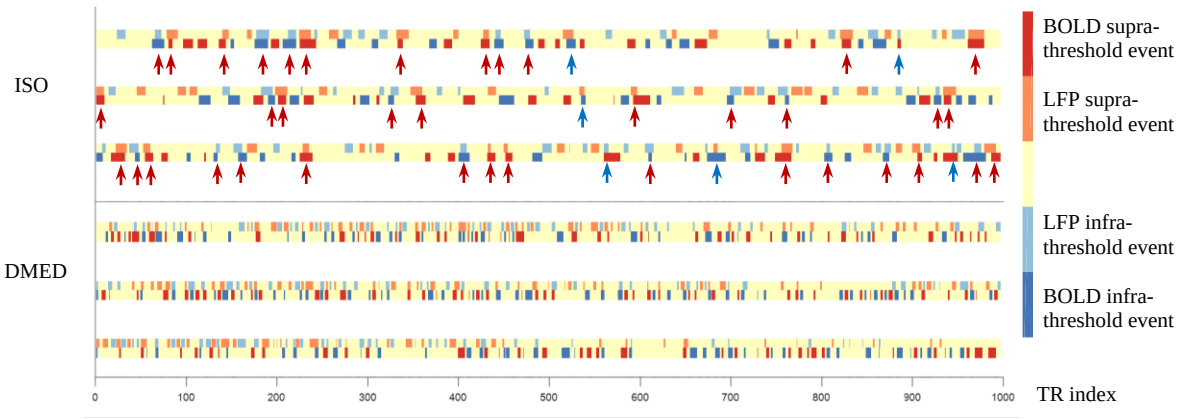

Figure S.5 Timing of LFP and BOLD supra-threshold and infra-threshold events. Three typical sessions were selected for display under each anesthesia condition. The threshold was set to 15% for infra-threshold events and 85% for supra-threshold events. It can be seen that although sometimes the LFP and BOLD activate or deactivate concurrently (indicated by red arrows), producing a positive correlation between the two, most of the time the LFP activations and BOLD activations do not overlap in the time domain, and sometimes are even in opposite directions (indicated by blue arrows). For the 32 scans under ISO and 22 scans under DMED, in total the fraction that overlap is 25.6% for activations and 24.3% for deactivations. Therefore the similarity between LFP-CAPs and BOLD-CAPs observed in Figure 5 might be attributable to other factors (like network structure) that might affect network dynamics, rather than the simple overlap in the timing.

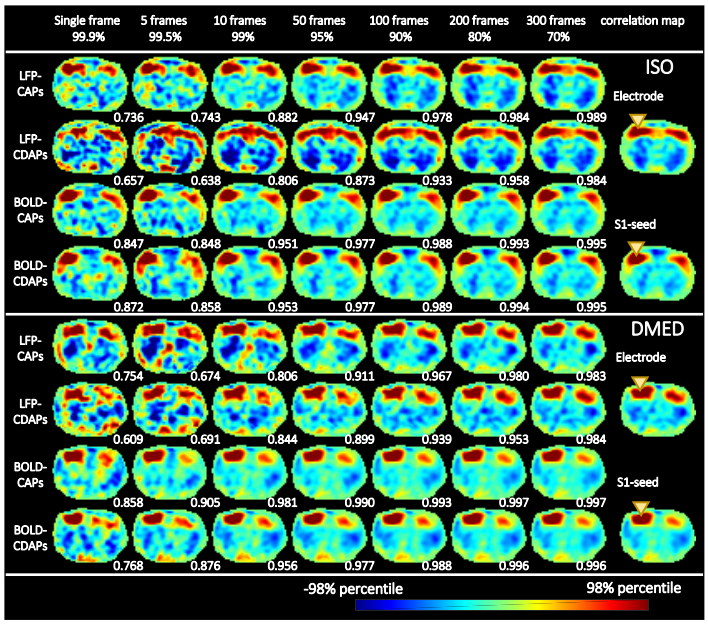

Figure S.6 Co-activation patterns become more similar to the correlation map as more frames are included for calculation. From left to right, as the threshold (shown in percentiles) become lower (for CAPs, it would be the opposite for CDAPs), more frames are included (The number of frames shown specifies how many frames from each scan are selected for calculation, the total number of frames for ISO and DMED should be this number times the numbers of scans, which are 32 and 22 respectively). The LFP-BOLD correlation map (at the maximally correlated lag) and BOLD S1-seeded correlation map are shown on the far right. For each CAP or CDAP, the spatial similarity with regard to the correlation map is shown in the bottom right corner of each image. It can be seen that the spatial similarity increases very quickly as more frames are included, and reaches a plateau near 1 when a certain amount of frames are included. Even if only 10%~20% of the dataset is used, most CAPs and CDAPs can replicate a spatial pattern nearly identical to the correlation map, which is calculated from the entire dataset (for LFP-CDAPs it takes a little longer, but 30% is enough to replicate the spatial pattern). It is worth noting that the display range of each image is different. Each image is normalized by its 98 percentile. The 98 percentile of LFP-BOLD correlation under ISO, BOLD S1-seeded correlation under ISO, LFP-BOLD correlation under DMED and BOLD S1-seeded correlation under DMED are 0.171, 0.299, 0.134 and 0.385 respectively. The similarities between LFP-BOLD correlation map and BOLD S1-seeded correlation map are 0.827 and 0.925 under ISO and DMED, respectively. The inter-anesthesia similarities are 0.761 and 0.569 for LFP-BOLD correlation map and BOLD S1-seeded correlation map, respectively.

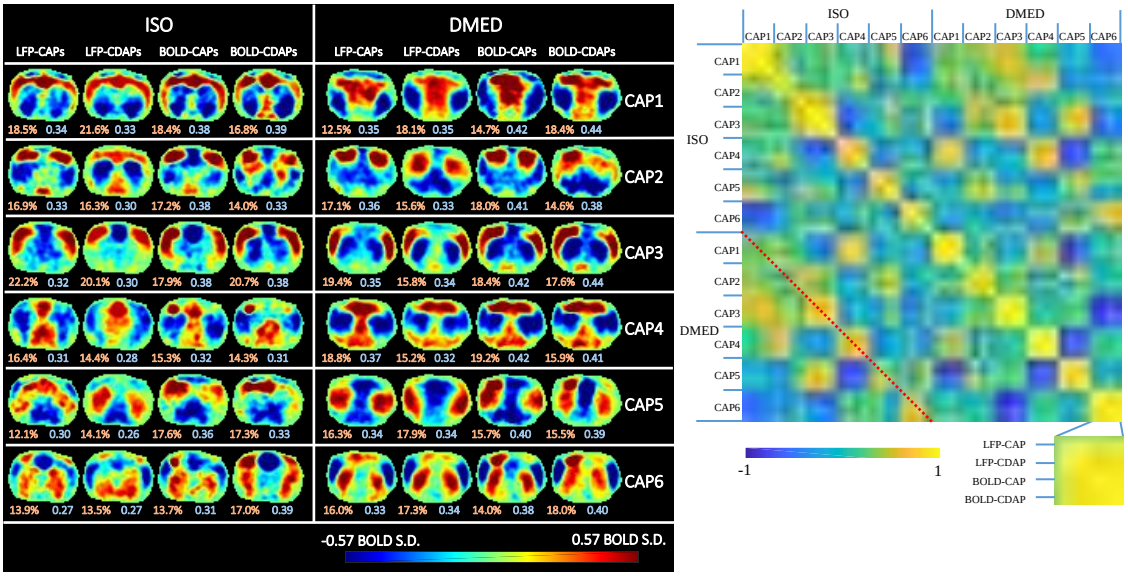

Figure S.7 Temporal decomposition of the selected co-activation frames and co-deactivation frames (left) and the similarity matrix (right). The selected frames that resemble the spatial pattern in cross correlation map are further divided into six clusters using k-means clustering (k=6) to produce CAPs and CDAPs. The threshold used for selecting frames was 15% for LFP-CAPs, BOLD-CAPs, BOLD-CDAPs, and 30% for LFP-CDAPs (the BOLD-CAPs and BOLD-CDAPs only need 5% to resemble the pattern, but to avoid randomness caused by extremely small sample size, the threshold was set to 15% as well. The LFP-CAPs under ISO are sorted based on the consistency (the average spatial similarity of each fMRI frame to the group mean). The LFP-CAPs under DMED are sorted to maximize the summed spatial similarity between LFP-CAPs under ISO and LFP-CAPs under DMED (for easier comparison across different anesthesia). The LFP-CDAPs, BOLD-CAPs, BOLD-CDAPs are also sorted in a similar way using LFP-CAPs as the benchmark. The consistency (light red) and fraction values (light blue) of the CAPs or CDAPs are shown on the bottom of each image. The similarity matrix shows the spatial similarity (Pearson correlation) between any combinations of two CAPs. Within each anesthetic agent group, there are 6 different CAPs group. Within each CAP group, there are also two elements: LFP-CAP and BOLD- CAP. So together there are 24x24 elements visualized in this matrix

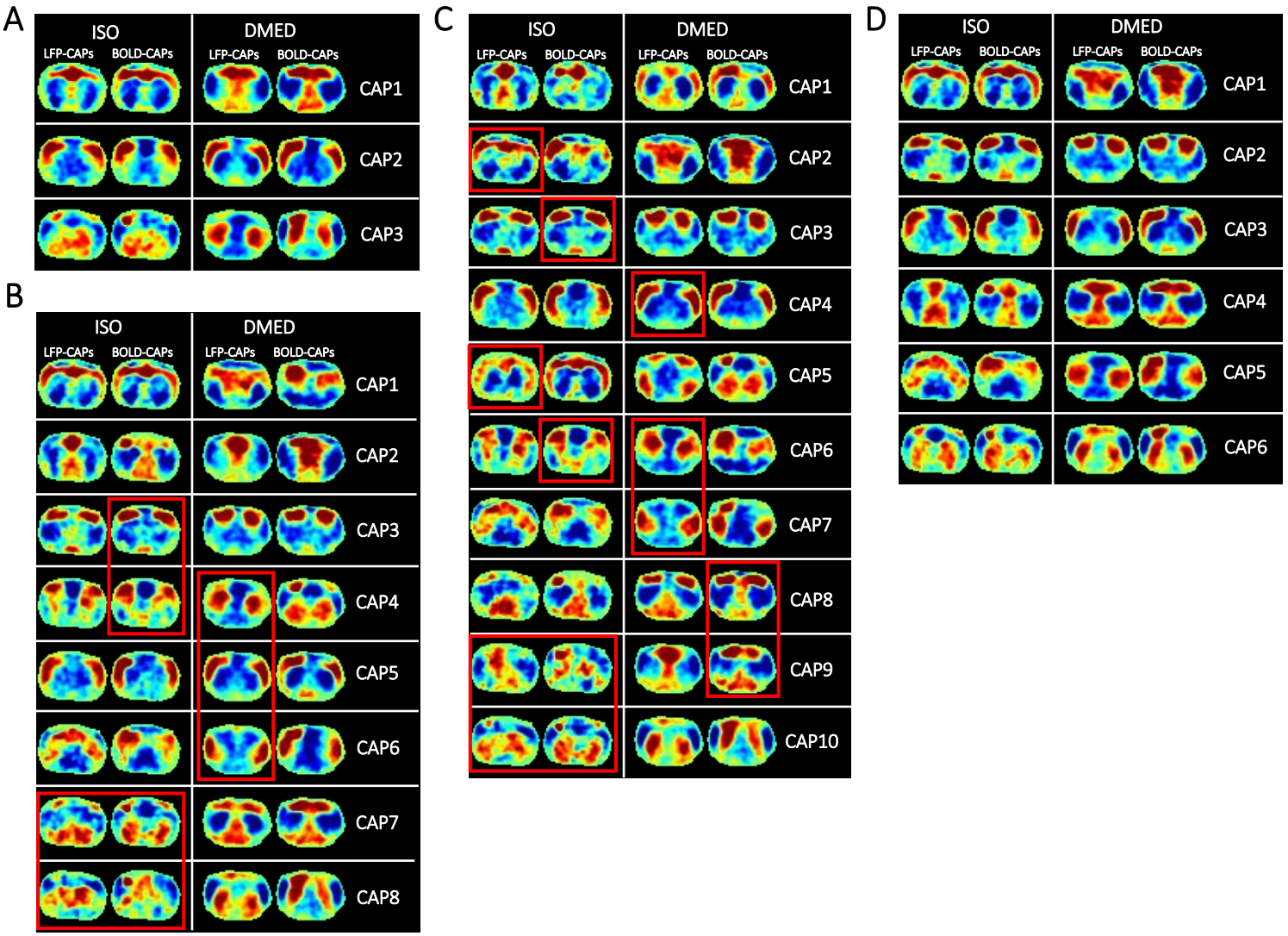

Figure S.8 Illustration of how the number of clusters influence the spatial patterns in CAPs. The number of clusters K equals to 3, 8, 10 in panel A, B, C, respectively. Panel D shows the results using K=6 (same as figure 5) for reference. It can be seen that, all spatial pattern is unique with K=6, but when K =8, there are a few redundant spatial patterns showing up (highlighted in red boxes), which suggests that 8 clusters might be too many. With K=10, this become more prominent. Therefore K=6 used in Figure 5 is around the optimal number of clusters.