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Supplementary Information for

Mind blanking is a distinct mental state linked to a recurrent brain profile of globally positive connectivity during ongoing mentation

Sepehr Mortaheb, Laurens Van Calster, Federico Raimondo, Manousos A. Klados, Paradeisios Alexandros Boulakis, Kleio Georgoula, Steve Majerus, Dimitri Van de Ville, and Athena Demertzi

Corresponding Author: Athena Demertzi, PhD
E-mail: a.demertzi@uliege.be

This PDF file includes:

Figs. S1 to S27 (not allowed for Brief Reports)
Tables S1 to S4 (not allowed for Brief Reports)

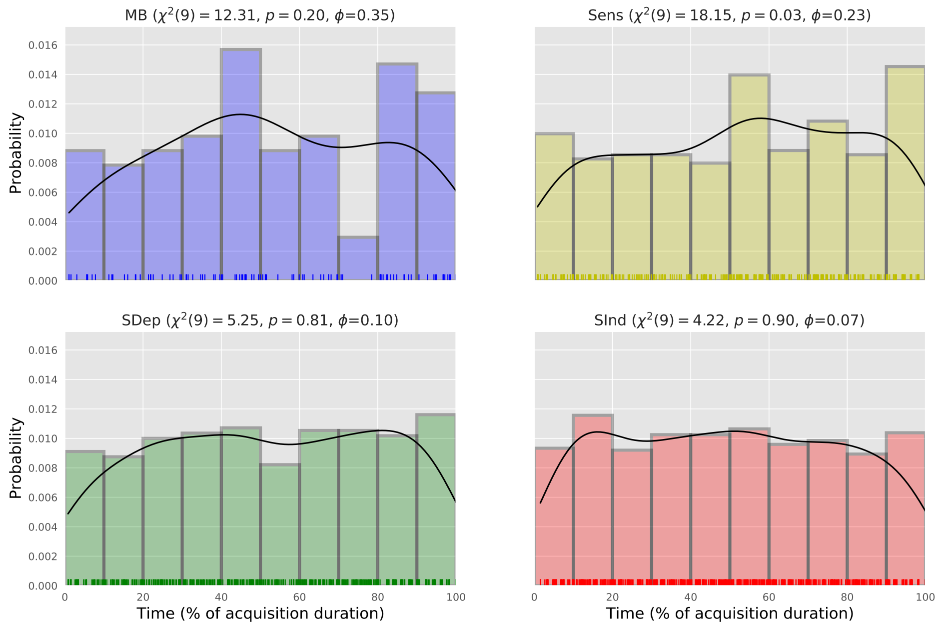

Fig. S1. Mind blanking reports are uniformly distributed across the acquisition time. By dividing the acquisition period into 10% bins, and counting the number of MB reports at each bin for all the subjects, the distribution of reports were found to be uniform (χ^2 test). The same result were found for SDep and SInd reports but the hypothesis of uniformity were rejected for the Sens reports.

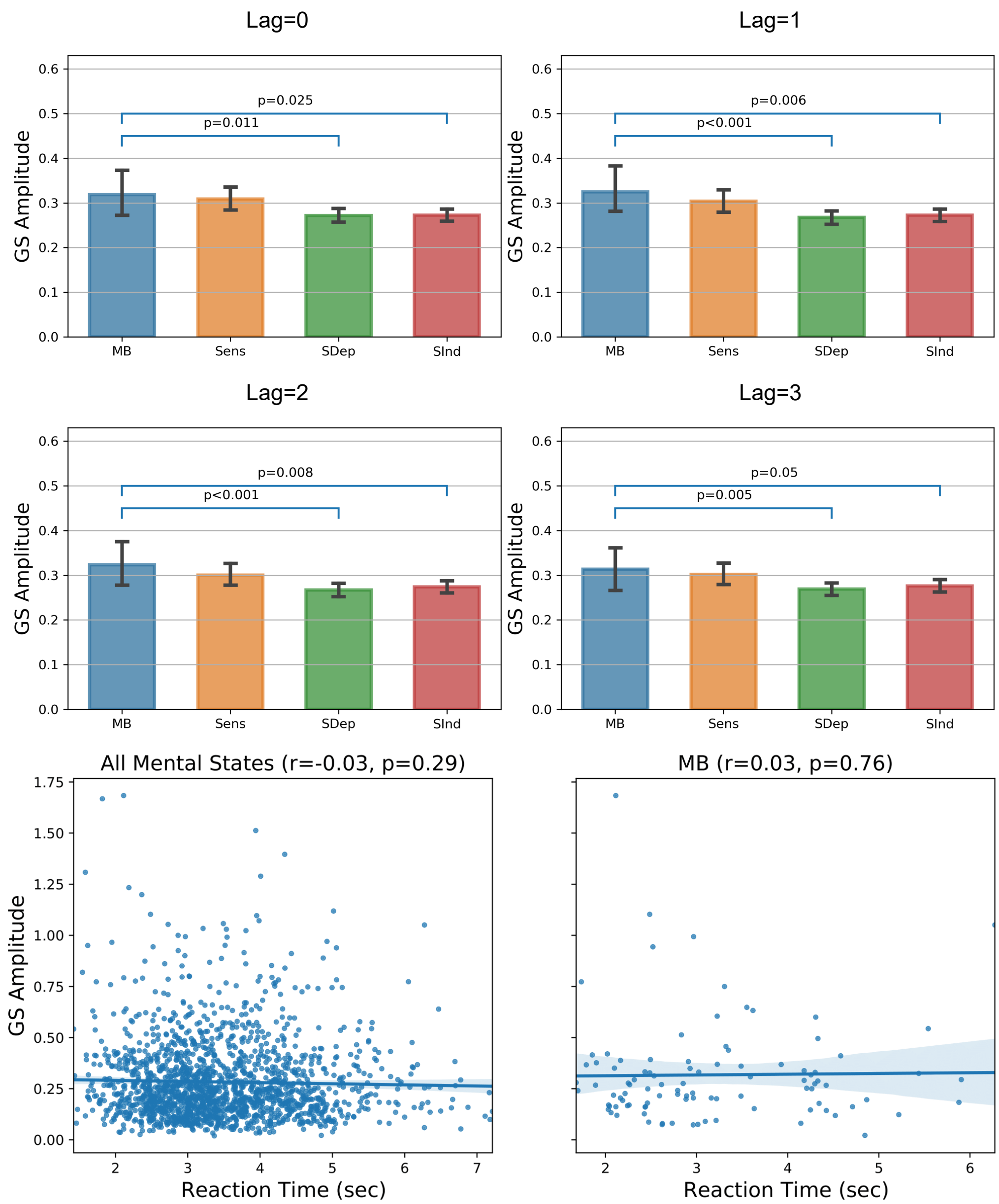

Fig. S2. Mind blanking is characterized by high cortical global signal amplitude. Average absolute value of the global signal of the 5 scans prior to each mental state (lag = 0) shows that the amplitude is significantly higher for MB reports compared to the thought-related states. These results are replicated considering different pre-probe window lags related to the hemodynamic response peak time, up to 3 lags after the probe. Also, global signal amplitude is not correlated with reaction times which shows that arousal/sleepiness is not confounded with MB reportability. (Bars show the mean of the magnitude and error bars are 95% confidence interval.)

Table S1. Performance of SVM classifier when predicting MB reports based on phase-based coherence matrices (Lag = 0). CI: 95% confidence interval.

	Balanced Accuracy	Recall	Precision
MB vs. Sens	0.97, CI=(0.87, 1)	0.94, CI=(0.73, 1)	0.99, CI=(0.97, 1)
MB vs. SDep	0.95, CI=(0.83, 1)	0.91, CI=(0.67, 1)	1, CI=(1,1)
MB vs. SInd	0.94, CI=(0.79, 1)	0.87, CI=(0.58, 1)	1, CI=(1,1)
MB vs. Others	0.90, CI=(0.73, 1)	0.79, CI=(0.45, 1)	1, CI=(1,1)
MB vs. Others (dummy)	*0.50, CI=(0.43, 0.57)*	0.05, CI=(-0.07, 0.18)	0.06, CI=(-0.10, 0.22)

Table S2. Performance of SVM classifier when predicting MB reports based on phase-based coherence matrices (Lag = 1). CI: 95% confidence interval.

	Balanced Accuracy	Recall	Precision
MB vs. Sens	0.97, CI=(0.87, 1)	0.94, CI=(0.74, 1)	0.99, CI=(0.98, 1)
MB vs. SDep	0.95, CI=(0.83, 1)	0.91, CI=(0.66, 1)	1, CI=(1,1)
MB vs. SInd	0.94, CI=(0.79, 1)	0.87, CI=(0.59, 1)	1, CI=(1,1)
MB vs. Others	0.90, CI=(0.74, 1)	0.79, CI=(0.49, 1)	1, CI=(1,1)
MB vs. Others (dummy)	0.50, CI=(0.43, 0.57)	0.05, CI=(-0.07, 0.18)	0.06, CI=(-0.10, 0.22)

Table S3. Performance of SVM classifier when predicting MB reports based on phase-based coherence matrices (Lag = 2). CI: 95% confidence interval.

	Balanced Accuracy	Recall	Precision
MB vs. Sens	0.98, CI=(0.88, 1)	0.95, CI=(0.75, 1)	0.99, CI=(0.98, 1)
MB vs. SDep	0.96, CI=(0.84, 1)	0.91, CI=(0.68, 1)	1, CI=(1,1)
MB vs. SInd	0.94, CI=(0.80, 1)	0.88, CI=(0.60, 1)	1, CI=(1,1)
MB vs. Others	0.90, CI=(0.78, 1)	0.81, CI=(0.55, 1)	1, CI=(1,1)
MB vs. Others (dummy)	*0.50, CI=(0.43, 0.57)*	0.05, CI=(-0.07, 0.18)	0.06, CI=(-0.10, 0.22)

Table S4. Performance of SVM classifier when predicting MB reports based on phase-based coherence matrices (Lag = 3). CI: 95% confidence interval.

	Balanced Accuracy	Recall	Precision
MB vs. Sens	0.97, CI=(0.87, 1)	0.95, CI=(0.75, 1)	0.99, CI=(0.98, 1)
MB vs. SDep	0.96, CI=(0.84, 1)	0.92, CI=(0.69, 1)	1, CI=(1,1)
MB vs. SInd	0.94, CI=(0.81, 1)	0.88, CI=(0.61, 1)	1, CI=(1,1)
MB vs. Others	0.90, CI=(0.77, 1)	0.81, CI=(0.54, 1)	1, CI=(1,1)
MB vs. Others (dummy)	*0.50, CI=(0.43, 0.57)*	0.05, CI=(-0.07, 0.18)	0.06, CI=(-0.10, 0.22)

Resting state recurrent connectivity patterns

Global Signal Included. Mental state window lag: 0

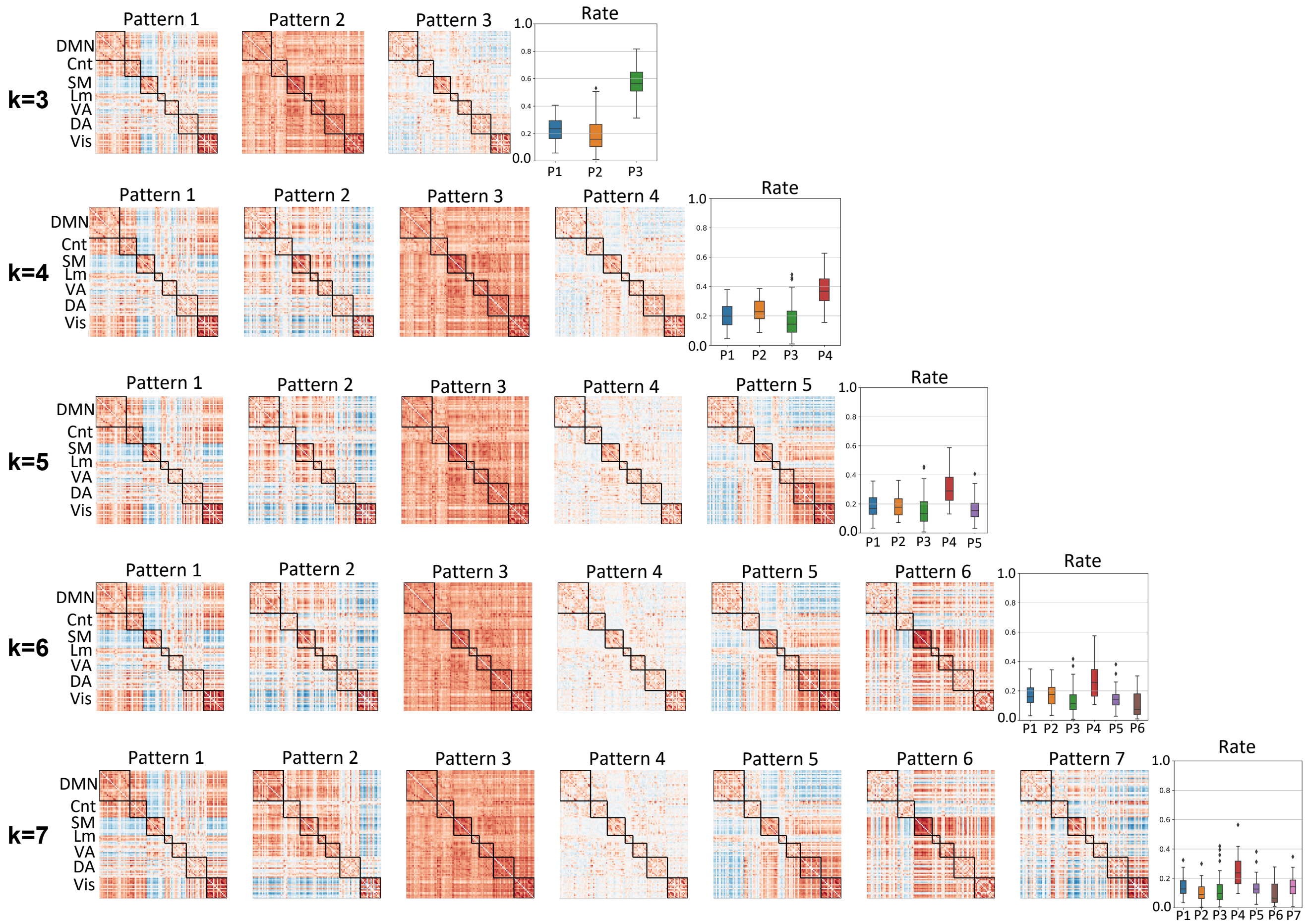

Fig. S3. Four main recurrent functional configurations characterize the resting periods of the experience-sampling paradigm (lag = 0). K-means clustering on the connectivity matrices related to the resting periods and 5 pre-probe matrices related to the reported mental states shows that four patterns recurrently appear during these periods of the experience-sampling even up to k=7 clusters.

Global Signal Included. Mental state window lag: 1

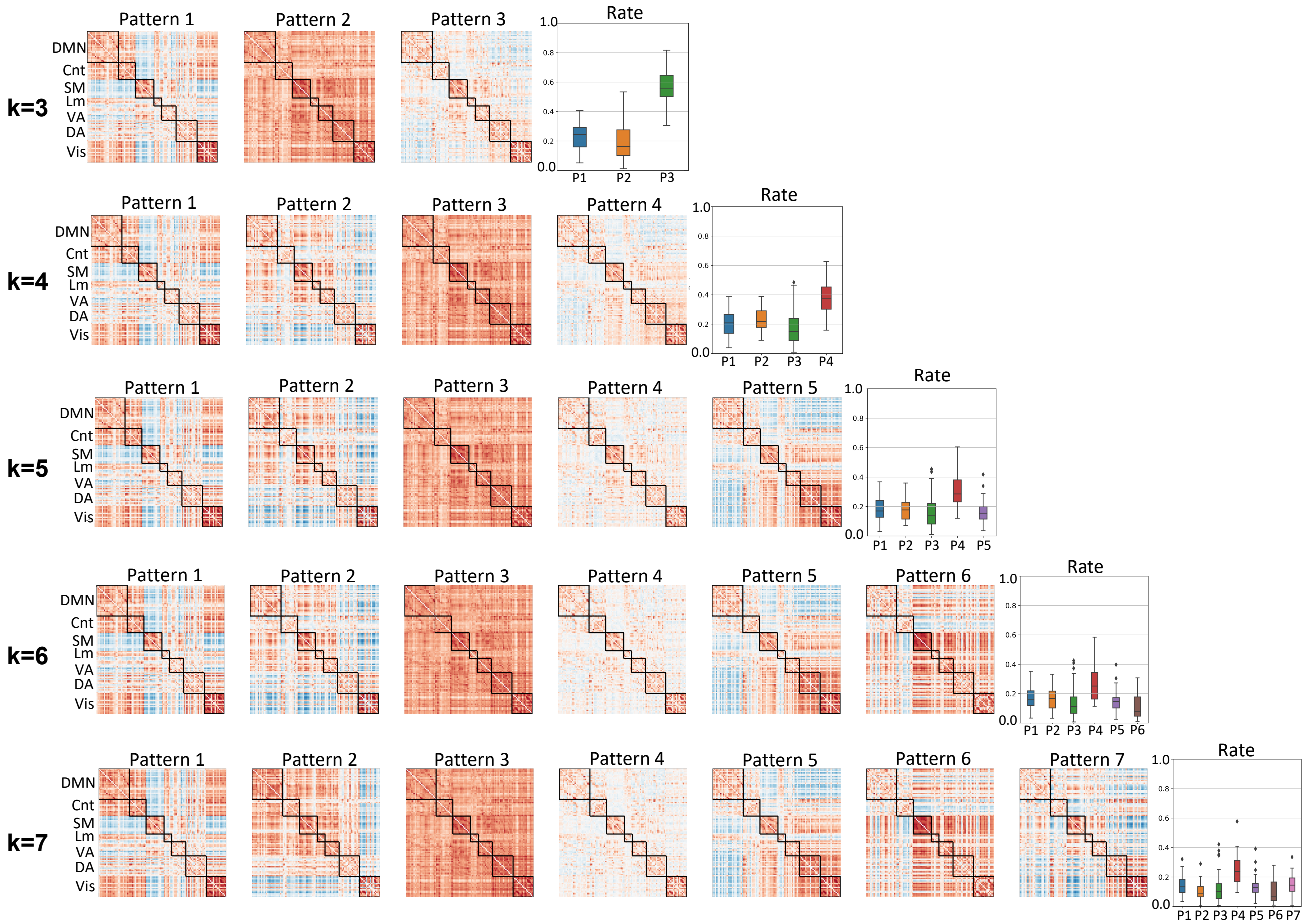

Fig. S4. Four main recurrent functional configurations characterize the resting periods of the experience-sampling paradigm (lag = 1). K-means clustering on the connectivity matrices related to the resting periods and 4 pre-probe and one post-probe matrices related to the reported mental states shows that four patterns recurrently appear during these periods of the experience-sampling even up to k=7 clusters.

Global Signal Included. Mental state window lag: 2

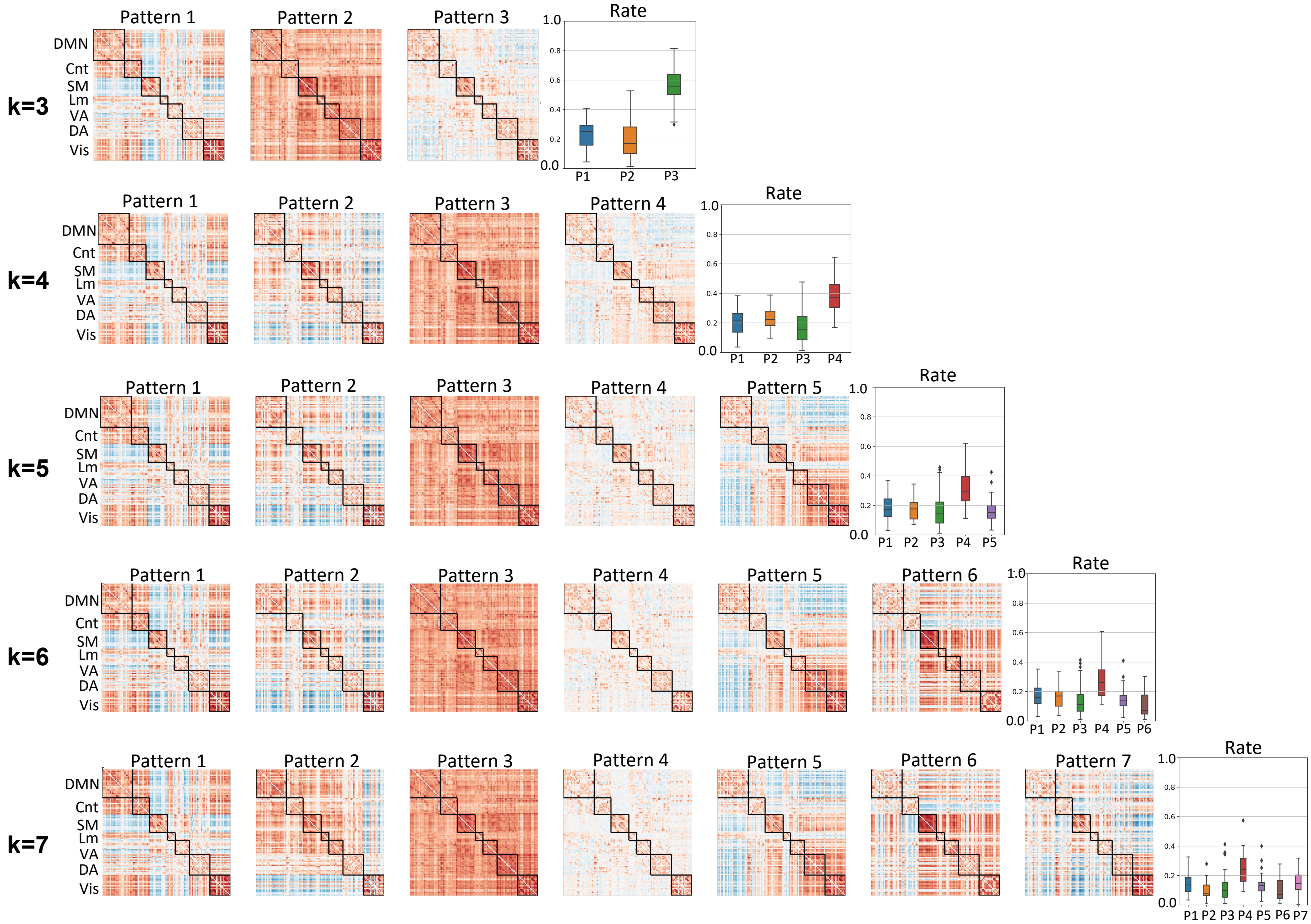

Fig. S5. Four main recurrent functional configurations characterize the resting periods of the experience-sampling paradigm (lag = 2). K-means clustering on the connectivity matrices related to the resting periods and 3 pre-probe and 2 post-probe matrices related to the reported mental states shows that four patterns recurrently appear during these periods of the experience-sampling even up to k=7 clusters.

Global Signal Included. Mental state window lag: 3

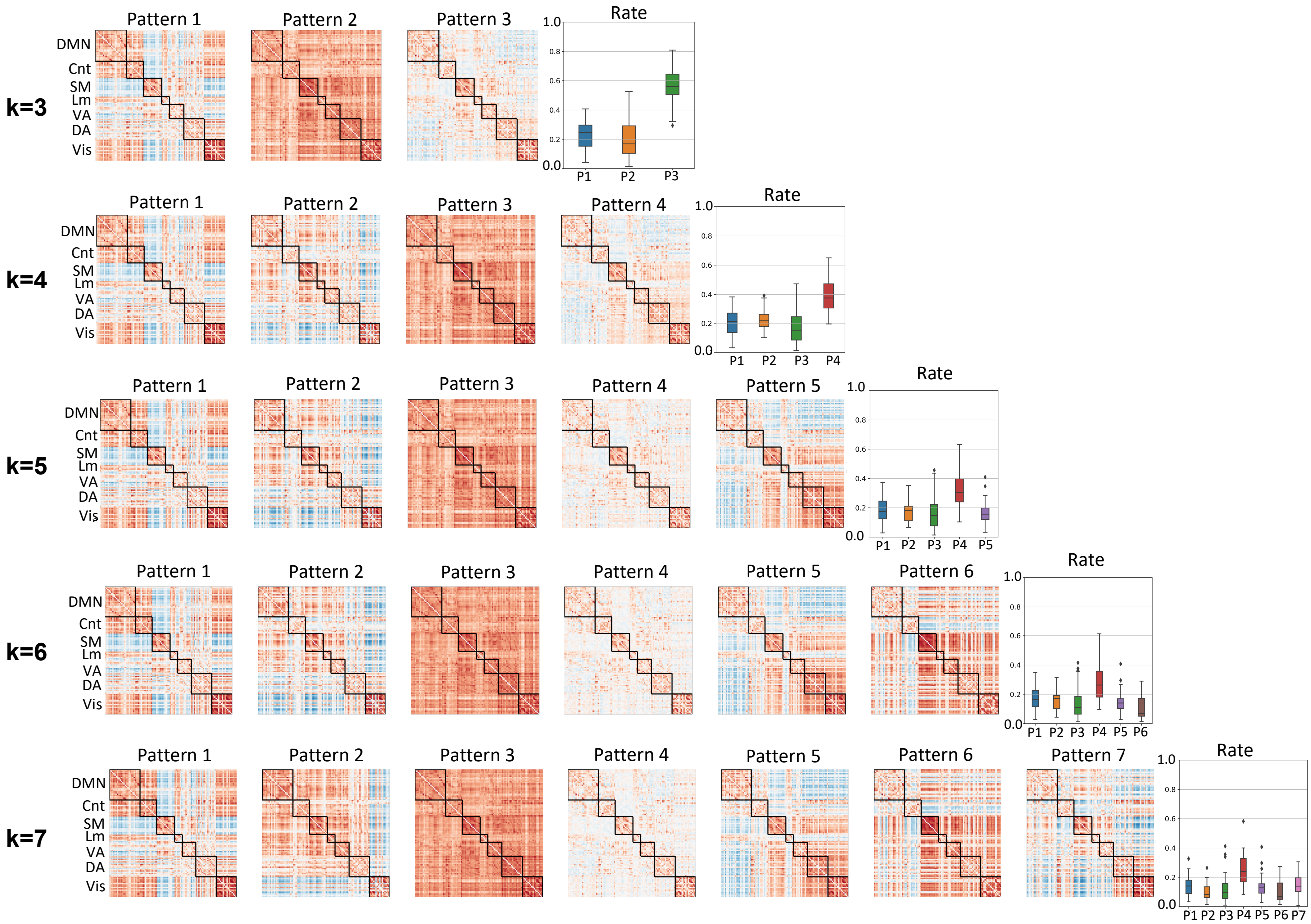

Fig. S6. Four main recurrent functional configurations characterize the resting periods of the experience-sampling paradigm (lag = 3). K-means clustering on the connectivity matrices related to the resting periods and 2 pre-probe and 3 post-probe matrices related to the reported mental states shows that four patterns recurrently appear during these periods of the experience-sampling even up to k=7 clusters.

Global Signal Subtraction. Mental state window lag: 0

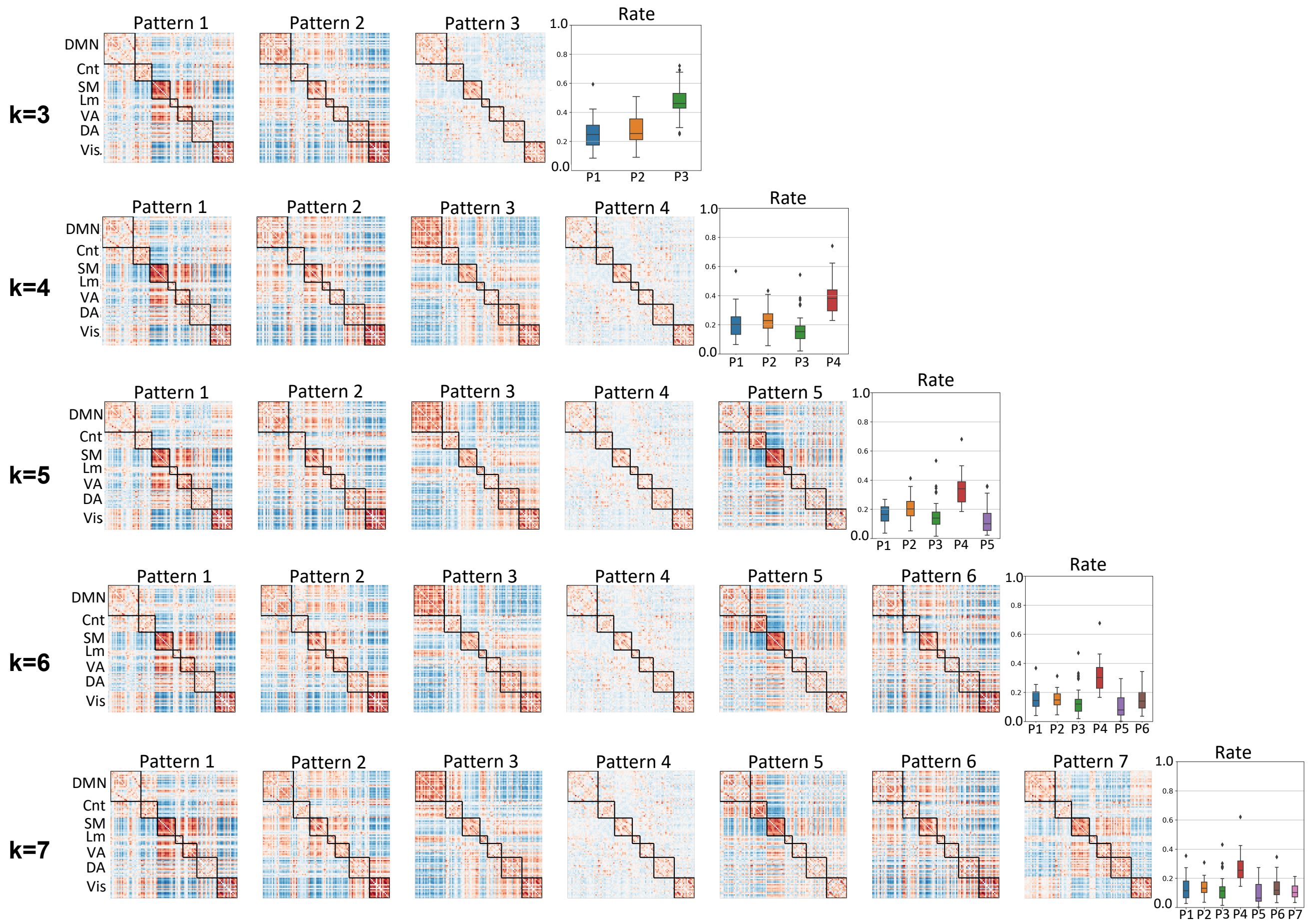

Fig. S7. Effect of global signal subtraction on the extracted brain patterns (lag = 0). After subtracting the global signal from regional time series, the resting periods of the experience-sampling paradigm fail to show the overall positive connectivity configuration, suggesting an important contribution of the global signal on this brain pattern. Notes: recurrent functional configurations are extracted using k-means clustering with number of clusters ranging from 3 to 7, considering 5 pre-probe connectivity matrices related to the reported mental state.

Global Signal Subtraction. Mental state window lag: 1

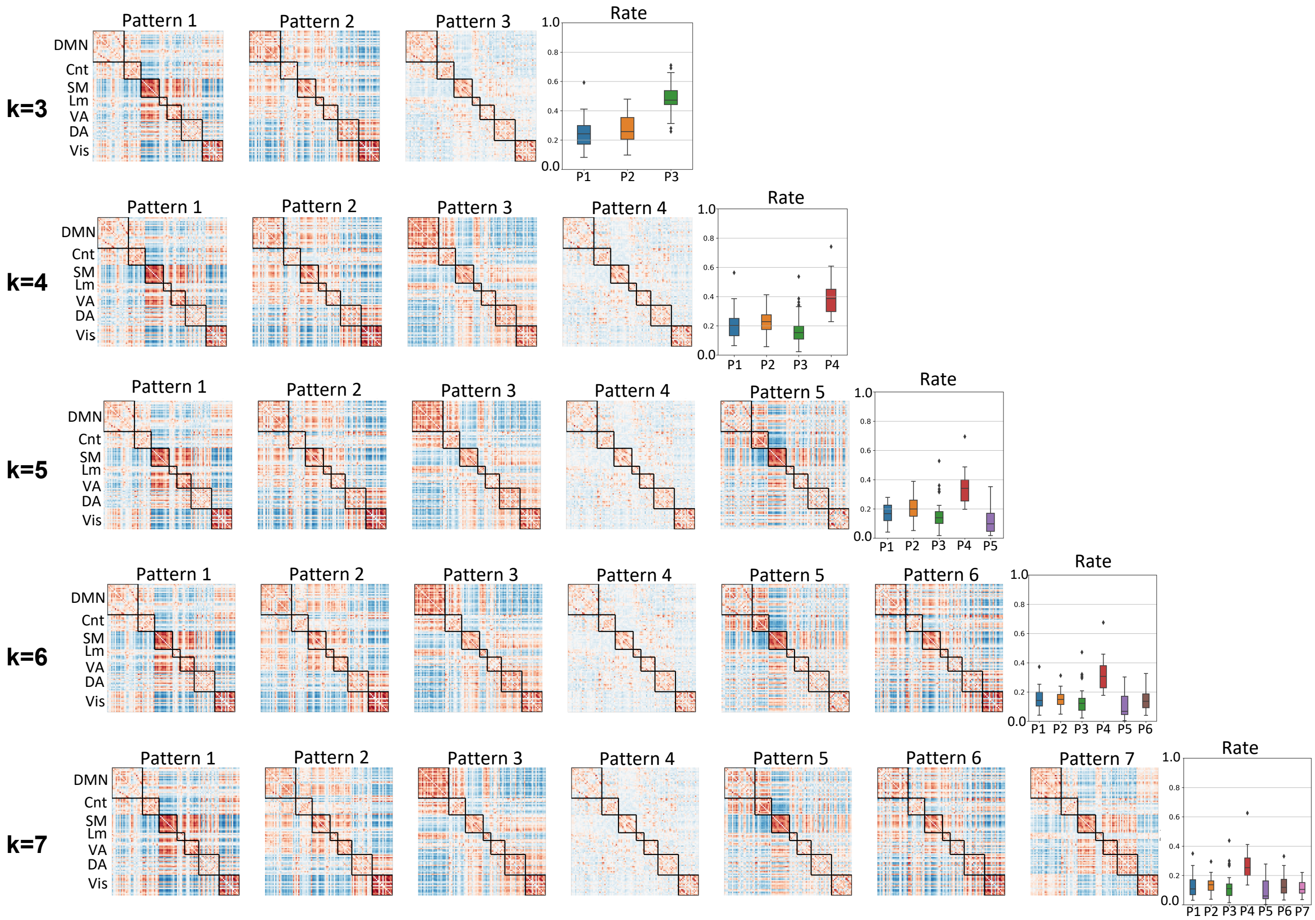

Fig. S8. Effect of global signal subtraction on the extracted brain patterns (lag = 1). After subtracting the global signal from regional time series, the resting periods of the experience-sampling paradigm fail to show the overall positive connectivity configuration, suggesting an important contribution of the global signal on this brain pattern. Notes: recurrent functional configurations are extracted using k-means clustering with number of clusters ranging from 3 to 7, considering 4 pre-probe and one post-probe connectivity matrices related to the reported mental state.

Global Signal Subtraction. Mental state window lag: 2

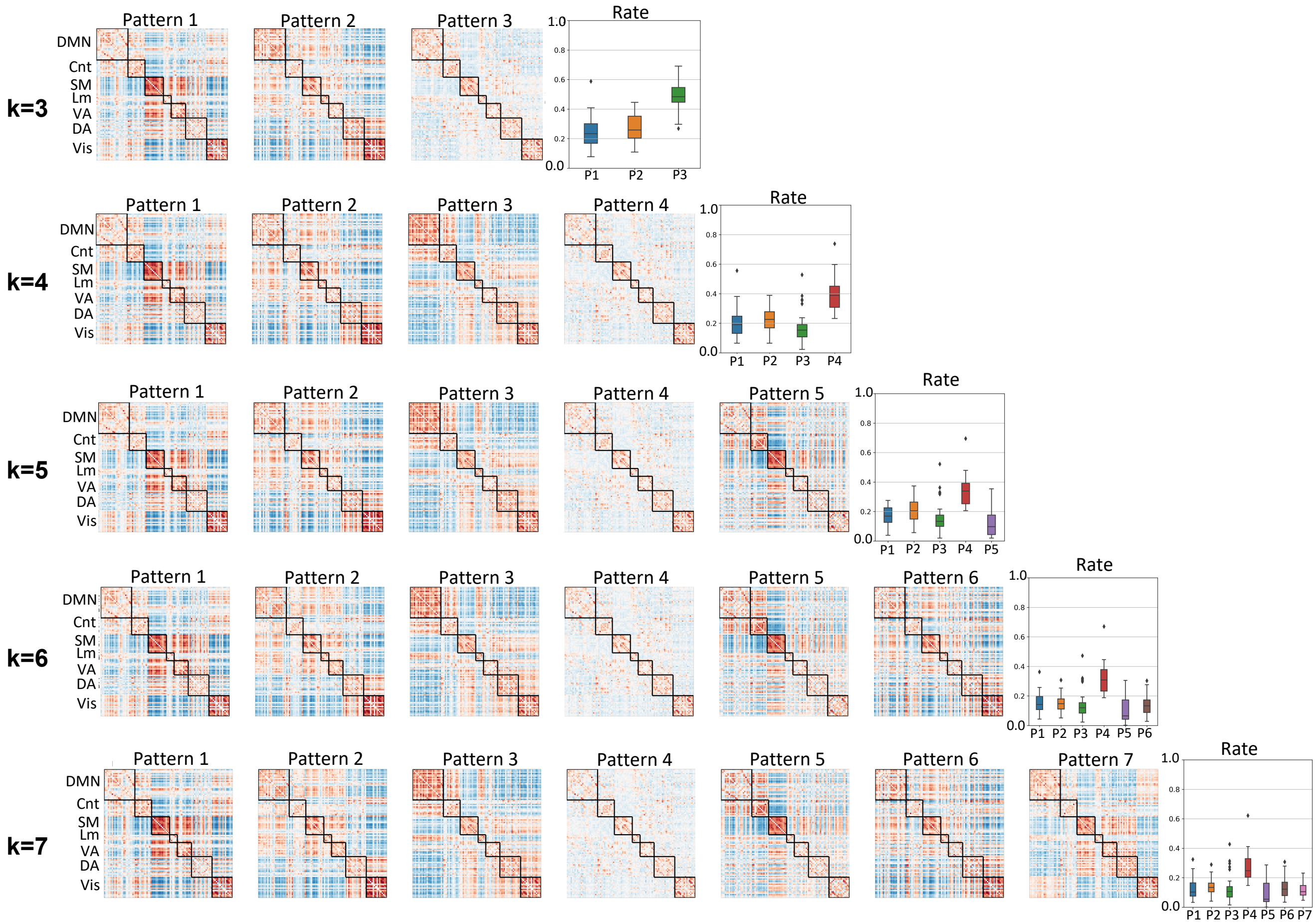

Fig. S9. Effect of global signal subtraction on the extracted brain patterns (lag = 2). After subtracting the global signal from regional time series, the resting periods of the experience-sampling paradigm fail to show the overall positive connectivity configuration, suggesting an important contribution of the global signal on this brain pattern. Notes: recurrent functional configurations are extracted using k-means clustering with number of clusters ranging from 3 to 7, considering 3 pre-probe and 2 post-probe connectivity matrices related to the reported mental state.

Global Signal Subtraction. Mental state window lag: 3

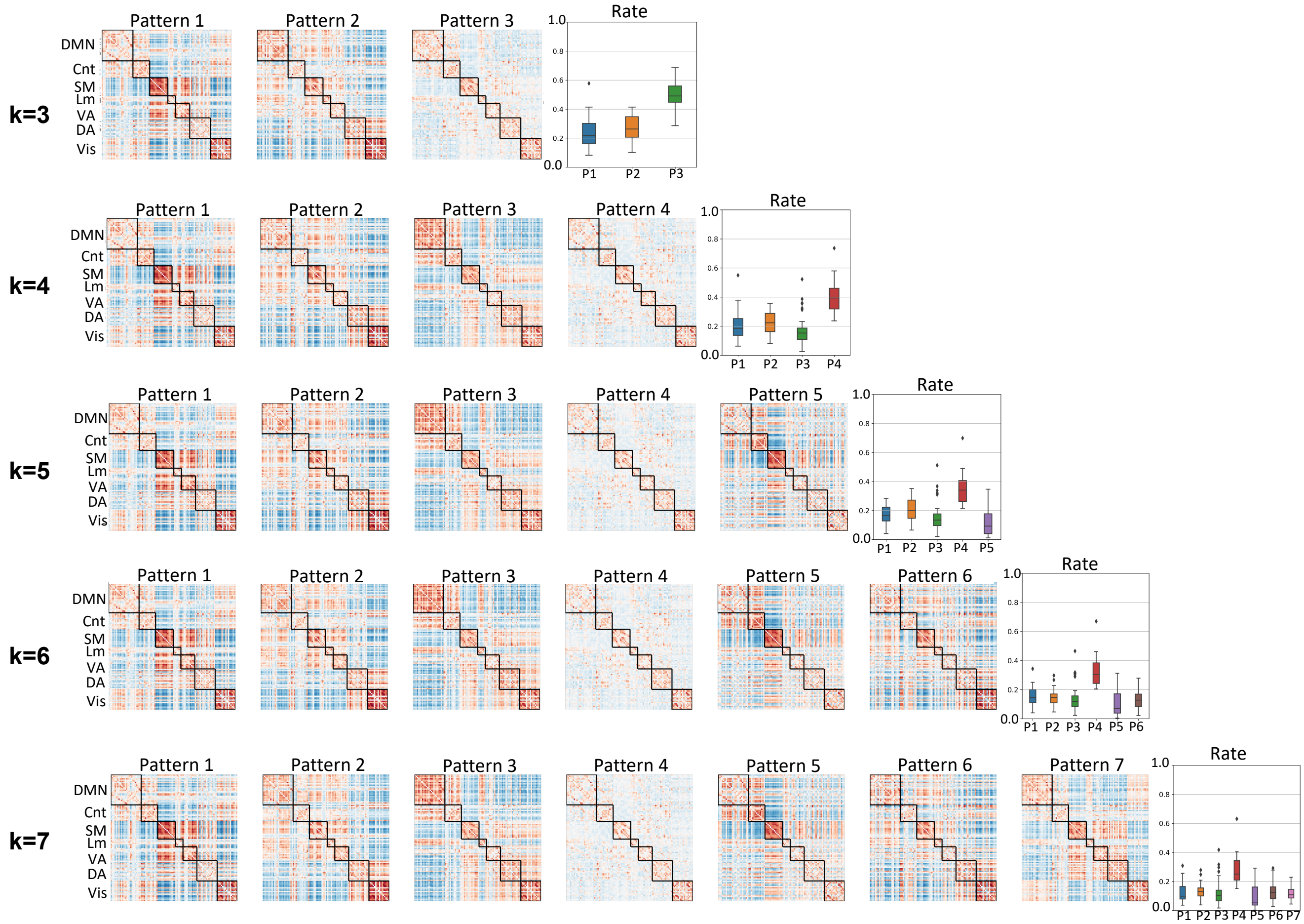

Fig. S10. Effect of global signal subtraction on the extracted brain patterns (lag = 3). After subtracting the global signal from regional time series, the resting periods of the experience-sampling paradigm fail to show the overall positive connectivity configuration, suggesting an important contribution of the global signal on this brain pattern. Notes: recurrent functional configurations are extracted using k-means clustering with number of clusters ranging from 3 to 7, considering 2 pre-probe and 3 post-probe connectivity matrices related to the reported mental state.

Global Signal Regression. Mental state window lag: 0

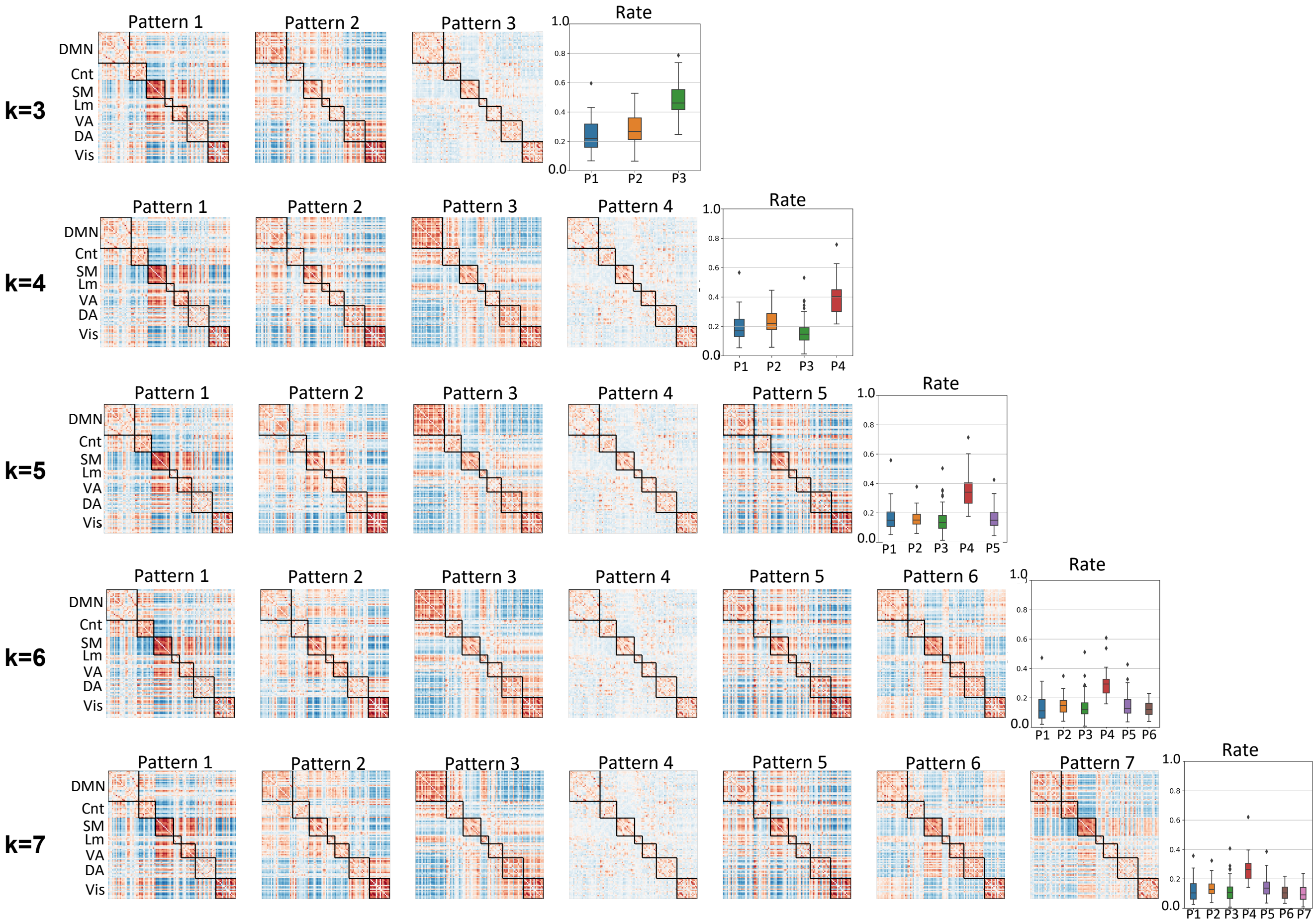

Fig. S11. Effect of global signal regression on the extracted brain patterns (lag = 0). After regressing out the global signal from regional time series, the resting periods of the experience-sampling paradigm fail to show the overall positive connectivity configuration, suggesting an important contribution of the global signal on this brain pattern. Notes: recurrent functional configurations are extracted using k-means clustering with number of clusters ranging from 3 to 7, considering 5 pre-probe connectivity matrices related to the reported mental state.

Global Signal Regression. Mental state window lag: 1

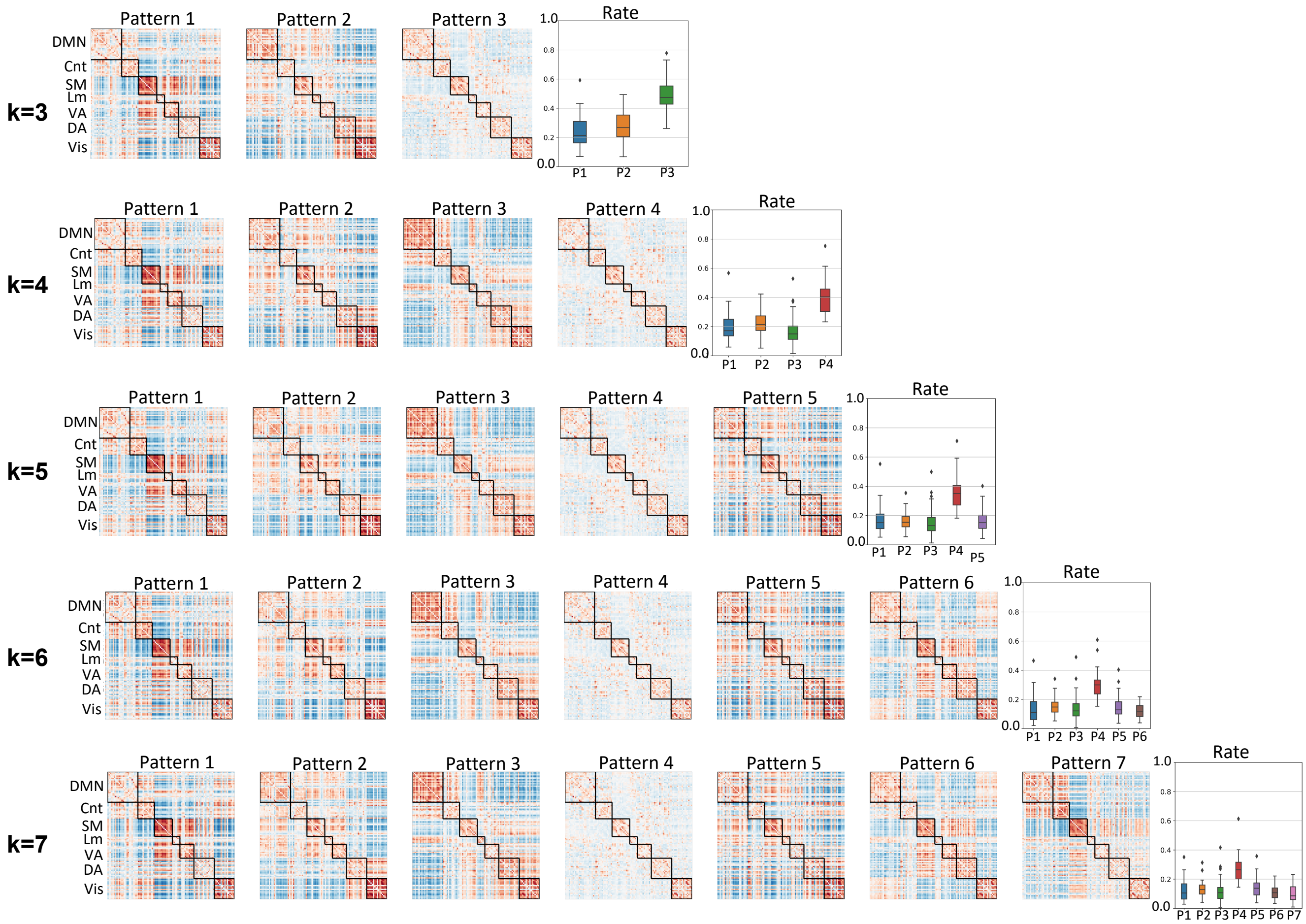

Fig. S12. Effect of global signal regression on the extracted brain patterns (lag = 1). After regressing out the global signal from regional time series, the resting periods of the experience-sampling paradigm fail to show the overall positive connectivity configuration, suggesting an important contribution of the global signal on this brain pattern. Notes: recurrent functional configurations are extracted using k-means clustering with number of clusters ranging from 3 to 7, considering 4 pre-probe and one post-probe connectivity matrices related to the reported mental state.

Global Signal Regression. Mental state window lag: 2

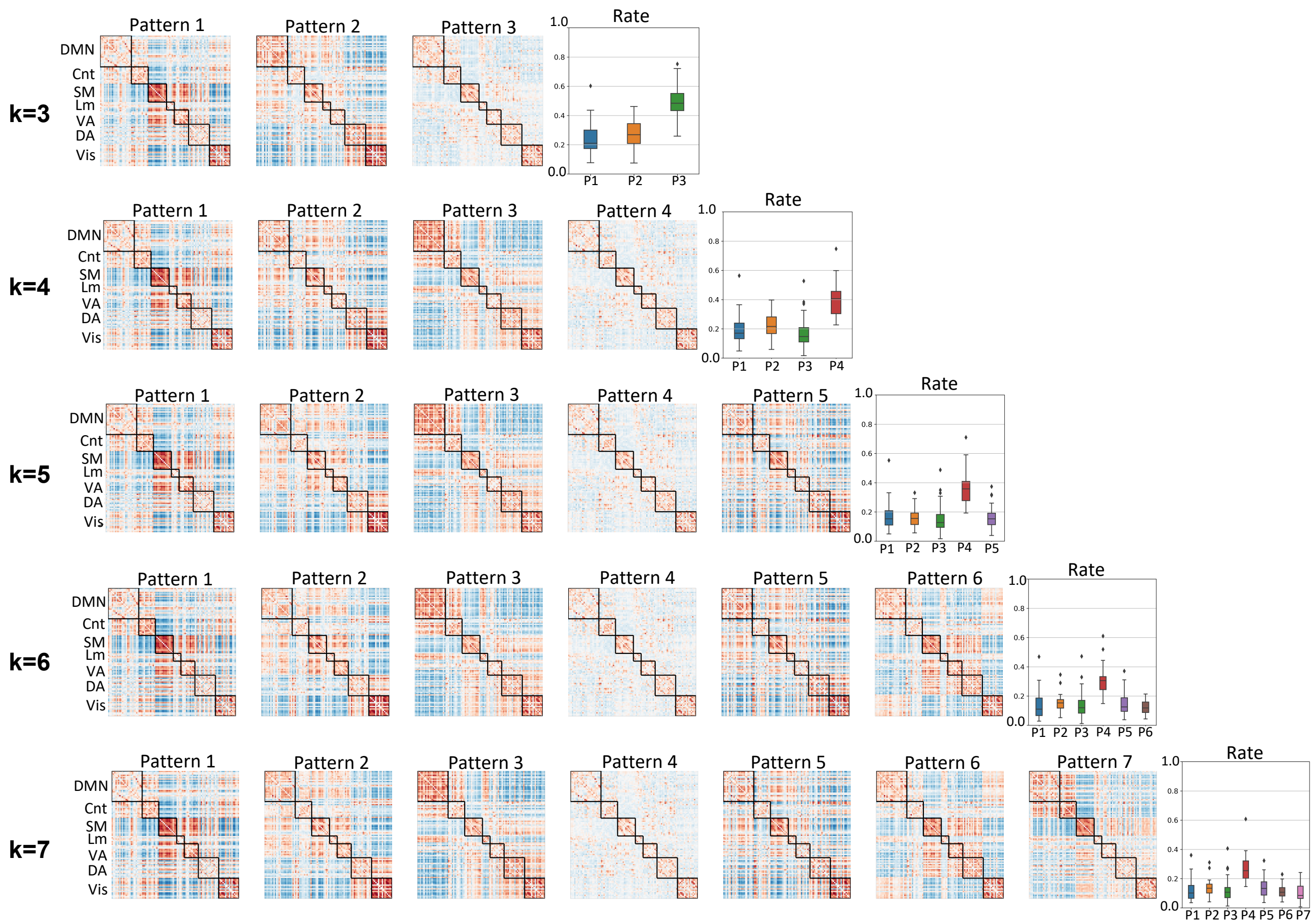

Fig. S13. Effect of global signal regression on the extracted brain patterns (lag = 2). After regressing out the global signal from regional time series, the resting periods of the experience-sampling paradigm fail to show the overall positive connectivity configuration, suggesting an important contribution of the global signal on this brain pattern. Notes: recurrent functional configurations are extracted using k-means clustering with number of clusters ranging from 3 to 7, considering 3 pre-probe and 2 post-probe connectivity matrices related to the reported mental state.

Global Signal Regression. Mental state window lag: 3

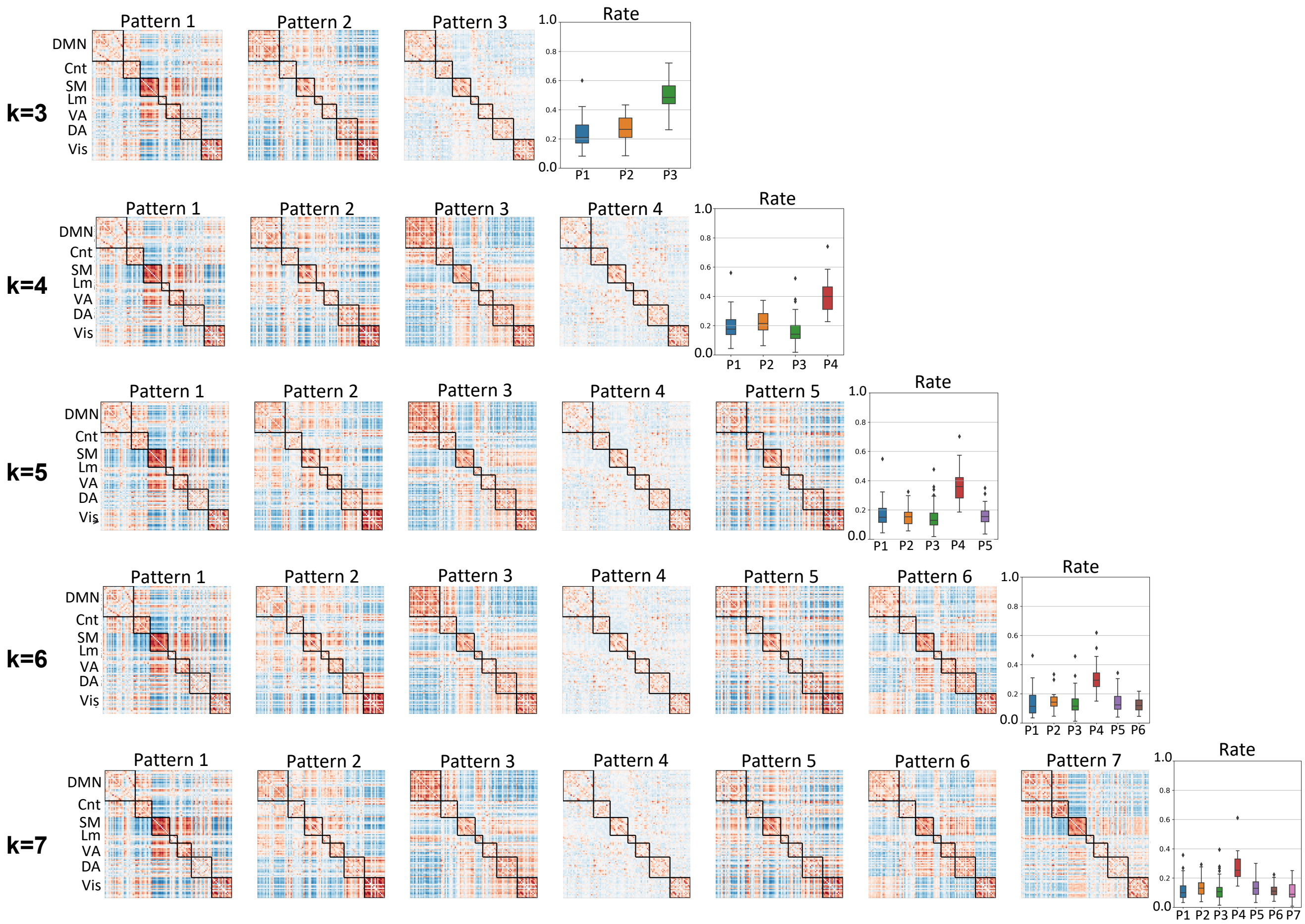

Fig. S14. Effect of global signal regression on the extracted brain patterns (lag = 3). After regressing out the global signal from regional time series, the resting periods of the experience-sampling paradigm fail to show the overall positive connectivity configuration, suggesting an important contribution of the global signal on this brain pattern. Notes: recurrent functional configurations are extracted using k-means clustering with number of clusters ranging from 3 to 7, considering 2 pre-probe and 3 post-probe connectivity matrices related to the reported mental state.

Comparison of GS-Included, GSS, and GSR

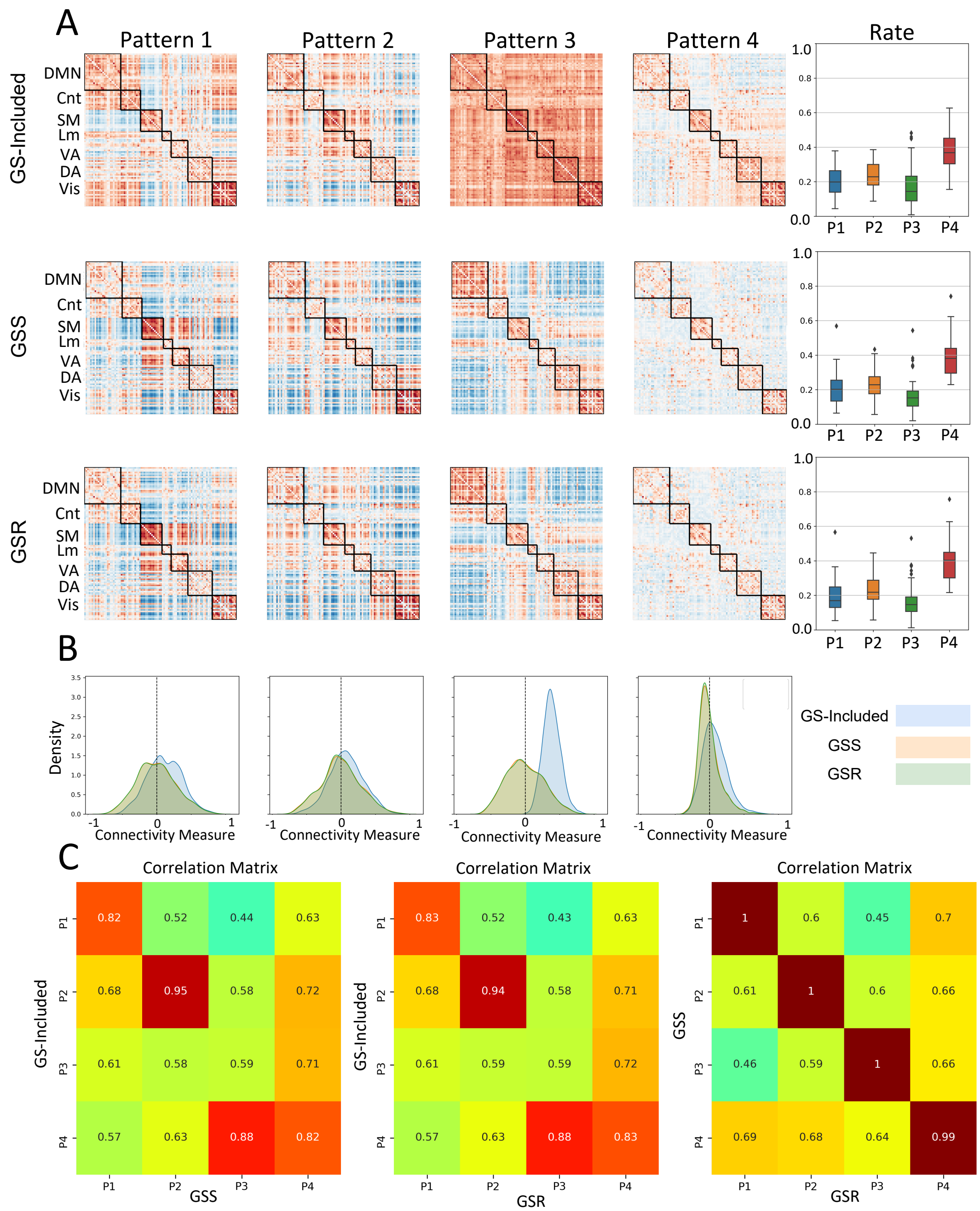

Fig. S15. The overall positive coherence configuration (Pattern 3) is mediated by the cortical global signal (GS). A) When subtracting (GSS)/regressing out (GSR) the global signal from the ROI time series, Pattern 3 positive connectivity reduces significantly. As the occurrence rate of Pattern 3 is relative to the occurrence rates of the other patterns its appearance is not influenced either when the GS is included in the analysis or removed by subtraction or regression. B) GSS/GSR shifts the connectivity distribution to more negative values and this effect is more prominent for Pattern 3. C) The similarity of Pattern 3 to itself is no longer significant after GSS-GSR whereas for the other patterns the GS removal strategies do not affect their intra-correlation values.

Neurofunctional Analysis

Global Signal Included. Mental state window lag: 0

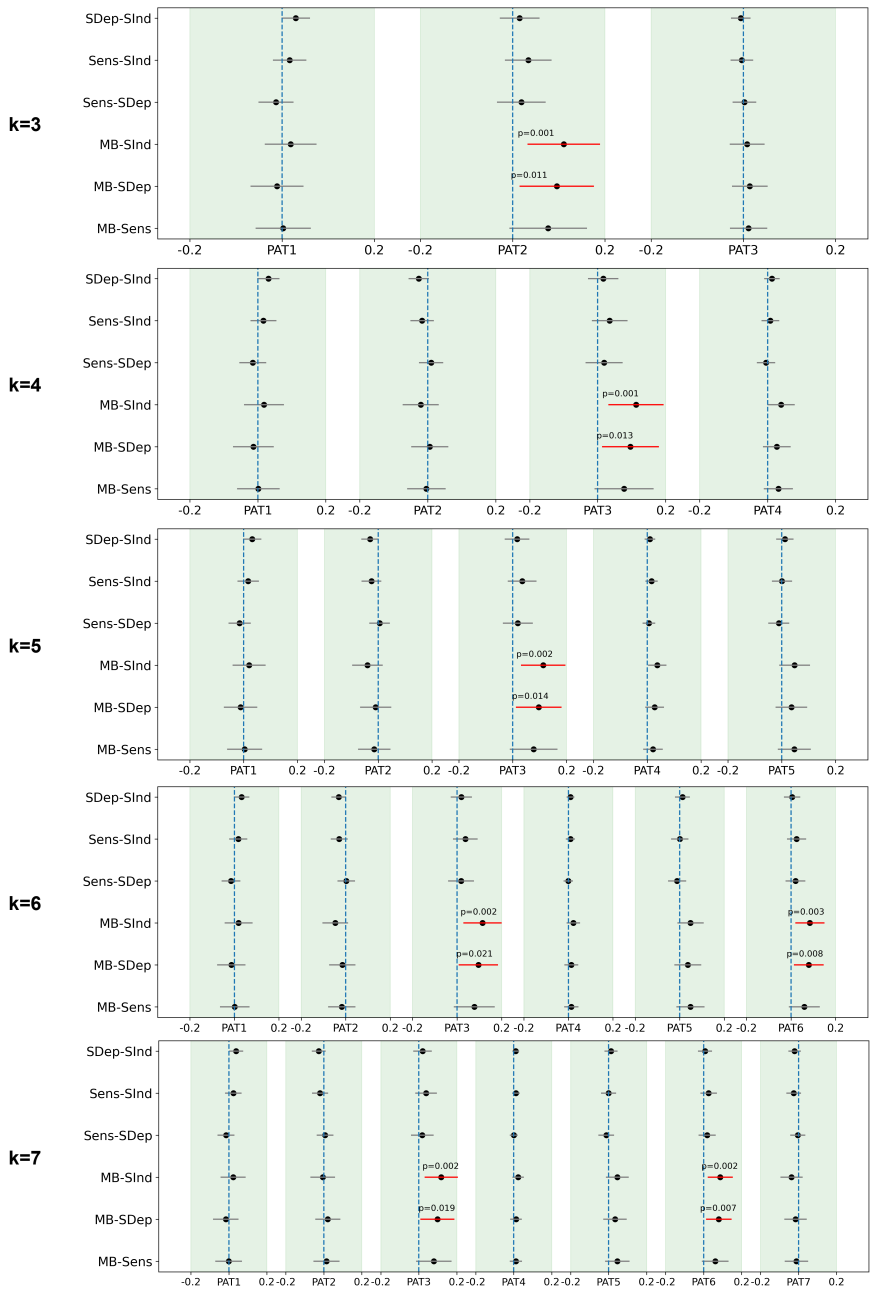

Fig. S16. The overall positive coherence Pattern 3 shows the highest similarity to connectivity patterns of the Mind Blanking (MB) reports even at high number of clusters (lag = 0). Considering a mental state analysis window with lag=0 (i.e., 5 pre-probe scans), a generalized linear mixed model analysis for each pattern separately shows the highest similarity of the overall positive coherence Pattern 3 to the connectivity matrices related to the MB reports. The results are replicated with different number of clusters (k=3-7). For each cluster number k, a model fit is considered significant if its p-value is lower than $\frac{0.05}{k}$ to correct for multiple tests. In case of significant fit, a post-hoc Tukey test was performed for contrast analysis between different mental state pairs. Notes: SDep = Stimulus Dependent Thought, SInd = Stimulus Independent Thought, Sens: Sensory Perception.

Global Signal Included. Mental state window lag: 1

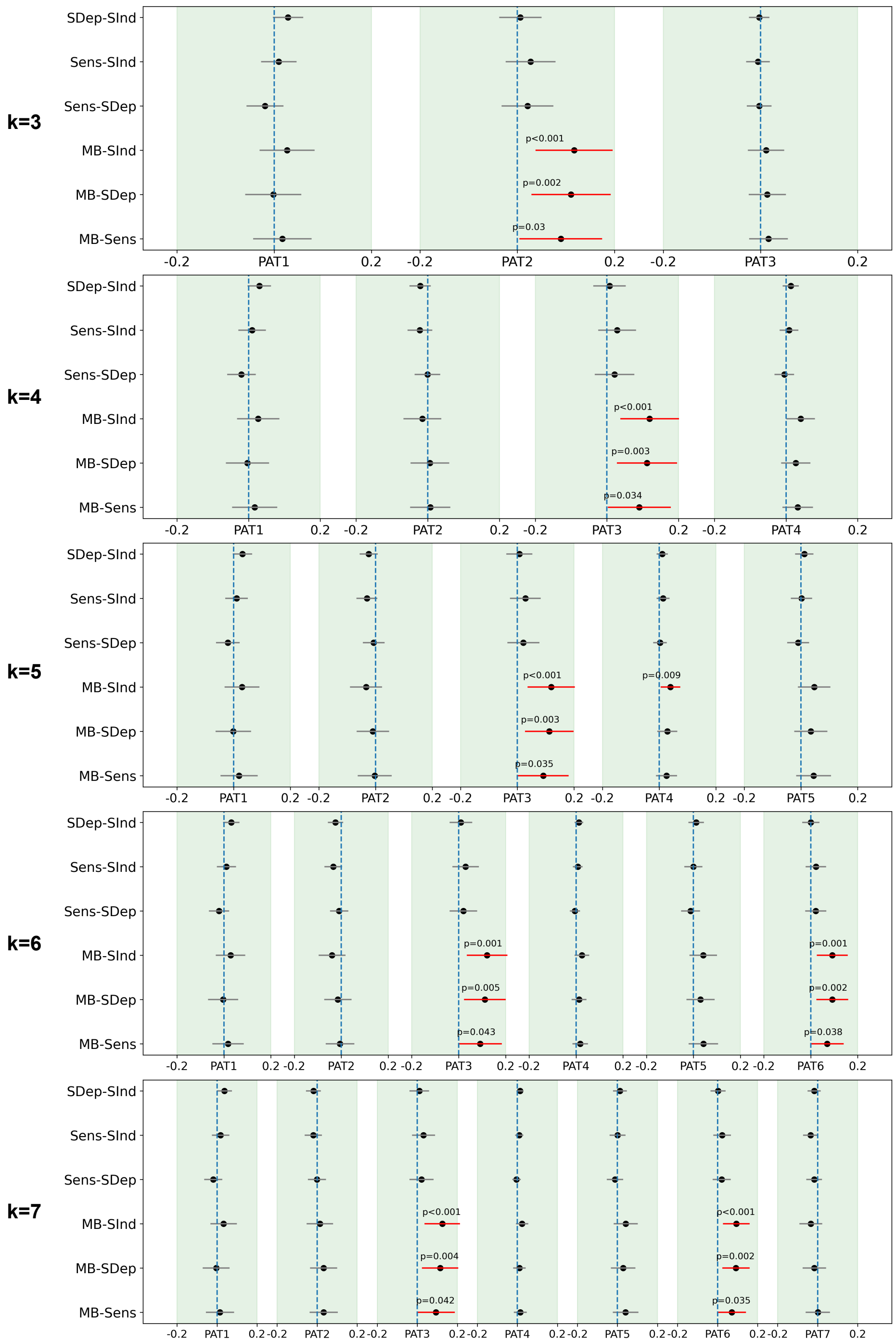

Fig. S17. The overall positive coherence Pattern 3 shows the highest similarity to connectivity patterns of the Mind Blanking (MB) reports even at high number of clusters (lag = 1). Considering a mental state analysis window with lag=1 (i.e., 4 pre-probe and one post-probe scans), a generalized linear mixed model analysis for each pattern separately shows the highest similarity of the overall positive coherence Pattern 3 to the connectivity matrices related to the MB reports. The results are replicated with different number of clusters (k=3-7). For each cluster number k, a model fit is considered significant if its p-value is lower than $\frac{0.05}{k}$ to correct for multiple tests. In case of significant fit, a post-hoc Tukey test was performed for contrast analysis between different mental state pairs. Notes: SDep = Stimulus Dependent Thought, SInd = Stimulus Independent Thought, Sens: Sensory Perception.

Global Signal Included. Mental state window lag: 2

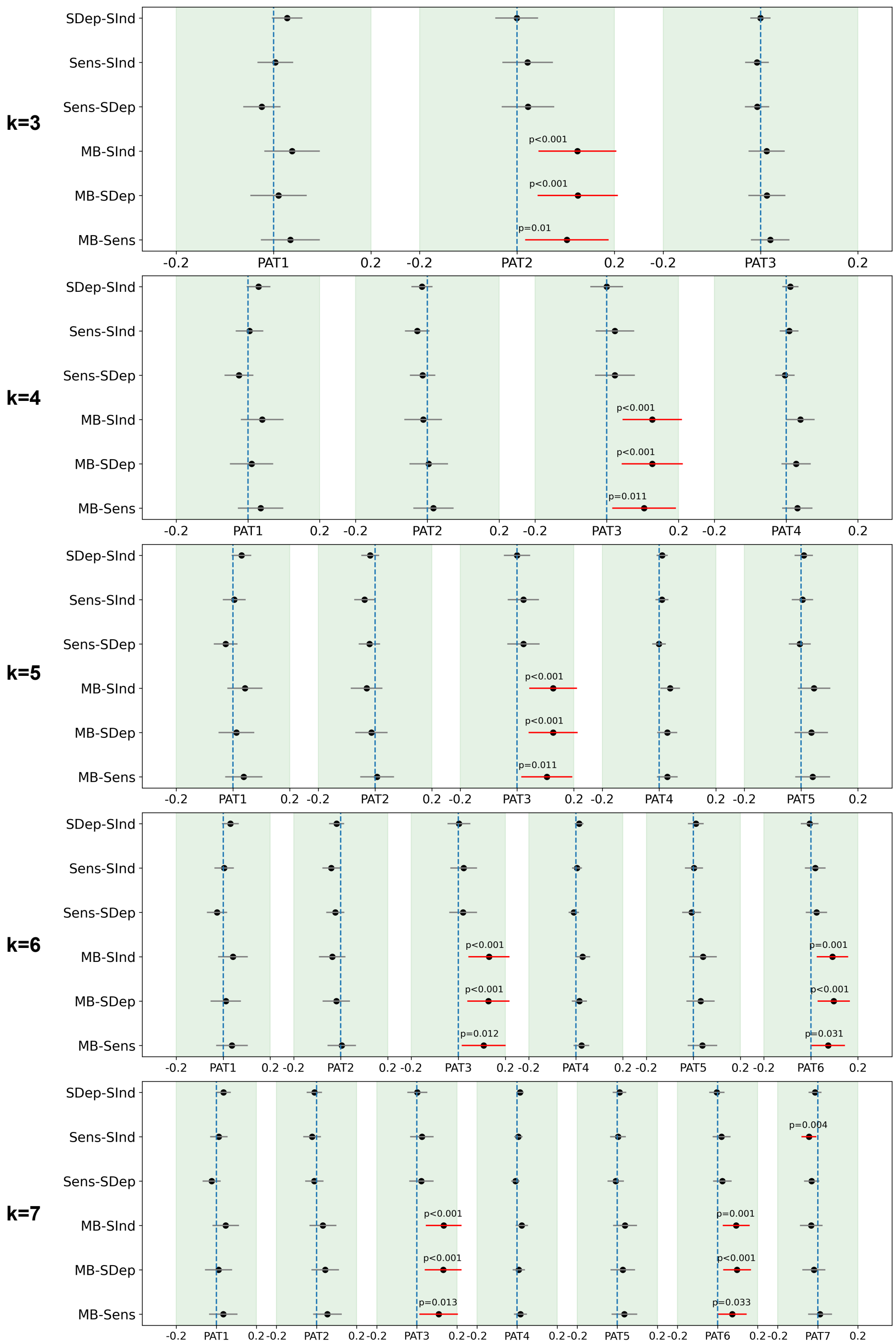

Fig. S18. The overall positive coherence Pattern 3 shows the highest similarity to connectivity patterns of the Mind Blanking (MB) reports even at high number of clusters (lag = 2). Considering a mental state analysis window with lag=2 (i.e., 3 pre-probe and 2 post-probe scans), a generalized linear mixed model analysis for each pattern separately shows the highest similarity of the overall positive coherence Pattern 3 to the connectivity matrices related to the MB reports. The results are replicated with different number of clusters (k=3-7). For each cluster number k, a model fit is considered significant if its p-value is lower than $\frac{0.05}{k}$ to correct for multiple tests. In case of significant fit, a post-hoc Tukey test was performed for contrast analysis between different mental state pairs. Notes: SDep = Stimulus Dependent Thought, SInd = Stimulus Independent Thought, Sens: Sensory Perception.

Global Signal Included. Mental state window lag: 3

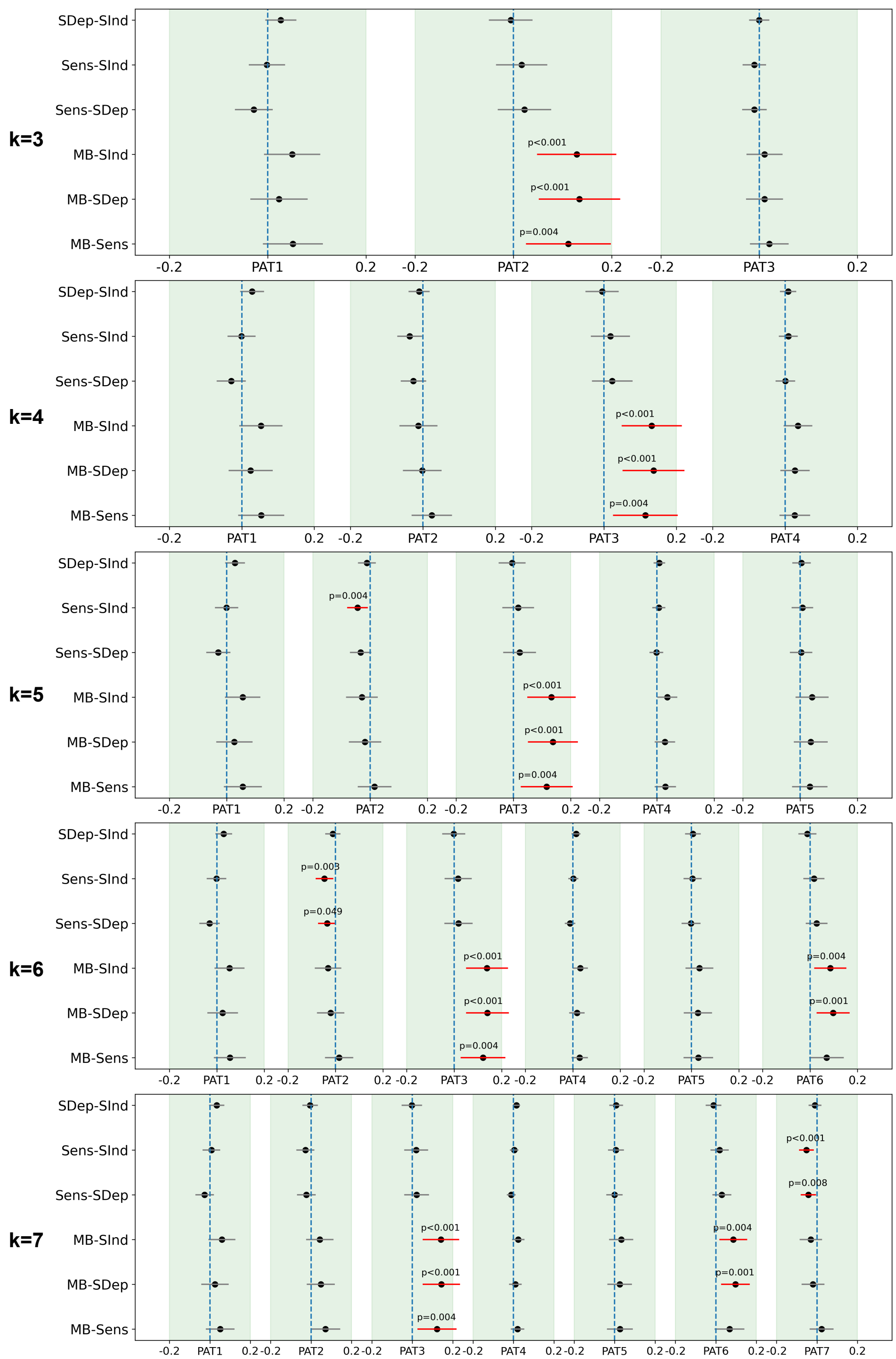

Fig. S19. The overall positive coherence Pattern 3 shows the highest similarity to connectivity patterns of the Mind Blanking (MB) reports even at high number of clusters (lag = 3). Considering a mental state analysis window with lag=3 (i.e., 2 pre-probe and 3 post-probe scans), a generalized linear mixed model analysis for each pattern separately shows the highest similarity of the overall positive coherence Pattern 3 to the connectivity matrices related to the MB reports. The results are replicated with different number of clusters (k=3-7). For each cluster number k, a model fit is considered significant if its p-value is lower than $\frac{0.05}{k}$ to correct for multiple tests. In case of significant fit, a post-hoc Tukey test was performed for contrast analysis between different mental state pairs. Notes: SDep = Stimulus Dependent Thought, SInd = Stimulus Independent Thought, Sens: Sensory Perception.

Global Signal Subtraction. Mental state window lag: 0

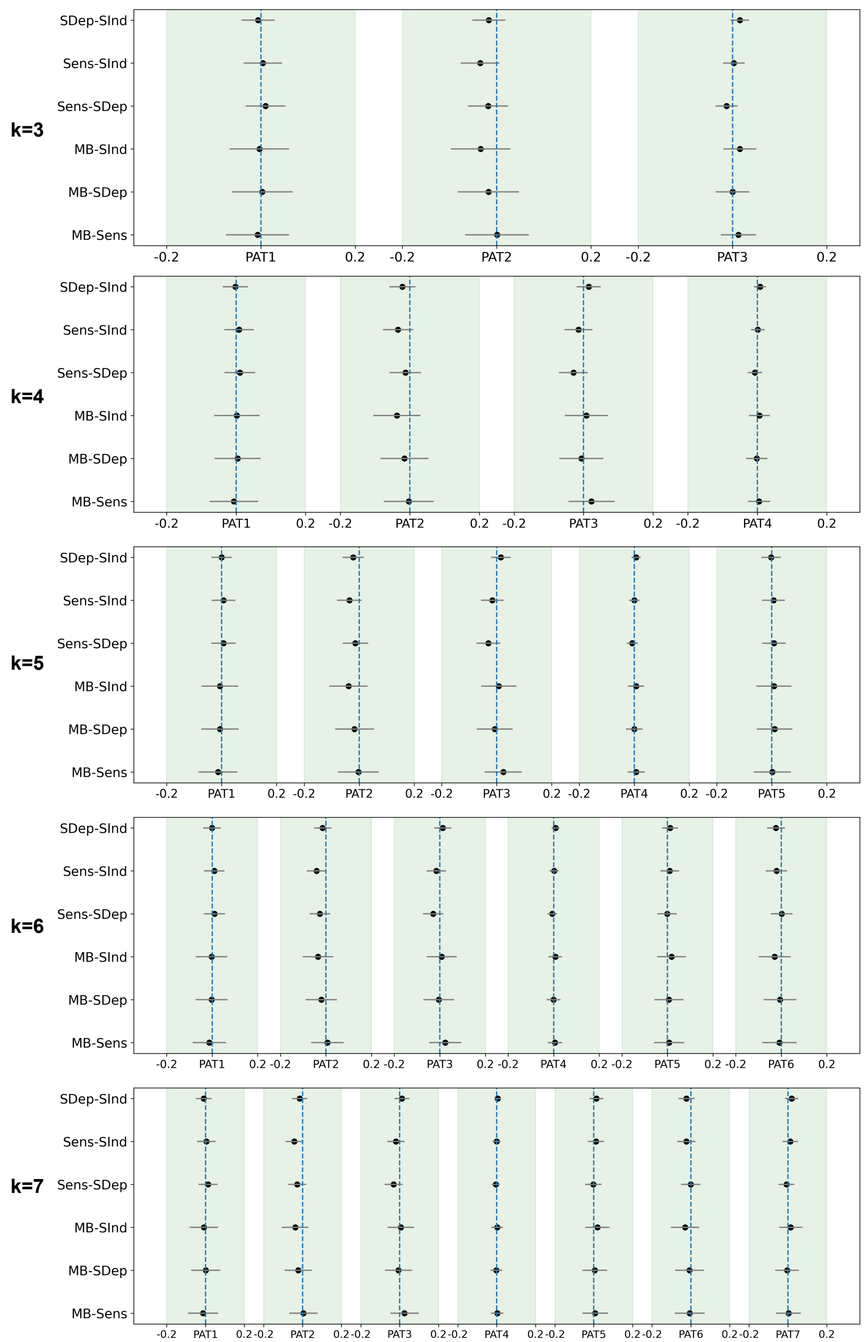

Fig. S20. After global signal subtraction, none of the functional connectivity patterns can be meaningfully assigned to MB (lag = 0). Considering a mental state analysis window with lag=0 (i.e., 5 pre-probe scans), a generalized linear mixed model analysis for each pattern separately could not result in significant similarity of any pattern to the connectivity matrices related to the MB reports. The results are replicated with different number of clusters (k=3-7). For each cluster number k, a model fit is considered significant if its p-value is lower than $\frac{0.05}{k}$ to correct for multiple tests. In case of significant fit, a post-hoc Tukey test was performed for contrast analysis between different mental state pairs.

Global Signal Subtraction. Mental state window lag: 1

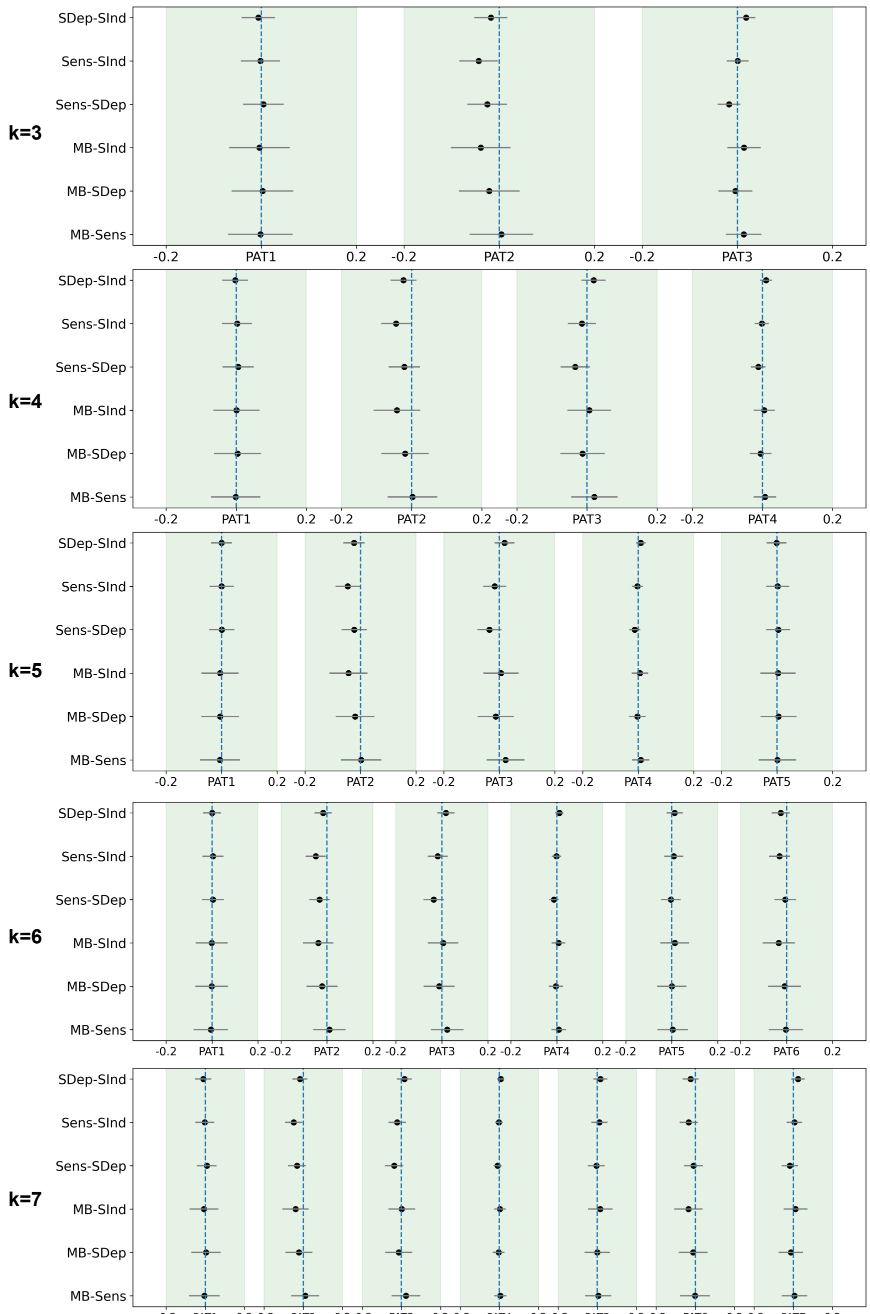

Fig. S21. After global signal subtraction, none of the functional connectivity patterns can be meaningfully assigned to MB (lag = 1). Considering a mental state analysis window with lag=1 (i.e., 4 pre-probe and one post-probe scans), a generalized linear mixed model analysis for each pattern separately could not result in significant similarity of any pattern to the connectivity matrices related to the MB reports. The results are replicated with different number of clusters (k=3-7). For each cluster number k, a model fit is considered significant if its p-value is lower than $\frac{0.05}{k}$ to correct for multiple tests. In case of significant fit, a post-hoc Tukey test was performed for contrast analysis between different mental state pairs.

Global Signal Subtraction. Mental state window lag: 2

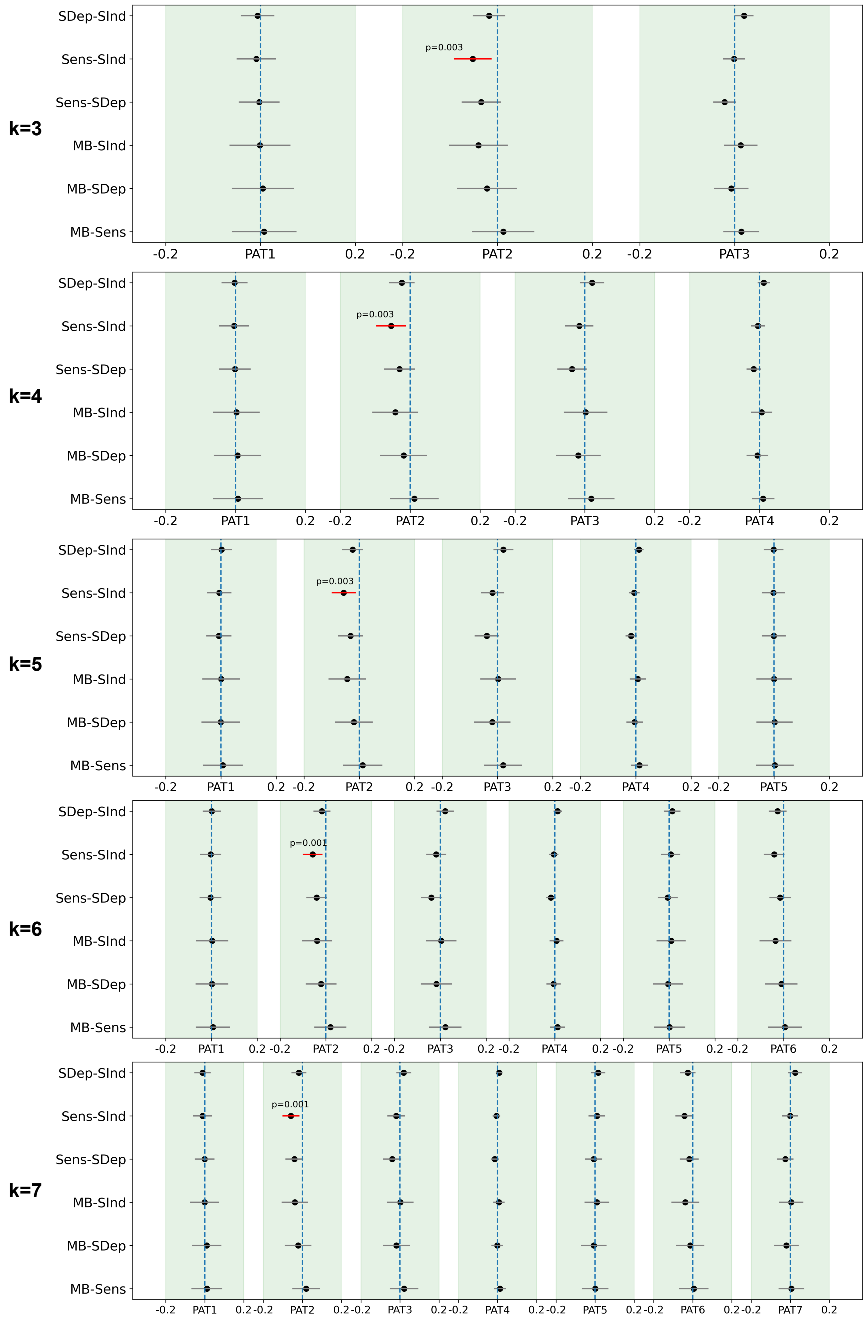

Fig. S22. After global signal subtraction, none of the functional connectivity patterns can be meaningfully assigned to MB (lag = 2). Considering a mental state analysis window with lag=2 (i.e., 3 pre-probe and 2 post-probe scans), a generalized linear mixed model analysis for each pattern separately could not result in significant similarity of any pattern to the connectivity matrices related to the MB reports. The results are replicated with different number of clusters (k=3-7). For each cluster number k, a model fit is considered significant if its p-value is lower than $\frac{0.05}{k}$ to correct for multiple tests. In case of significant fit, a post-hoc Tukey test was performed for contrast analysis between different mental state pairs.

Global Signal Subtraction. Mental state window lag: 3

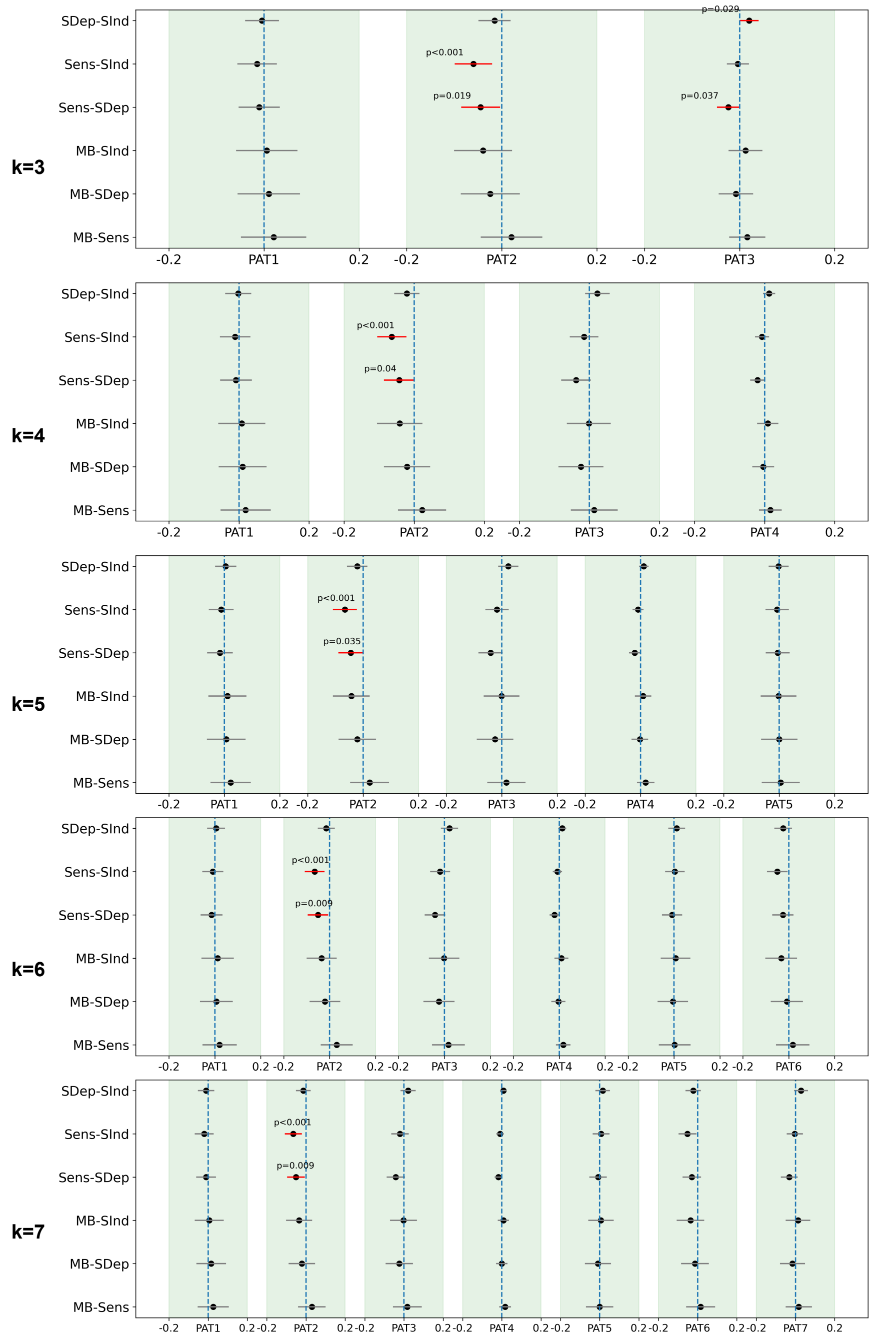

Fig. S23. After global signal subtraction, none of the functional connectivity patterns can be meaningfully assigned to MB (lag = 3). Considering a mental state analysis window with lag=3 (i.e., 2 pre-probe and 3 post-probe scans), a generalized linear mixed model analysis for each pattern separately could not result in significant similarity of any pattern to the connectivity matrices related to the MB reports. The results are replicated with different number of clusters (k=3-7). For each cluster number k, a model fit is considered significant if its p-value is lower than $\frac{0.05}{k}$ to correct for multiple tests. In case of significant fit, a post-hoc Tukey test was performed for contrast analysis between different mental state pairs.

Global Signal Regression. **Mental state window lag: 0**

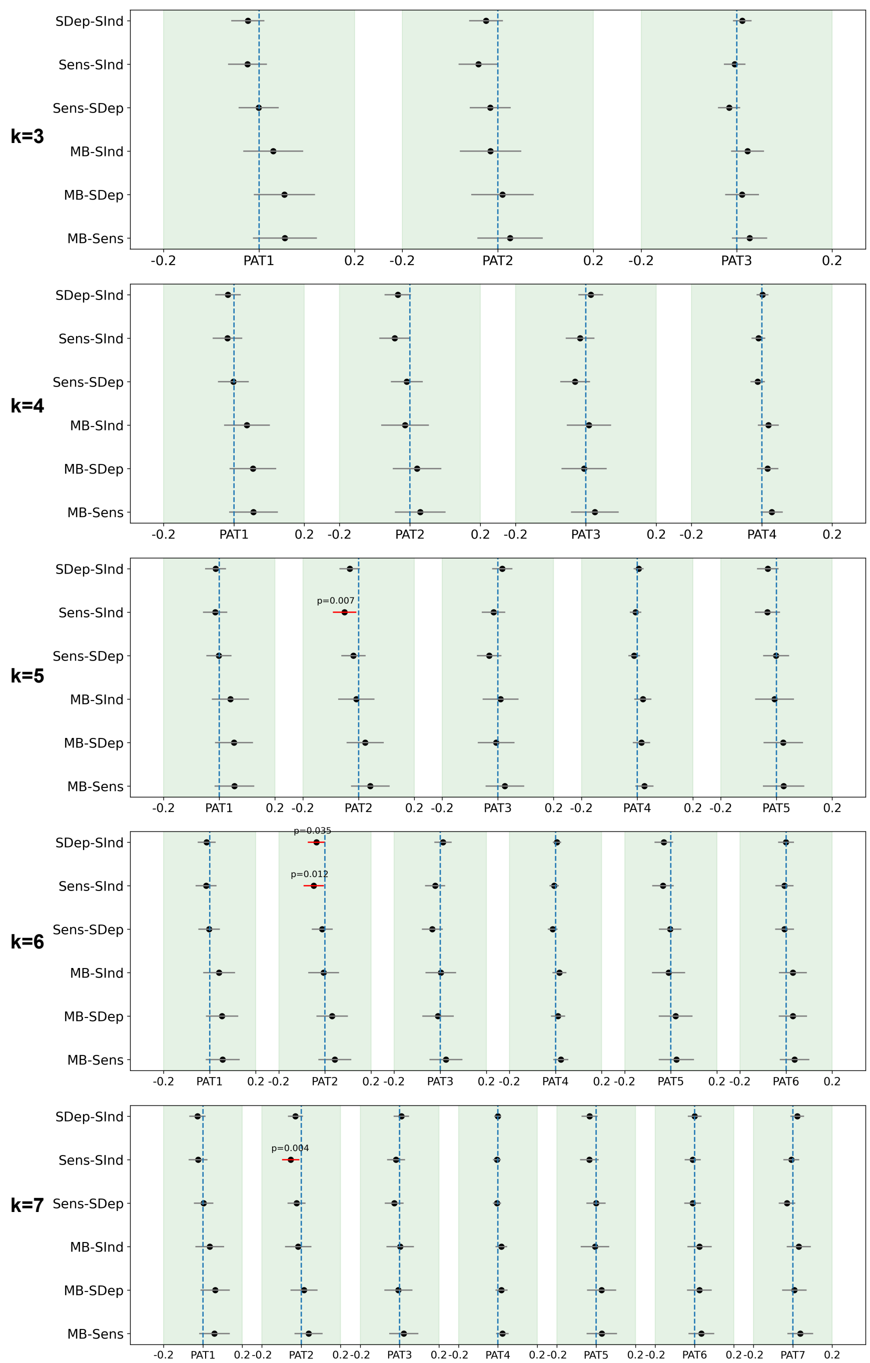

Fig. S24. After global signal regression, none of the functional connectivity patterns can be meaningfully assigned to MB (lag = 0). Considering a mental state analysis window with lag=0 (i.e., 5 pre-probe scans), a generalized linear mixed model analysis for each pattern separately could not result in significant similarity of any pattern to the connectivity matrices related to the MB reports. The results are replicated with different number of clusters (k=3-7). For each cluster number k, a model fit is considered significant if its p-value is lower than $\frac{0.05}{k}$ to correct for multiple tests. In case of significant fit, a post-hoc Tukey test was performed for contrast analysis between different mental state pairs.

Global Signal Regression. Mental state window lag: 1

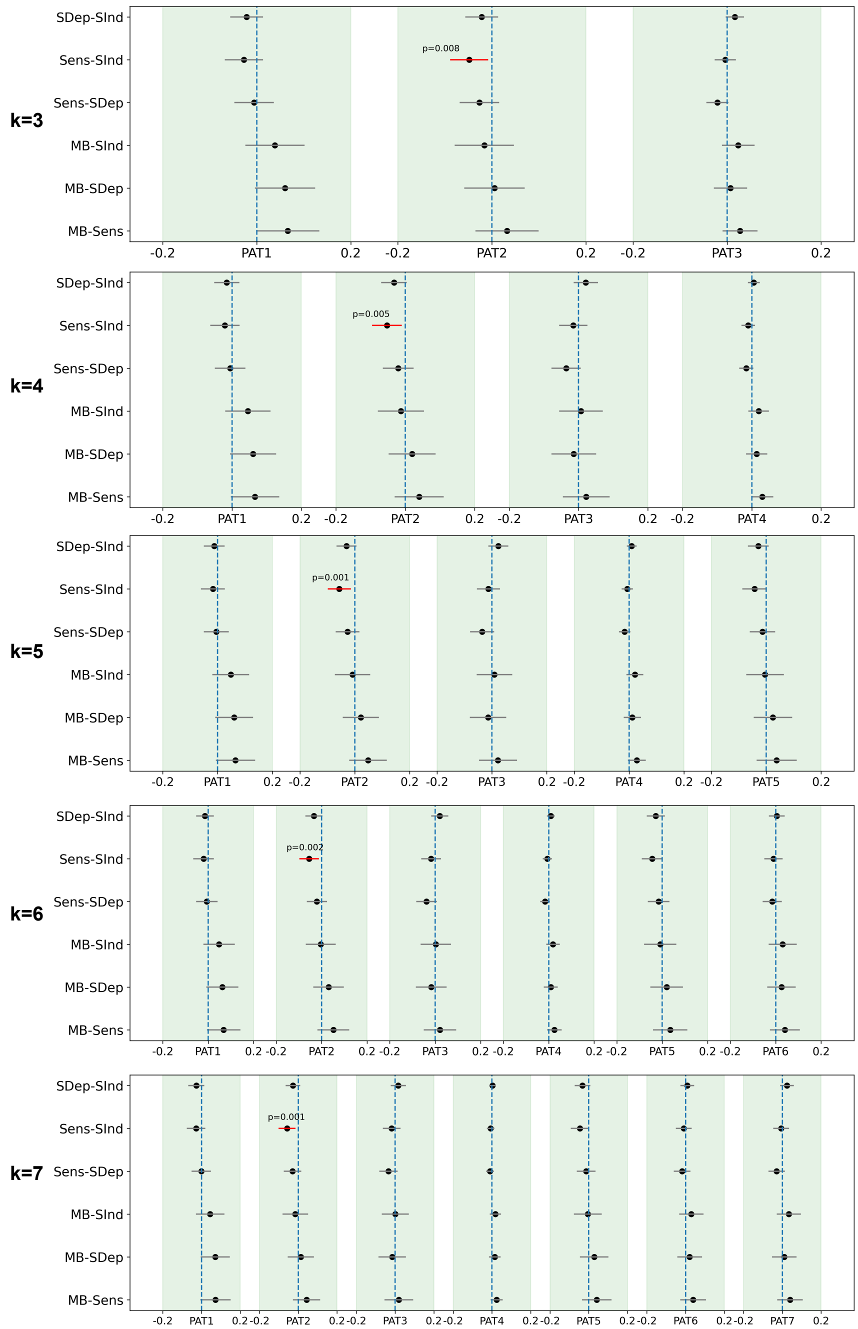

Fig. S25. After global signal regression, none of the functional connectivity patterns can be meaningfully assigned to MB (lag = 1). Considering a mental state analysis window with lag=1 (i.e., 4 pre-probe and one post-probe scans), a generalized linear mixed model analysis for each pattern separately could not result in significant similarity of any pattern to the connectivity matrices related to the MB reports. The results are replicated with different number of clusters (k=3-7). For each cluster number k, a model fit is considered significant if its p-value is lower than $\frac{0.05}{k}$ to correct for multiple tests. In case of significant fit, a post-hoc Tukey test was performed for contrast analysis between different mental state pairs.

Global Signal Regression. Mental state window lag: 2

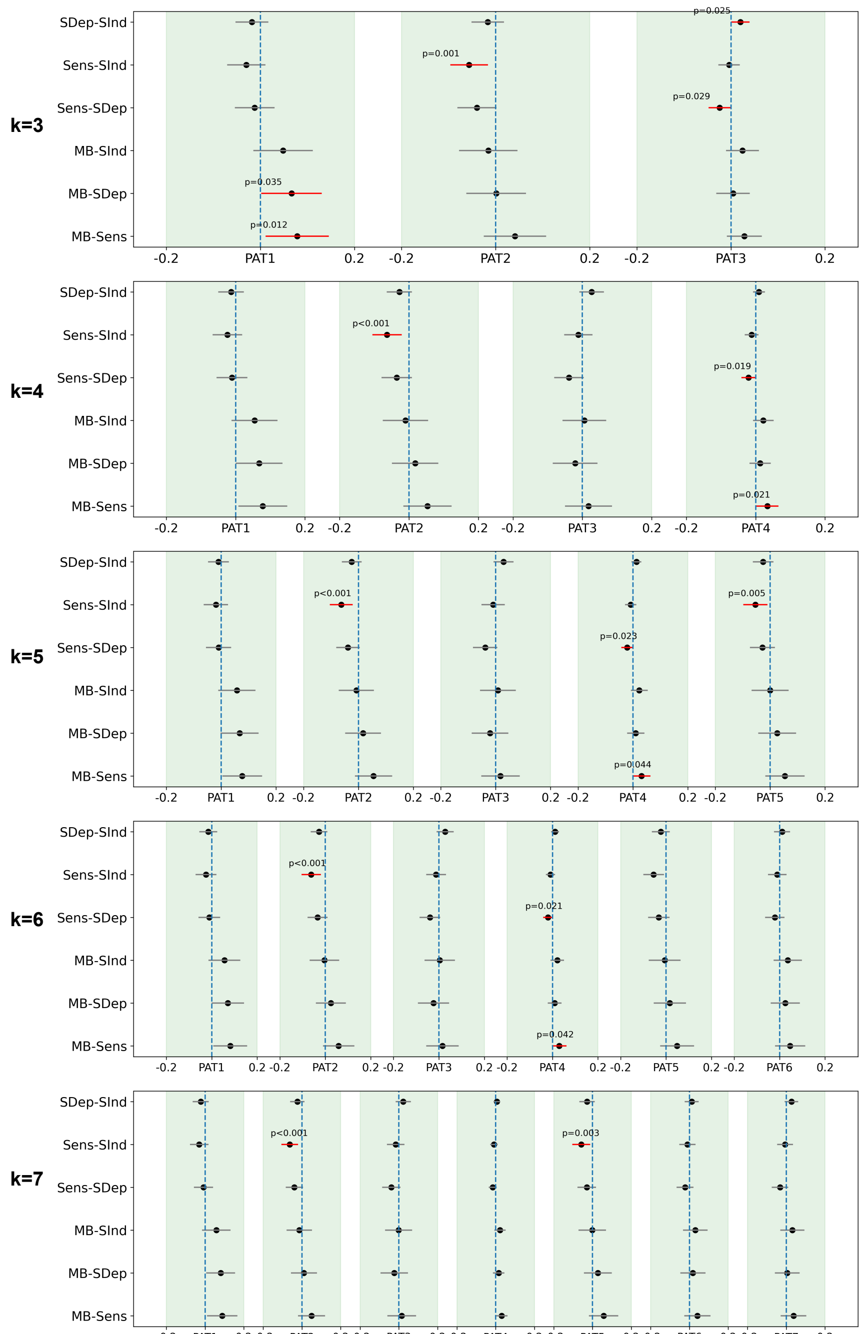

Fig. S26. After global signal regression, none of the functional connectivity patterns can be meaningfully assigned to MB (lag = 2). Considering a mental state analysis window with lag=2 (i.e., 3 pre-probe and 2 post-probe scans), a generalized linear mixed model analysis for each pattern separately could not result in significant similarity of any pattern to the connectivity matrices related to the MB reports. The results are replicated with different number of clusters (k=3-7). For each cluster number k, a model fit is considered significant if its p-value is lower than $\frac{0.05}{k}$ to correct for multiple tests. In case of significant fit, a post-hoc Tukey test was performed for contrast analysis between different mental state pairs.

Global Signal Regression. Mental state window lag: 3

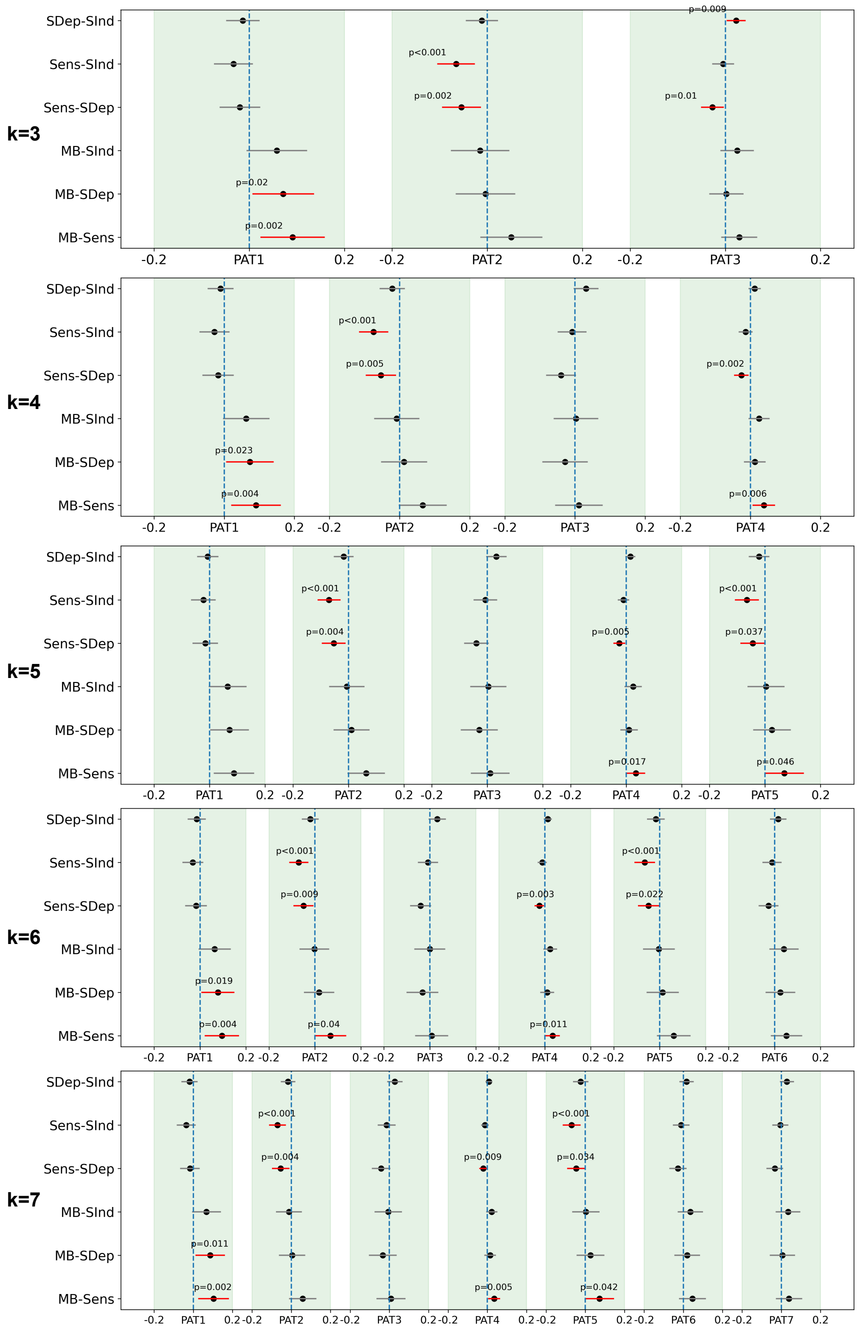

Fig. S27. After global signal regression, none of the functional connectivity patterns can be meaningfully assigned to MB (lag = 3). Considering a mental state analysis window with lag=3 (i.e., 2 pre-probe and 3 post-probe scans), a generalized linear mixed model analysis for each pattern separately could not result in significant similarity of any pattern to the connectivity matrices related to the MB reports. The results are replicated with different number of clusters (k=3-7). For each cluster number k, a model fit is considered significant if its p-value is lower than $\frac{0.05}{k}$ to correct for multiple tests. In case of significant fit, a post-hoc Tukey test was performed for contrast analysis between different mental state pairs.