features in signal space. Then, we consider the problem of demixing the contribution of correlated sources within each system. Such problem cannot be solved by sPCA since its assumptions do not hold in this case. Therefore, we introduce the Minimum Overlap Component Analysis, employing a pure spatial criterion to unmix pairs of correlates sources.The proposed methods are extensively tested in simulations. A validation of the method with real EEG data has been also performed, which reveals interaction patterns consistent with the previously reported generators of α and μ rhythms. In particular, bilateral M1-PM cortex interaction was found for μ and occipito-parietal interaction for α.

8-4: MEG Beamformer Functional Imaging of Frequency Differences

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The scalar linearly constrained minimum-variance beamformer is widely used in MEG to image event-related activity within specified frequency bands - comparing source strength for time segments, relative to events. This approach has limited value in interpreting the cortical sources from MEG studies of sleep, for which no clear pattern emerges when comparing alpha band power for awake, sleep transition, and sleep stages 1 and 2. Furthermore, no pattern emerges when parsing the raw MEG signal into segments containing exclusively either alpha or sigma (sleep spindle) activity. When source waveforms for sites having large alpha or sigma are examined by beamformer, we observe that both kinds of activity are present - implying that there are no exclusive generators of either alpha or sigma spindles. Hence, a beamformer derived functional image relating these rhythms to sleep is unrevealing. In order to visualize the changes occurring in alpha and sigma bands during the sleep onset transition, we have developed a new functional imaging modality for comparing the relative power of two frequency bands. For the sleep study, we parsed the MEG data into 60-second segments, and compared alpha (8 to 11 Hz) and sigma (11 to 15 Hz) frequencies. For each time segment, the beamformer estimated the source power within both frequency bands. Voxel values were computed as the difference in source power between sigma and alpha frequencies, divided by the beamformer noise. Repeating this for all voxels generates a functional image. The resulting images reveal a source distribution with a unique pattern for each frequency during the transition from wake to sleep stages 1 and 2. This functional imaging method can be applied to MEG studies where changes in frequency are observed. Research supported by NIH/NINDS Grant No. R01-NS30914.

8-5: Dynamical indicators of chaos for fetal magnetocardiographic signals

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Fetal magnetocardiography (fMCG) has been used to detect fetal cardiac activity at different gestational ages during the second half of pregnancy. Recently the independent component analysis (ICA) has been applied to reconstruct reliable fetal cardiac signals (Comani et al. 2004a and 2004b). An entropy-based method using some entropy estimators (approximated and sample entropies) was applied for the automated categorization of fetal and maternal components separated with ICA from fMCG (Comani et al. 2007).

To achieve a simple theoretical model describing maternal and fetal cardiac activity and their possible interdependency, the dynamical properties of the original signals and of their components separated with ICA have been investigated. We determined the properties of the attractors in the phase space calculating the embedding dimensions. We also calculated the Lyapunov exponents (LE), which, measuring the rate of convergence or divergence of nearby trajectories of a dynamical system in the phase space, can be dynamical indicators of chaos. The distribution of the LE can give informations on the possible deterministic nature of the system and on the number of degrees of freedom involved in the collected experimental data (Stefanovska and Bracic 1999). Analysing the fMCG signals as a whole and its two subsystems (separated fetal and maternal signals) one can highlight correlations between them, providing a first step toward a description of the fMCG signals in terms of a set of differential equations for coupled oscillators.

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8-6: Feature Extraction in Brain Computer Interface using Sample Entropy

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Brain computer interface (BCI) is a device that could provide user a communication system between the brain and the external devices, usually using electroencephalography (EEG) which reflects human intentions such as imagining moving hand or multiplication task. The feature extraction of EEG signals plays a crucial role for classifying these spontaneous mental activities. Five subjects participated in the BCI experiment which contains two mental including left hand imagery movement and right hand imagery movement. In this paper, after preprocessing, a nonlinear dynamic method called Sample Entropy (SampEn) was applied to extract the feature of EEG signals got from two mental tasks, thereafter a Support vector machine (SVM) classifier was applied to classify the feature extracted. After that, the performance of the SampEn-based features was compared with that of autoregressive (AR) model-based features.The results show that it can be used an effective method for classifying different mental tasks to extract the feature by sample entropy, and it can promote the accuracy of classification. Due to it's lacking in sensitivity to power-line interference and ocular artifact, the sample entropy has its high practical value in the field of brain computer interface.

8-7: A Recursive MMSE Estimator for High-Resolution MEG Imaging

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In this paper a new technique is developed for MEG imaging that is robust to the intrinsically ill-posed nature of the image reconstruction problem and to temporal correlations between spatially-distributed sources, and does not require a priori constraints. The new technique, denoted as Source AFFine Image REconstruction (SAFFIRE) is based on a recursive implementation of Minimum Mean-Square Error (MMSE) estimation. The nature of the MEG imaging problem yields a forward model that is highly ill-conditioned thus eliciting potentially severe bias error. The SAFFIRE algorithm operates in an affine domain in which the leadfield vectors are all scaled to unit length so as to partially compensate for biasing effects. The initialization for this recursive algorithm, which is based on the matched filter bank concept, is far less ambitious than minimum-norm-based solutions such as FOCUSS thereby providing additional robustness to bias. Furthermore, the MMSE structure of the SAFFIRE algorithm provides a natural mechanism with which to incorporate both noise and ambient electromagnetic brain activity into the estimation process. Finally, unlike approaches such as LCMV beamforming, SAFFIRE does not require computation of a spatial covariance matrix from ensemble time samples. As a result, SAFFIRE does not suffer from the effects of temporal correlation of spatially distributed sources and can achieve high temporal resolution. Alternatively, some temporal resolution may be traded for SNR gain by non-coherently combining the spatial source estimates within each recursion. Upon convergence, the source estimates are inverse affine transformed to obtain the true source scaling according to the leadfield forward model.

8-8: Reconstruction of functional brain networks by Wasserstein distances in a listening task

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Motivation: The reconstruction of functional brain networks is a necessary first step in the analysis of neural processes by mathematical models. In the usual approach, synchronization measures are interpreted as functional distances and graph-theoretic methods are then applied to the derived networks. We have investigated an alternative approach based on reconstructing the dynamical behavior of neural populations from MEG time series that allows an independent evaluation of network structure.

Data: Whole head MEG recordings of eight subjects under a periodical listening task. An auditory stimulus at a rate of 1.2 Hz was presented (data courtesy A. Daffertshofer and S. Houweling).

Methods: From the MEG time series of each sensor we reconstructed the long-term dynamics by delay vector reconstruction. Interpreting the reconstructed attractors as invariant probability measures, we have calculated Wasserstein distances between each pair of sensors to quantify the differences in dynamical behavior. These distances, being defined as the solutions of an optimal transportation problem, are non-parametric and robust, and naturally arise in a number of applications. We have visualized these distances by canonical coordinate analysis in 2D space and the network topology has been reconstructed by (i) the usual threshold method and (ii) a new flow decomposition technique incorporating the sensors' geodesic distances.

Results and Discussion: Network reconstruction by Wasserstein distances is an interesting independent method of network identification. We discuss its properties and merits, and compare our findings with results obtained in the literature by ARIMA modeling and partial cross correlations of residuals.

8-9: Phase and Topography of Coherently Oscillating Sources

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Objective: In order to demonstrate cortical motor control a pinch grip task is used, requiring subjects to execute an isometric muscular contraction. In this task electromyographic activity (EMG) recorded from finger muscles oscillates coherently with brain activity recorded over primary motor cortex using electro- (EEG) or magnetoencephalography (MEG)[1]. Looking at the derivative of the phase with respect to frequency the time delay between brain signals and EMG is inferred. Phase differences between EMG and the brain signal as well as the topography of the coherent activity are usually estimated for individual frequencies. In order to improve the estimates of topography, phase shifts and time lags a new approach is presented. Methods: In this method the estimate of topography and phase is based on an extended frequency range. The complex coherence spectrum for different channels c and frequencies f, B=(bcf), is regarded as linear combination of the topographies of different sources s, L=(lcs) that are weighted by a complex matrix W=(wsf) describing phase shifts and contributions of different sources. Decomposing the coherence spectrum B=LW using a least-square fit approach, phase angles, topographies and weights are obtained. Results: Simulations and the analysis of experimental data are presented, demonstrating the applicability of the method. Conclusion: The method allows for robust estimates of source topographies of cortico-motor coherence as well as phase information. Moreover, the method is also useful for the study of cortico-cortical coherence. A slightly modified approach can be even used for the removal of powerline artifacts taking into account the specific topography of the artifact. References & Acknowledgments: [1] Braun et al. 2007. Supported by BMBF Bernstein-Project 01GQ0761 and DFG (SFB 550/C6).

8-10: Magnetomyographic Recording And Identification Of Uterine Contractions Using Hilbert-Wavelet Transform

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Objective: To detect uterine contractions, measured with non-invasive magnetomyogram (MMG), using Hilbert-Wavelet transform (HWT).
Materials and Methods: Using a 151-SQUID sensor array we recorded uterine MMG (sampled at 312.5 Hz) from five pregnant women in the gestation age between 36 and 38 weeks. Each recording lasted for 20 minutes. In order to effectively detect the low frequency contractions, the data was down sampled to 25 Hz. These signals were digitally band-pass filtered between 0.1-1 Hz using 8th order zero-phase Butterworth filter. We then partitioned the signals in 30 sec disjoint windows and decomposed them into nine levels using second order Daubechies wavelet. Each level of decomposition would result in a set of approximate coefficients and detail coefficients (dc). In each decomposition level the signals were reconstructed using the dc at that particular level. We further applied the Hilbert transform (HT) to the reconstructed signals and computed the Hilbert amplitude (HA). The power of the signals in each window was quantified by integrating HA which were then partitioned using a novel clustering technique - affinity propagation. These results were compared to the contractions perceived by the mother that were recorded along with the MMG measurement.
Results: Significant power changes were observed in two frequency bands: 0.1-0.2Hz and 0.2-0.4Hz. Qualitatively, there is a good agreement between the contractions detected by this approach and the contractions perceived by the mothers.
Conclusions: Uterine MMG technique provides a non-invasive approach to study the spatio-temporal distribution of uterine contractions. Future studies including the frequency of the contractions would help to predict the nature of the labor.

8-11: Multivariate statistical analysis applied to MEG time series

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We propose a new method to detect task-related brain activity from MEG measurements based on Multivariate Analysis of Variance (MANOVA) modeling. Minimum-norm inverse imaging, combined with Morlet wavelet time-frequency decomposition, provides power observations over several time and frequency bands for each cortical source. We form vector observations by concatenating the power in each frequency band, and fit them in separate MANOVA models for each time band and cortical location. Experimental conditions are used as predictor variables in the design matrix of the