Task-Modulated Cortical Representations of Natural Sound Source Categories

In everyday sound environments, we recognize sound sources and events by attending to relevant aspects of an acoustic input. Evidence about the cortical mechanisms involved in extracting relevant category information from natural sounds is, however, limited to speech. Here, we used functional MRI to measure cortical response patterns while human listeners categorized real-world sounds created by objects of different solid materials (glass, metal, wood) manipulated by different sound-producing actions (striking, rattling, dropping). In different sessions, subjects had to identify either material or action categories in the same sound stimuli. The sound-producing action and the material of the sound source could be decoded from multivoxel activity patterns in auditory cortex, including Heschl’s gyrus and planum temporale. Importantly, decoding success depended on task relevance and category discriminability. Action categories were more accurately decoded in auditory cortex when subjects identified action information. Conversely, the material of the same sound sources was decoded with higher accuracy in the inferior frontal cortex during material identification. Representational similarity analyses indicated that both early and higher-order auditory cortex selectively enhanced spectrotemporal features relevant to the target category. Together, the results indicate a cortical selection mechanism that favors task-relevant information in the processing of nonvocal sound categories.
How to target inter-regional phase synchronization with dual-site Transcranial Alternating Current Stimulation

Large-scale synchronization of neural oscillations is a key mechanism for functional information exchange among brain areas. Dual-site Transcranial Alternating Current Stimulation (ds-TACS) has been recently introduced as non-invasive technique to manipulate the temporal phase relationship of local oscillations in two connected cortical areas. While the frequency of ds-TACS is matched, the phase of stimulation is either identical (in-phase stimulation) or opposite (anti-phase stimulation) in the two cortical target areas. In-phase stimulation is thought to synchronize the endogenous oscillations and hereby to improve behavioral performance. Conversely, anti-phase stimulation is thought to desynchronize neural oscillations in the two areas, which is expected to decrease performance. Critically, in- and anti-phase ds-TACS should only differ with respect to temporal phase, while all other stimulation parameters such as focality and stimulation intensity should be matched to enable an unambiguous interpretation of the behavioral effects. Using electric field simulations
based on a realistic head geometry, we tested how well this goal has been met in studies, which have employed ds-TACS up to now. Separating the induced electrical fields in their spatial and temporal components, we investigated how the chosen electrode montages determined the spatial field distribution and the generation of phase variations in the injected electric fields. Considering the basic physical mechanisms, we derived recommendations for an optimized stimulation montage. The latter allows for a principled design of in- and anti-phase ds-TACS conditions with matched spatial distributions of the electric field. This knowledge will help cognitive neuroscientists to design optimal ds-TACS configurations, which are suited to probe unambiguously the causal contribution of phase coupling to specific cognitive processes in the human brain.
Introduction Traumatic brain injury (TBI) is considered one of the most pervasive causes of disability in people under the age of 45. TBI often results in disorders of consciousness, and clinical assessment of the state of consciousness in these patients is challenging due to the lack of behavioural responsiveness. Functional neuroimaging offers a means to assess these patients without the need for behavioural signs, indicating that brain connectivity plays a major role in consciousness emergence and maintenance. However, little is known regarding how changes in connectivity during recovery from TBI accompany changes in the level of consciousness. Here, we aim to combine cutting-edge neuroimaging techniques to follow changes in brain connectivity in patients recovering from severe TBI. Methods and analysis A multimodal, longitudinal assessment of 30 patients in the subacute stage after severe TBI will be made comprising an MRI session combined with electroencephalography (EEG), a positron emission tomography session and a transcranial magnetic stimulation (TMS) combined with EEG (TMS/EEG) session. A group of 20 healthy participants will be included for comparison. Four sessions for patients and two sessions for healthy participants will be planned. Data analysis techniques will focus on whole-brain, both data-driven and hypothesis-driven, connectivity measures that will be specific to the imaging modality. Ethics and dissemination The project has received ethical approval by the local ethics committee of the Capital Region of Denmark and by the Danish Data Protection. Results will be published as original research articles in peer-reviewed journals and disseminated in international conferences. None of the measurements will have any direct clinical impact on the patients included in the study but may benefit future patients through a better understanding of the mechanisms underlying the recovery process after TBI. Trial registration number: NCT02424656; Pre-results.
Infinite von Mises-Fisher Mixture Modeling of Whole Brain fMRI Data
Cluster analysis of functional magnetic resonance imaging (fMRI) data is often performed using gaussian mixture models, but when the time series are standardized such that the data reside on a hypersphere, this modeling assumption is questionable. The consequences of ignoring the underlying spherical manifold are rarely analyzed, in part due to the computational challenges imposed by directional statistics. In this letter, we discuss a Bayesian von Mises-Fisher (vMF) mixture model for data on the unit hypersphere and present an efficient inference procedure based on collapsed Markov chain Monte Carlo sampling. Comparing the vMF and gaussian mixture models on synthetic data, we demonstrate that the vMF model has a slight advantage inferring the true underlying clustering when compared to gaussian-based models on data generated from both a mixture of vMFs and a mixture of gaussians subsequently normalized. Thus, when performing model selection, the two models are not in agreement. Analyzing multisubject whole brain resting-state fMRI data from healthy adult subjects, we find that the vMF mixture model is considerably more reliable than the gaussian mixture model when comparing solutions across models trained on different groups of subjects, and again we find that the two models disagree on the optimal number of components. The analysis indicates that the fMRI data support more than a thousand clusters, and we confirm this is not a result of overfitting by demonstrating better prediction on data from held-out subjects. Our results highlight the utility of using directional statistics to model standardized fMRI data and demonstrate that whole brain segmentation of fMRI data requires a very large number of functional units in order to adequately account for the discernible statistical patterns in the data.
**Modeling dynamic functional connectivity using a wishart mixture model**

Dynamic functional connectivity (dFC) has recently become a popular way of tracking the temporal evolution of the brains functional integration. However, there does not seem to be a consensus on how to choose the complexity, i.e. number of brain states, and the time-scale of the dynamics, i.e. the window length. In this work we use the Wishart Mixture Model (WMM) as a probabilistic model for dFC based on variational inference. The framework admits arbitrary window lengths and number of dynamic components and includes the static one-component model as a special case. We exploit that the WMM framework provides model selection by quantifying models generalization to new data. We use this to quantify the number of states within a prespecified window length. We further propose a heuristic procedure for choosing the window length based on contrasting for each window length the predictive performance of dFC models to their static counterparts and choosing the window length having largest difference as most favorable for characterizing dFC. On synthetic data we find that generalizability is influenced by window length and signal-to-noise ratio. Too long windows cause dynamic states to be mixed together whereas short windows are more unstable and influenced by noise and we find that our heuristic correctly identifies an adequate level of complexity. On single subject resting state fMRI data we find that dynamic models generally outperform static models and using the proposed heuristic points to a windowlength of around 30 seconds provides largest difference between the predictive likelihood of static and dynamic FC.

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**Quantifying functional connectivity in multi-subject fMRI data using component models**

Functional magnetic resonance imaging (fMRI) is increasingly used to characterize functional connectivity between brain regions. Given the vast number of between-voxel interactions in high-dimensional fMRI data, it is an ongoing challenge to detect stable and generalizable functional connectivity in the brain among groups of subjects. Component models can be used to define subspace representations of functional connectivity that are more interpretable. It is, however, unclear which component model provides the optimal representation of functional networks for multi-subject fMRI datasets. A flexible cross-validation approach that assesses the ability of the models to predict voxel-wise covariance in new data, using three different measures of generalization was proposed. This framework is used to compare a range of component models with varying degrees of flexibility in their representation of functional connectivity, evaluated on both simulated and experimental resting-state fMRI data. It was demonstrated that highly flexible subject-specific component subspaces, as well as very constrained average models, are poor predictors of whole-brain functional connectivity, whereas the best-generalizing models account for subject variability within a common spatial subspace. Within this set of models, spatial Independent Component Analysis (sICA) on concatenated data provides more interpretable brain patterns, whereas a consistent-covariance model that accounts for subject-specific network scaling (PARAFAC2) provides greater stability in functional connectivity relationships between components and their spatial representations. The proposed evaluation framework is a promising quantitative approach to evaluating component models, and reveals important differences between subspace models in terms of predictability, robustness, characterization of subject variability, and interpretability of the model parameters. Hum Brain Mapp, 2016.

**General information**
Risk for affective disorders is associated with greater prefrontal gray matter volumes: A prospective longitudinal study

Background: Major depression and bipolar disorders aggregates in families and are linked with a wide range of neurobiological abnormalities including cortical gray matter (GM) alterations. Prospective studies of individuals at familial risk may expose the neural mechanisms underlying risk transmission. Methods: We used voxel based morphometry to investigate changes in regional GM brain volume, over a seven-year period, in 37 initially healthy individuals having a mono- or di-zygotic twin diagnosed with major depression or bipolar disorder (high-risk group; mean age 41.6 yrs.) as compared to 36 individuals with no history of affective disorders in the index twin and firstdegree relatives (low-risk group; mean age 38.5 yrs.). Results: Groups did not differ in regional GM volume changes over time. However, independent of time, high-risk twins had significantly greater GM volumes in bilateral dorsal anterior cingulate, inferior frontal gyrus and temporoparietal regions as compared to low-risk twins. Further, individuals who developed an affective disorder at follow-up (n=12), had relatively the largest GM volumes, both at baseline and follow-up, in the right dorsal anterior cingulate cortex and right inferior frontal cortex compared to high- and low-risk twins who remained well at follow-up. Conclusion: This pattern of apparently stable grater regional GM volume may constitute a neural marker of an increased risk for developing an affective disorder in individuals at familial risk.

Scalable group level probabilistic sparse factor analysis

Many data-driven approaches exist to extract neural representations of functional magnetic resonance imaging (fMRI) data, but most of them lack a proper probabilistic formulation. We propose a scalable group level probabilistic sparse factor analysis (psFA) allowing spatially sparse maps, component pruning using automatic relevance determination (ARD) and subject specific heteroscedastic spatial noise modeling. For task-based and resting state fMRI, we show that the sparsity constraint gives rise to components similar to those obtained by group independent component analysis. The noise modeling shows that noise is reduced in areas typically associated with activation by the experimental design. The psFA model identifies sparse components and the probabilistic setting provides a natural way to handle parameter uncertainties. The variational Bayesian framework easily extends to more complex noise models than the presently considered.

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Whole-brain functional connectivity predicted by indirect structural connections

Modern functional and diffusion magnetic resonance imaging (fMRI and dMRI) provide data from which macro-scale networks of functional and structural whole brain connectivity can be estimated. Although networks derived from these two modalities describe different properties of the human brain, they emerge from the same underlying brain organization, and functional communication is presumably mediated by structural connections. In this paper, we assess the structure-function relationship by evaluating how well functional connectivity can be predicted from structural graphs. Using high-resolution whole brain networks generated with varying density, we contrast the performance of several non-parametric link predictors that measure structural communication flow. While functional connectivity is not well predicted directly by structural connections, we show that superior predictions can be achieved by taking indirect structural pathways into account. In particular, we find that the length of the shortest structural path between brain regions is a good predictor of functional connectivity in sparse networks (density less than one percent), and that this improvement comes from integrating indirect pathways comprising up to three steps. Our results support the existence of important indirect relationships between structure and function, extending beyond the immediate direct structural connections that are typically investigated.

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Working Memory Modulation of Frontoparietal Network Connectivity in First-Episode Schizophrenia

Working memory (WM) impairment is regarded as a core aspect of schizophrenia. However, the neural mechanisms behind this cognitive deficit remain unclear. The connectivity of a frontoparietal network is known to be important for subserving WM. Using functional magnetic resonance imaging, the current study investigated whether WM-dependent modulation of effective connectivity in this network is affected in a group of first-episode schizophrenia (FES) patients compared with similarly performing healthy participants during a verbal n-back task. Dynamic causal modeling (DCM) of the coupling between regions (left inferior frontal gyrus (IFG), left inferior parietal lobe (IPL), and primary visual area) identified in a psychophysiological interaction (PPI) analysis was performed to characterize effective connectivity during the n-back task. The PPI analysis revealed that the connectivity between the left IFG and left IPL was modulated by WM and that this modulation was reduced in FES patients. The subsequent DCM analysis confirmed this modulation by WM and found evidence that FES patients had reduced forward connectivity from IPL to IFG. These findings provide evidence for impaired WM modulation of frontoparietal effective connectivity in the early phase of schizophrenia, even with intact WM performance, suggesting a failure of context-sensitive coupling in the schizophrenic brain.

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Aberrant neural signatures of decision-making: Pathological gamblers display cortico-striatal hypersensitivity to extreme gambles

Pathological gambling is an addictive disorder characterized by an irresistible urge to gamble despite severe consequences. One of the hallmarks of pathological gambling is maladaptive and highly risky decision-making, which has been linked to dysregulation of reward-related brain regions such as the ventral striatum. However, previous studies have produced contradictory results regarding the implication of this network, revealing either hypo- or hypersensitivity to monetary gains and losses. One possible explanation is that the gambling brain might be misrepresenting the benefits and costs when weighting the potential outcomes, and not the gains and losses per se. To address this issue, we investigated whether pathological gambling is associated with abnormal brain activity during decisions that weight the utility of possible gains against possible losses. Pathological gamblers and healthy human subjects underwent functional magnetic resonance imaging while they accepted or rejected mixed gain/loss gambles with fifty-fifty chances of winning or losing. Contrary to healthy individuals, gamblers showed a U-shaped response profile reflecting hypersensitivity to the most appetitive and most aversive bets in an executive cortico-striatal network including the dorsolateral prefrontal cortex and caudate nucleus. This network is concerned with the evaluation of action-outcome contingencies, monitoring recent actions and anticipating their consequences. The dysregulation of this specific network, especially for extreme bets with large potential consequences, offers a novel understanding of the neural basis of pathological gambling in terms of deficient associations between gambling actions and their financial impact.
Archetypal Analysis for Modeling Multisubject fMRI Data

Functional magnetic resonance imaging (fMRI) is widely used to measure brain function during various cognitive states. However, it remains a challenge to obtain low-rank models of functional networks in fMRI that have interpretable latent features and generalize across groups of subjects, due to significant intersubject variability in the signal structure and
noise. Group-level modeling is typically performed using component decompositions such as independent component analysis (ICA), which represent data as a linear combination of latent brain patterns, or using clustering models, where data are assumed to be generated by a set of prototype time series. Archetypal analysis (AA) provides a promising alternative, combining the advantages of component-model flexibility with highly interpretable latent 'archetypes' (similar to cluster-model prototypes). To date, AA has not been applied to group-level fMRI; a major limitation is that it does not generalize to multi-subject datasets, which may have significant variations in blood oxygenation-level-dependent signal and heteroscedastic noise. We develop multi-subject AA (MS-AA), which accounts for group-level data by assuming that archetypal temporal profiles have a common latent generator across subjects, ensuring that the temporal components are derived from a consistent set of brain regions. In addition, the model accounts for noise heteroscedasticity by modeling subject- and voxel-specific noise variance. This provides a novel approach to group-level modeling and an alternative to preexisting methods that account for inter-subject variability by extracting individual maps as a postprocessing step (e.g., dual-regression ICA), or assuming spatial dependency of maps across subjects (e.g., independent vector analysis). MS-AA shows robust performance when modeling archetypes for a motor task experiment. The procedure extracts a 'seed map' across subjects, used to provide brain parcellations with subject-specific temporal profiles. Our approach thus decomposes multisubject fMRI data into distinct interpretable component archetypes that may help to model both consistent group-level measures of fMRI data and individual variability.

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Independent vector analysis for capturing common components in fMRI group analysis

Independent component analysis (ICA) is a widely used blind source separation method for decomposing resting state functional magnetic resonance imaging (rs-fMRI) data into latent components. However, it can be challenging to obtain subject-specific component representations in multi-subject studies. Independent vector analysis (IVA) is a promising alternative approach to perform group fMRI analysis, which has been shown to better capture components with high inter-subject variability. The most widely applied IVA method is based on the multivariate Laplace distribution (IVA-GL), which assumes independence within subject components coupled across subjects only through shared scaling. In this study, we propose a more natural formulation of IVA based on a Normal-Inverse-Gamma distribution (IVA-NIG), in which the components can be directly interpreted as realizations of a common mean component with individual subject variability. We evaluate the performance of IVA-NIG compared to IVA-GL and similar decomposition methods, through the application of two types of simulated data and on real task fMRI data. The results show that IVA-NIG offers superior detection of components in simulated fMRI data. On real fMRI data with low inter-subject variability we find that all methods identify similar and plausible components.

Measuring Motion-Induced B0-Fluctuations in the Brain Using Field Probes

Purpose: Fluctuations of the background magnetic field (B0) due to body and breathing motion can lead to significant artifacts in brain imaging at ultrahigh field. Corrections based on real-time sensing using external field probes show great potential. This study evaluates different aspects of field interpolation from these probes into the brain which is implicit in such methods. Measurements and simulations were performed to quantify how well B0-fluctuations in the brain due to body and breathing motion are reflected in external field probe measurements. Methods: Field probe measurements were compared with scanner acquired B0-maps from experiments with breathing and shoulder movements. A realistic simulation of B0-fluctuations caused by breathing was performed, and used for testing different sets of field probe positions. Results: The B0-fluctuations were well reflected in the field probe measurements in the shoulder experiments, while the breathing experiments showed only moderate correspondence. The simulations showed the importance of the probe positions, and that performing full 3rd order corrections based on 16 field probes is not recommended. Conclusion: Methods for quantitative assessment of the field interpolation problem were developed and demonstrated. Field corrections based on external field measurements show great potential, although potential pitfalls were identified.
**Prospective motion correction for MRI using EEG-equipment**

A new prospective motion correction technique is presented that is based on signals from gradient switching, in an EEG-cap with interconnected electrodes the subject wears during scanning. The method has no line-of-sight limitations as optical methods, requires no interleaved navigator modules or additional hardware for sites already doing EEG-fMRI. Instead a training scan is performed were signals recorded with the EEG-system are correlated with motion parameters estimated by image realignment. Initial results from application of the method in a phantom are promising.

**Recovery from an acute relapse is associated with changes in motor resting-state connectivity in multiple sclerosis**

Resting-state functional MRI (rs-fMRI) of the brain has been successfully used to identify altered functional connectivity in the motor network in multiple sclerosis (MS). \(^1\) In clinically stable patients with MS, we recently demonstrated increased coupling between the basal ganglia and the motor network. \(^1\) Accordingly, rs-fMRI in MS is particularly suited to investigate functional reorganisation of the motor network in the remission phase after a relapse because the resting-state connectivity pattern is not influenced by interindividual differences in motor ability and task performance. In this prospective rs-fMRI study, we mapped acute changes in resting-state motor connectivity in 12 patients with relapsing forms of MS presenting with an acute relapse involving an upper limb paresis. Previous functional MRI (fMRI) studies have shown that the activation of sensorimotor areas was stronger and more widespread in the brain of patients with MS compared to healthy controls and increased proportionally with the extent of MS-related brain damage. \(^2\) We therefore hypothesised that a motor relapse involving paresis of the upper limbs would trigger an acute compensatory increase in motor resting-state connectivity and that the compensatory increase in functional connectivity would decrease over the following days or weeks in proportion to the degree of clinical remission.
Resting-State Connectivity Predicts Levodopa-Induced Dyskinesias in Parkinson's Disease

Background: Levodopa-induced dyskinesias are a common side effect of dopaminergic therapy in PD, but their neural correlates remain poorly understood.

Objectives: This study examines whether dyskinesias are associated with abnormal dopaminergic modulation of resting-state cortico-striatal connectivity.

Methods: Twelve PD patients with peak-of-dose dyskinesias and 12 patients without dyskinesias were withdrawn from dopaminergic medication. All patients received a single dose of fast-acting soluble levodopa and then underwent resting-
state functional magnetic resonance imaging before any dyskinesias emerged. Levodopa-induced modulation of cortico-striatal resting-state connectivity was assessed between the putamen and the following 3 cortical regions of interest: supplementary motor area, primary sensorimotor cortex, and right inferior frontal gyrus. These functional connectivity measures were entered into a linear support vector classifier to predict whether an individual patient would develop dyskinesias after levodopa intake. Linear regression analysis was applied to test which connectivity measures would predict dyskinesia severity.

Results: Dopaminergic modulation of resting-state connectivity between the putamen and primary sensorimotor cortex in the most affected hemisphere predicted whether patients would develop dyskinesias with a specificity of 100% and a sensitivity of 91% (P < .0001). Modulation of resting-state connectivity between the supplementary motor area and putamen predicted interindividual differences in dyskinesia severity (R2 = 0.627, P = .004). Resting-state connectivity between the right inferior frontal gyrus and putamen neither predicted dyskinesia status nor dyskinesia severity.

Conclusions: The results corroborate the notion that altered dopaminergic modulation of cortico-striatal connectivity plays a key role in the pathophysiology of dyskinesias in PD.

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Task relevance differentially shapes ventral visual stream sensitivity to visible and invisible faces

Top-down modulations of the visual cortex can be driven by task relevance. Yet, several accounts propose that the perceptual inferences underlying conscious recognition involve similar top-down modulations of sensory responses. Studying the pure impact of task relevance on sensory responses requires dissociating it from the top-down influences underlying conscious recognition. Here, using visual masking to abolish perceptual consciousness in humans, we report that functional magnetic resonance imaging (fMRI) responses to invisible faces in the fusiform gyrus are enhanced when they are task-relevant, but suppressed when they are task-irrelevant compared to other object categories. Under conscious perceptual conditions, task-related modulations were also present but drastically reduced, with visible faces always eliciting greater activity in the fusiform gyrus compared to other object categories. Thus, task relevance crucially shapes the sensitivity of fusiform regions to face stimuli, leading from enhancement to suppression of neural activity when the top-down influences accruing from conscious recognition are prevented.

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The Functional Segregation and Integration Model: Mixture Model Representations of Consistent and Variable Group-Level Connectivity in fMRI

The brain consists of specialized cortical regions that exchange information between each other, reflecting a combination of segregated (local) and integrated (distributed) processes that define brain function. Functional magnetic resonance imaging (fMRI) is widely used to characterize these functional relationships, although it is an upcoming challenge to develop robust, interpretable models for high-dimensional fMRI data. Gaussian mixture models (GMMs) are a powerful tool for parcellating the brain, based on the similarity of voxel time series. However, conventional GMMs have limited parametric flexibility: they only estimate segregated structure and do not model interregional functional connectivity, nor do they account for network variability across voxels or between subjects. To address these issues, this paper develops the functional segregation and integration model (FSIM). This extension of the GMM framework simultaneously estimates spatial clustering and the most consistent group functional connectivity structure. It also explicitly models network variability, based on voxel- and subject-specific network scaling profiles. We compared the FSIM to standard GMM in a predictive cross-validation framework and examined the importance of different model parameters, using both simulated and experimental resting-state data. The reliability of parcellations is not significantly altered by flexibility of the FSIM, whereas voxel- and subject-specific network scaling profiles significantly improve the ability to predict functional connectivity in independent test data. Moreover, the FSIM provides a set of interpretable parameters to characterize both consistent and variable aspects functional connectivity structure. As an example of its utility, we use subject-specific network profiles to identify brain regions where network expression predicts subject age in the experimental data. Thus, the FSIM is effective at summarizing functional connectivity structure in group-level fMRI, with applications in modeling the relationships between network variability and behavioral/demographic variables.

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Towards Motion-Insensitive Magnetic Resonance Imaging Using Dynamic Field Measurements.

Magnetic resonance imaging (MRI) of the brain is frequently used for both clinical diagnosis and brain research. This is due to the great versatility of the technique and the excellent ability to distinguish different types of soft tissue. The image quality is, however, heavily degraded when the subject being scanned moves, which in many cases is impossible to avoid. Subject motion during scanning is therefore one of the big challenges for the method. Techniques to correct for image quality degradation due to subject motion are under rapid development. A promising approach is to monitor the head motion during scanning and update the MRI scanner in real-time such that the imaging volume follows the head motion (prospective motion correction). In this thesis, prospective motion correction is presented where head motion is determined from signals measured with an electroencephalography (EEG) cap with inter-connected electrodes that the subject wears during scanning. The signals measured with the EEG system are induced voltages due to temporal changes of the gradient fields. The signals contain information about the head position because these magnetic field changes are spatially depending, and because the induced voltages also depend on the orientation of the wire-loops relative to the direction of field changes. Some of the advantages with the developed technique are that it can be used in closed head coils where camera based tracking is facing problems, and that it does not require additional hardware for the many hospitals and research institutions that already have an EEG-system for use in an MRI environment. In the thesis, the technique is considered in detail and proof of concept is demonstrated with phantom experiments. The experiments show that the newly developed technique has potential, but further optimization is required to improve accuracy and precision, and to improve the practical usability.

During MR examinations, a radio frequency (RF) field is transmitted into the subject to tip the magnetization of the hydrogen nuclei in the body away from equilibrium, and measurable signal is emitted. Changes in the transmitted RF field due to subject motion has up to now largely been left undescribed in the literature. This effect of subject motion is considered in the second study of the thesis, which focuses on single voxel spectroscopy where the effects are believed to have significant impact. A linear model is proposed to estimate tip angle changes during the scan from motion parameters, e.g. obtained from an external tracking system. The technique requires a previously performed calibration scan where the tip angle changes are measured for different head positions. A method for measuring actual tip angle changes was therefore implemented and pilot experiments were performed in a phantom and a healthy volunteer. The simple model seems promising based on these preliminary results. In MRI of the brain, not only head motion, but also motion of other parts of the body can lead to image degradation. This is because tissue is magnetized by the very strong, static background field (B0) such that the tissue contributes slightly to the background field. Motion of the body is thus felt in the brain as small fluctuations in the background field, and e.g. breathing motion can lead to substantial image quality degradation for certain brain imaging sequences through this effect. It has previously been
shown that magnetic field sensors (field probes) can be applied to stabilize the B0 field during scanning. However, the field probes are placed around the head, while it is the B0-fluctuations inside the head that are of interest. This interpolation problem is the subject of the last study in the thesis. Experiments were performed with healthy volunteers to test how field estimates in the brain based on outside field probe measurements compare to field measurements performed in the brain, in cases with breathing and shoulder motion. Simulations were performed to elucidate where the field probes should be placed in order to optimize the correspondence.

Variational group-PCA for intrinsic dimensionality determination in fMRI data
Functional Magnetic Resonance Imaging (fMRI) is widely used to gain a better understanding of the human brain's functional organization. As fMRI data are high dimensional it is challenging to analyse using conventional methods thus low-rank approximations such as principal component analysis (PCA), and independent component analysis (ICA) is often applied as a preprocessing step before any additional analysis. Low-rank methods generally require that the rank or latent dimensionality is known beforehand. When this is not the case a range of plausible dimensionalities have to be tested and compared. Furthermore, in an fMRI-context it is not fully understood how information from multiple subjects should best be incorporated when applying dimensionality reduction. We propose a Bayesian group principal component analysis (Group-BPCA) model with an automatic relevance determination (ARD) prior to determine the number of active components supported by the data. All subjects share the same spatial maps (components), but the uncertainties on these maps as well as the noise is subject specific. We find an approximate solution using the mature variational Bayesian framework and develop a fast and scalable implementation using a graphical processing unit (GPU). We test the model on fMRI data from 29 healthy subjects performing a block-design fingertapping experiment. The model identified 10 active components. Neither variational Bayesian PCA on temporally concatenated data nor Group-BPCA, where uncertainties on the spatial maps are shared, leads to pruning components, but provide better generalization in two of three scenarios. We show that the right level of subject variability is highly dependent on the chosen validation scheme.

Abnormal dopaminergic modulation of striato-cortical networks underlies levodopa-induced dyskinesias in humans
Dopaminergic signalling in the striatum contributes to reinforcement of actions and motivational enhancement of motor vigour. Parkinson's disease leads to progressive dopaminergic denervation of the striatum, impairing the function of cortico-basal ganglia networks. While levodopa therapy alleviates basal ganglia dysfunction in Parkinson's disease, it often elicits involuntary movements, referred to as levodopa-induced peak-of-dose dyskinesias. Here, we used a novel pharmacodynamic neuroimaging approach to identify the changes in cortico-basal ganglia connectivity that herald the
emergence of levodopa-induced dyskinesias. Twenty-six patients with Parkinson's disease (age range: 51–84 years; 11 females) received a single dose of levodopa and then performed a task in which they had to produce or suppress a movement in response to visual cues. Task-related activity was continuously mapped with functional magnetic resonance imaging. Dynamic causal modelling was applied to assess levodopa-induced modulation of effective connectivity between the pre-supplementary motor area, primary motor cortex and putamen when patients suppressed a motor response. Bayesian model selection revealed that patients who later developed levodopa-induced dyskinesias, but not patients without dyskinesias, showed a linear increase in connectivity between the putamen and primary motor cortex after levodopa intake during movement suppression. Individual dyskinesia severity was predicted by levodopa-induced modulation of striato-cortical feedback connections from putamen to the pre-supplementary motor area (Pcorrected = 0.020) and primary motor cortex (Pcorrected = 0.044), but not feed-forward connections from the cortex to the putamen. Our results identify for the first time, aberrant dopaminergic modulation of striatal-cortical connectivity as a neural signature of levodopa-induced dyskinesias in humans. We argue that excessive striato-cortical connectivity in response to levodopa produces an aberrant reinforcement signal producing an abnormal motor drive that ultimately triggers involuntary movements.

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Amygdala signals subjective appetitiveness and aversiveness of mixed gambles

People are more sensitive to losses than to equivalent gains when making financial decisions. We used functional magnetic resonance imaging (fMRI) to illuminate how the amygdala contributes to loss aversion. The blood oxygen level dependent (BOLD) response of the amygdala was mapped while healthy individuals were responding to 50/50 gambles with varying potential gain and loss amounts. Overall, subjects demanded twice as high potential gain as loss to accept a gamble. The individual level of loss aversion was expressed by the decision boundary, i.e., the gain-loss ratio at which subjects accepted and rejected gambles with equal probability. Amygdala activity increased the more the gain-loss ratio deviated from the individual decision boundary showing that the amygdala codes action value. This response pattern was more strongly expressed in loss averse individuals, linking amygdala activity with individual differences in loss aversion. Together, the results show that the amygdala signals subjective appetitiveness or aversiveness of gain-loss ratios at the time of choice. (C) 2015 Elsevier Ltd. All rights reserved.
Role of emotional processing in depressive responses to sex-hormone manipulation: a pharmacological fMRI study

Sex-hormone fluctuations may increase risk for developing depressive symptoms and alter emotional processing as supported by observations in menopausal and pre- to postpartum transition. In this double-blinded, placebo-controlled study, we used blood-oxygen level dependent functional magnetic resonance imaging (fMRI) to investigate if sex-steroid hormone manipulation with a gonadotropin-releasing hormone agonist (GnRHa) influences emotional processing. Fifty-six healthy women were investigated twice: at baseline (follicular phase of menstrual cycle) and 16 +/- 3 days post intervention. At both sessions, fMRI-scans during exposure to faces expressing fear, anger, happiness or no emotion, depressive symptom scores and estradiol levels were acquired. The fMRI analyses focused on regions of interest for emotional processing. As expected, GnRHa initially increased and subsequently reduced estradiol to menopausal levels, which was accompanied by an increase in subclinical depressive symptoms relative to placebo. Women who displayed larger GnRHa-induced increase in depressive symptoms had a larger increase in both negative and positive emotion-elicited activity in the anterior insula. When considering the post-GnRHa scan only, depressive responses were associated with emotion-elicited activity in the anterior insula and amygdala. The effect on regional activity in anterior insula was not associated with the estradiol net decline, only by the GnRHa-induced changes in mood. Our data implicate enhanced insula recruitment during emotional processing in the emergence of depressive symptoms following sex-hormone fluctuations. This may correspond to the emotional hypersensitivity frequently experienced by women postpartum.
Transcranial Magnetic Stimulation: An Automated Procedure to Obtain Coil-specific Models for Field Calculations

Background: Field calculations for transcranial magnetic stimulation (TMS) are increasingly implemented online in neuronavigation systems and in more realistic offline approaches based on finite-element methods. They are often based on simplified and/or non-validated models of the magnetic vector potential of the TMS coils.

Objective: To develop an approach to reconstruct the magnetic vector potential based on automated measurements.

Methods: We implemented a setup that simultaneously measures the three components of the magnetic field with high spatial resolution. This is complemented by a novel approach to determine the magnetic vector potential via volume integration of the measured field.

Results: The integration approach reproduces the vector potential with very good accuracy. The vector potential distribution of a standard figure-of-eight shaped coil determined with our setup corresponds well with that calculated using a model reconstructed from x-ray images.

Conclusion: The setup can supply validated models for existing and newly appearing TMS coils.
Unsupervised segmentation of task activated regions in fMRI

Functional Magnetic Resonance Imaging has become a central measuring modality to quantify functional activation of the brain in both task and rest. Most analysis used to quantify functional activation requires supervised approaches as employed in statistical parametric mapping (SPM) to extract maps of task induced functional activations. This requires strong knowledge and assumptions on the BOLD response as a function of activation while smoothing in general enhances the statistical power but at the cost of spatial resolution. We propose a fully unsupervised approach for the extraction of task activated functional units in multi-subject fMRI data that exploits that regions of task activation are consistent across subjects and can be more reliably inferred than regions that are not activated. We develop a non-parametric Gaussian mixture model that apriori assumes activations are smooth using a Gaussian Process prior while assuming the segmented functional maps are the same across subjects but having individual time-courses and noise variances. To improve inference we propose an enhanced split-merge procedure. We find that our approach well extracts the induced activity of a finger tapping fMRI paradigm with maps that well corresponds to a supervised group SPM analysis. We further find interesting regions that are not activated time locked to the paradigm. Demonstrating that we in a fully unsupervised manner are able to extract the task-induced activations forms a promising framework for the analysis of task fMRI and resting-state data in general where strong knowledge of how the task induces a BOLD response is missing.
It is critical for survival to quickly respond to environmental stimuli with the most appropriate action. This task becomes most challenging when response tendencies induced by relevant and irrelevant stimulus features are in conflict, and have to be resolved in real time. Inputs from the pre-supplementary motor area (pre-SMA) and inferior frontal gyrus (IFG) to the subthalamic nucleus (STN) are thought to support this function, but the connectivity and causality of these regions in calibrating motor control has not been delineated. In this study, we combined off-line noninvasive brain stimulation and functional magnetic resonance imaging, while young healthy human participants performed a modified version of the Simon task. We show that impairing pre-SMA function by noninvasive brain stimulation improved control over impulsive response tendencies, but only when participants were explicitly rewarded for fast and accurate responses. These effects were mediated by enhanced activation and connectivity of the IFG–STN pathway. These results provide causal evidence for a pivotal role of the IFG–STN pathway during action control. Additionally, they suggest a parallel rather than hierarchical organization of the pre-SMA–STN and IFG–STN pathways, since interruption of pre-SMA function can enhance IFG–STN connectivity and improve control over inappropriate responses.
Non-parametric Bayesian graph models reveal community structure in resting state fMRI

Modeling of resting state functional magnetic resonance imaging (rs-fMRI) data using network models is of increasing interest. It is often desirable to group nodes into clusters to interpret the communication patterns between nodes. In this study we consider three different nonparametric Bayesian models for node clustering in complex networks. In particular, we test their ability to predict unseen data and their ability to reproduce clustering across datasets. The three generative models considered are the Infinite Relational Model (IRM), Bayesian Community Detection (BCD), and the Infinite Diagonal Model (IDM). The models define probabilities of generating links within and between clusters and the difference between the models lies in the restrictions they impose upon the between-cluster link probabilities. IRM is the most flexible model with no restrictions on the probabilities of links between clusters. BCD restricts the between-cluster link probabilities to be strictly lower than within-cluster link probabilities to conform to the community structure typically seen in social networks. IDM only models a single between-cluster link probability, which can be interpreted as a background noise probability. These probabilistic models are compared against three other approaches for node clustering, namely Infomap, Louvain modularity, and hierarchical clustering. Using 3 different datasets comprising healthy volunteers’ rs-fMRI we found that the BCD model was in general the most predictive and reproducible model. This suggests that rs-fMRI data exhibits community structure and furthermore points to the significance of modeling heterogeneous between-cluster link probabilities.
Complex network, Graph theory, Infinite Relational Model, Bayesian Community Detection, Resting state fMRI
The Acute Brain Response to Levodopa Heralds Dyskinesias in Parkinson Disease

In Parkinson disease (PD), long-term treatment with the dopamine precursor levodopa gradually induces involuntary “dyskinesia” movements. The neural mechanisms underlying the emergence of levodopa-induced dyskinesias in vivo are still poorly understood. Here, we applied functional magnetic resonance imaging (fMRI) to map the emergence of peak-of-dose dyskinesias in patients with PD. Thirteen PD patients with dyskinesias and 13 PD patients without dyskinesias received 200mg fast-acting oral levodopa following prolonged withdrawal from their normal dopaminergic medication. Immediately before and after levodopa intake, we performed fMRI, while patients produced a mouse click with the right or left hand or no action (No-Go) contingent on 3 arbitrary cues. The scan was continued for 45 minutes after levodopa intake or until dyskinesias emerged. During No-Go trials, PD patients who would later develop dyskinesias showed an abnormal gradual increase of activity in the presupplementary motor area (preSMA) and the bilateral putamen. This hyperactivity emerged during the first 20 minutes after levodopa intake. At the individual level, the excessive No-Go activity in the predyskinesia period predicted whether an individual patient would subsequently develop dyskinesias (p <0.001) as well as severity of their day-to-day symptomatic dyskinesias (p <0.001). PD patients with dyskinesias display an immediate hypersensitivity of preSMA and putamen to levodopa, which heralds the failure of neural networks to suppress involuntary dyskinetic movements. Ann Neurol 2014;75:829–836

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Expanded functional coupling of subcortical nuclei with the motor resting-state network in multiple sclerosis

Background: Multiple sclerosis (MS) impairs signal transmission along cortico-cortical and cortico-subcortical connections, affecting functional integration within the motor network. Functional magnetic resonance imaging (fMRI) during motor tasks has revealed altered functional connectivity in MS, but it is unclear how much motor disability contributed to these abnormal functional interaction patterns.

Objective: To avoid any influence of impaired task performance, we examined disease-related changes in functional motor connectivity in MS at rest.

Methods: A total of 42 patients with MS and 30 matched controls underwent a 20-minute resting-state fMRI session at 3 Tesla. Independent component analysis was applied to the fMRI data to identify disease-related changes in motor resting-state connectivity.

Results: Patients with MS showed a spatial expansion of motor resting-state connectivity in deep subcortical nuclei but not at the cortical level. The anterior and middle parts of the putamen, adjacent globus pallidus, anterior and posterior thalamus and the subthalamic region showed stronger functional connectivity with the motor network in the MS group compared with controls.

Conclusion: MS is characterised by more widespread motor connectivity in the basal ganglia while cortical motor resting-state connectivity is preserved. The expansion of subcortical motor resting-state connectivity in MS indicates less efficient funnelling of neural processing in the executive motor cortico-basal ganglia-thalamo-cortical loops.
Multiple sclerosis impairs regional functional connectivity in the cerebellum

Resting-state functional magnetic resonance imaging (rs-fMRI) has been used to study changes in long-range functional brain connectivity in multiple sclerosis (MS). Yet little is known about how MS affects functional brain connectivity at the local level. Here we studied 42 patients with MS and 30 matched healthy controls with whole-brain rs-fMRI at 3 T to examine local functional connectivity. Using the Kendall's Coefficient of Concordance, regional homogeneity of blood-oxygen-level-dependent (BOLD)-signal fluctuations was calculated for each voxel and used as a measure of local connectivity. Patients with MS showed a decrease in regional homogeneity in the upper left cerebellar hemisphere in lobules V and VI relative to healthy controls. Similar trend changes in regional homogeneity were present in the right cerebellar hemisphere. The results indicate a disintegration of regional processing in the cerebellum in MS. This might be caused by a functional disruption of cortico-ponto-cerebellar and spino-cerebellar inputs, since patients with higher lesion load in the left cerebellar peduncles showed a stronger reduction in cerebellar homogeneity. In patients, two clusters in the left posterior cerebellum expressed a reduction in regional homogeneity with increasing global disability as reflected by the Expanded Disability Status Scale (EDSS) score or higher ataxia scores. The two clusters were mainly located in Crus I and extended into Crus II and the dentate nucleus but with little spatial overlap. These findings suggest a link between impaired regional integration in the cerebellum and general disability and ataxia.
Neural markers of negative symptom outcomes in distributed working memory brain activity of antipsychotic-naive schizophrenia patients

Since working memory deficits in schizophrenia have been linked to negative symptoms, we tested whether features of the one could predict the treatment outcome in the other. Specifically, we hypothesized that working memory-related functional connectivity at pre-treatment can predict improvement of negative symptoms in antipsychotic-treated patients. Fourteen antipsychotic-naive patients with first-episode schizophrenia were clinically assessed before and after 7 months of quetiapine monotherapy. At baseline, patients underwent functional magnetic resonance imaging while performing a verbal n-back task. Spatial independent component analysis identified task-modulated brain networks. A linear support vector machine was trained with these components to discriminate six patients who showed improvement in negative symptoms from eight non-improvers. Classification accuracy and significance was estimated by leave-one-out cross-validation and permutation tests, respectively. Two frontoparietal and one default mode network components predicted negative symptom improvement with a classification accuracy of 79% (p = 0.003). Discriminating features were found in the frontoparietal networks but not the default mode network. These preliminary data suggest that functional patterns at baseline can predict negative symptom treatment–response in schizophrenia. This information may be used to stratify patients into subgroups thereby facilitating personalized treatment.
Postoperative increase in grey matter volume in visual cortex after unilateral cataract surgery

Purpose: The developing visual cortex has a strong potential to undergo plastic changes. Little is known about the potential of the ageing visual cortex to express plasticity. A pertinent question is whether therapeutic interventions can trigger plastic changes in the ageing visual cortex by restoring vision.

Methods: Twelve patients aged 50–85 years underwent structural high-resolution T1-weighted MRI of the whole brain 2 days and 6 weeks after unilateral cataract surgery. Voxel-based morphometry (VBM) based on T1-weighted magnetic resonance imaging (MRI) was employed to test whether cataract surgery induces a regional increase in grey matter in areas V1 and V2 of the visual cortex.

Results: In all patients, cataract surgery immediately improved visual acuity, contrast sensitivity and mean sensitivity in the visual field of the operated eye. The improvement in vision was stable throughout the 6 weeks after operation. VBM revealed a regional expansion of grey matter volume in area V2 contralateral to the operated eye during the 6-week period after surgery. Individual increases in grey matter were predicted by the symmetry in visual acuity between the operated and non-operated eyes.
eye and nonoperated eye. The more symmetrical visual acuity became after unilateral cataract surgery, the more pronounced was the grey matter increase in visual cortex.

Conclusion: The data suggest that cataract surgery triggered a use-dependent structural plasticity in V2 presumably through improved binocular integration of visual input from both eyes. We conclude that activity-dependent cortical plasticity is preserved in the ageing visual cortex and may be triggered by restoring impaired vision.

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Resting-state connectivity of pre-motor cortex reflects disability in multiple sclerosis

Objective
To characterize the relationship between motor resting-state connectivity of the dorsal pre-motor cortex (PMd) and clinical disability in patients with multiple sclerosis (MS).

Materials and methods
A total of 27 patients with relapsing–remitting MS (RR-MS) and 15 patients with secondary progressive MS (SP-MS) underwent functional resting-state magnetic resonance imaging. Clinical disability was assessed using the Expanded Disability Status Scale (EDSS). Independent component analysis was used to characterize motor resting-state connectivity. Multiple regression analysis was performed in SPM8 between the individual expression of motor resting-state connectivity in PMd and EDSS scores including age as covariate. Separate post hoc analyses were performed for patients with RR-MS and SP-MS.

Results
The EDSS scores ranged from 0 to 7 with a median score of 4.3. Motor resting-state connectivity of left PMd showed a positive linear relation with clinical disability in patients with MS. This effect was stronger when considering the group of patients with RR-MS alone, whereas patients with SP-MS showed no increase in coupling strength between left PMd and the motor resting-state network with increasing clinical disability. No significant relation between motor resting-state connectivity of the right PMd and clinical disability was detected in MS.

Conclusions
The increase in functional coupling between left PMd and the motor resting-state network with increasing clinical disability can be interpreted as adaptive reorganization of the motor system to maintain motor function, which appears to be limited to the relapsing–remitting stage of the disease.
Decoding Complex Cognitive States Online by Manifold Regularization in Real-Time fMRI

Human decision making is complex and influenced by many factors on multiple time scales, reflected in the numerous brain networks and connectivity patterns involved as revealed by fMRI. We address mislabeling issues in paradigms involving complex cognition, by considering a manifold regularizing prior for modeling a sequence of neural events leading to a decision. The method is directly applicable for online learning in the context of real-time fMRI, and our experimental results show that the method can efficiently avoid model degeneracy caused by mislabeling.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Cognitive Systems
Authors: Hansen, T. J. (Intern), Hansen, L. K. (Intern), Madsen, K. H. (Intern)
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Main Research Area: Technical/natural sciences
Workshop: International Workshop on Machine Learning and Interpretation in Neuroimaging (MLINI 2011), Granada, Spain, 16/12/2011 - 16/12/2011
DOIs:
Identification of Functional Clusters in the Striatum Using Infinite Relational Modeling

In this paper we investigate how the Infinite Relational Model can be used to infer functional groupings of the human striatum using resting state fMRI data from 30 healthy subjects. The Infinite Relational Model is a non-parametric Bayesian method for inferring community structure in complex networks. We visualize the solution found by performing evidence accumulation clustering on the maximum a posteriori solutions found in 100 runs of the sampling scheme. The striatal groupings found are symmetric between hemispheres indicating that the model is able to group voxels across hemispheres, which are involved in the same neural computations. The reproducibility of the groupings found are assessed by calculating mutual information between half splits of the subject sample for various hyperparameter values. Finally, the model's ability to predict unobserved links is assessed by randomly treating links and non-links in the graphs as missing. We find that the model is performing well above chance for all subjects.

Nonlinear Denoising and Analysis of Neuroimages With Kernel Principal Component Analysis and Pre-Image Estimation

We investigate the use of kernel principal component analysis (PCA) and the inverse problem known as pre-image estimation in neuroimaging: i) We explore kernel PCA and pre-image estimation as a means for image denoising as part of the image preprocessing pipeline. Evaluation of the denoising procedure is performed within a data-driven split-half evaluation framework. ii) We introduce manifold navigation for exploration of a nonlinear data manifold, and illustrate how pre-image estimation can be used to generate brain maps in the continuum between experimentally defined brain states/classes. We base these illustrations on two fMRI BOLD data sets — one from a simple finger tapping experiment and the other from an experiment on object recognition in the ventral temporal lobe.
Visualization of Nonlinear Classification Models in Neuroimaging - Signed Sensitivity Maps

Classification models are becoming increasingly popular tools in the analysis of neuroimaging data sets. Besides obtaining good prediction accuracy, a competing goal is to interpret how the classifier works. From a neuroscientific perspective, we are interested in the brain pattern reflecting the underlying neural encoding of an experiment defining multiple brain states. In this relation there is a great desire for the researcher to generate brain maps, that highlight brain locations of importance to the classifier's decisions. Based on sensitivity analysis, we develop further procedures for model visualization. Specifically we focus on the generation of summary maps of a nonlinear classifier, that reveal how the classifier works in different parts of the input domain. Each of the maps includes sign information, unlike earlier related methods. The sign information allows the researcher to assess in which direction the individual locations influence the classification. We illustrate the visualization procedure on a real data from a simple functional magnetic resonance imaging experiment.

Mathematical modeling and visualization of functional neuroimages

This dissertation presents research results regarding mathematical modeling in the context of the analysis of functional neuroimages. Specifically, the research focuses on pattern-based analysis methods that recently have become popular within the neuroimaging community. Such methods attempt to predict or decode experimentally defined cognitive states based on brain scans. The topics covered in the dissertation are divided into two broad parts: The first part investigates the relative importance of model selection on the brain patterns extracted from analysis models. Typical neuroimaging data sets are characterized by relatively few data observations in a high dimensional space. The process of building models in such data sets often requires strong regularization. Often, the degree of model regularization is chosen in order to maximize prediction accuracy. We focus on the relative influence of model regularization parameter choices on the model generalization, the reliability of the spatial brain patterns extracted from the analysis model, and the ability of the resulting model to identify relevant brain networks defining the underlying neural encoding of the experiment. We show that known parts of brain networks can be overlooked in pursuing maximization of prediction accuracy. This supports the view that the quality of spatial patterns extracted from models cannot be assessed purely by focusing on prediction accuracy. Our results instead suggest that model regularization parameters must be carefully selected, so that the model and its visualization enhance our ability to interpret the brain. The second part concerns interpretation of nonlinear models and procedures for extraction of 'brain maps' from nonlinear kernel models. We assess the performance of the sensitivity map as means for extracting a global summary map from a trained model. Such summary maps provide the investigator with an overview of brain locations of importance to the model's predictions. The sensitivity map proves as a versatile technique for model visualization. Furthermore, we perform a preliminary investigation of the use of pre-image estimation for localized interpretation of nonlinear models. In the context of image denoising the pre-image analysis proves to enhance the reliability of brain patterns extracted from multivariate models of the neuroimaging data.
Monocular Visual Deprivation Suppresses Excitability in Adult Human Visual Cortex

The adult visual cortex maintains a substantial potential for plasticity in response to a change in visual input. For instance, transcranial magnetic stimulation (TMS) studies have shown that binocular deprivation (BD) increases the cortical excitability for inducing phosphenes with TMS. Here, we employed TMS to trace plastic changes in adult visual cortex before, during, and after 48 h of monocular deprivation (MD) of the right dominant eye. In healthy adult volunteers, MD-induced changes in visual cortex excitability were probed with paired-pulse TMS applied to the left and right occipital cortex. Stimulus–response curves were constructed by recording the intensity of the reported phosphenes evoked in the contralateral visual field at range of TMS intensities. Phosphene measurements revealed that MD produced a rapid and robust decrease in cortical excitability relative to a control condition without MD. The cortical excitability returned to preinterventional baseline levels within 3 h after the end of MD. The results show that in contrast to the excitability increase in response to BD, MD acutely triggers a reversible decrease in visual cortical excitability. This shows that the pattern of visual deprivation has a substantial impact on experience-dependent plasticity of the human visual cortex.

General information

State: Published
Organisations: Cognitive Systems, Department of Informatics and Mathematical Modeling, University of Copenhagen, Copenhagen University Hospital
Authors: Lou, A. R. (Ekstern), Madsen, K. H. (Intern), Paulson, O. B. (Ekstern), Julian, H. O. (Ekstern), Prause, J. U. (Ekstern), Siebner, H. R. (Ekstern), Kjaer, T. W. (Ekstern)
Pages: 2876-2882
Publication date: 2011
Main Research Area: Technical/natural sciences

Publication information

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Web of Science (2017): Indexed yes
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Scopus rating (2016): CiteScore 5.5 SJR 3.706 SNIP 1.521
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 4.818 SNIP 1.815 CiteScore 6.68
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 4.815 SNIP 2 CiteScore 6.86
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 5.34 SNIP 1.909 CiteScore 7.26
ISI indexed (2013): ISI indexed yes
Visualization of nonlinear kernel models in neuroimaging by sensitivity maps

There is significant current interest in decoding mental states from neuroimages. In this context kernel methods, e.g., support vector machines (SVM) are frequently adopted to learn statistical relations between patterns of brain activation and experimental conditions. In this paper we focus on visualization of such nonlinear kernel models. Specifically, we investigate the sensitivity map as a technique for generation of global summary maps of kernel classification models. We illustrate the performance of the sensitivity map on functional magnetic resonance (fMRI) data based on visual stimuli. We show that the performance of linear models is reduced for certain scan labelings/categorizations in this data set, while the nonlinear models provide more flexibility. We show that the sensitivity map can be used to visualize nonlinear versions of kernel logistic regression, the kernel Fisher discriminant, and the SVM, and conclude that the sensitivity map is a versatile and computationally efficient tool for visualization of nonlinear kernel models in neuroimaging.

General information
State: Published
Organisations: Cognitive Systems, Department of Informatics and Mathematical Modeling, Aarhus University Hospital
Authors: Rasmussen, P. M. (Intern), Madsen, K. H. (Intern), Lund, T. E. (Ekstern), Hansen, L. K. (Intern)
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Publication date: 2011
Main Research Area: Technical/natural sciences

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BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 6.31 SJR 3.823 SNIP 1.752
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 4.48 SNIP 1.84 CiteScore 6.71
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 4.201 SNIP 2.029 CiteScore 6.9
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 4.376 SNIP 2.026 CiteScore 7.06
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 3.922 SNIP 1.937 CiteScore 6.86
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 3.626 SNIP 1.81 CiteScore 6.31
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 3.573 SNIP 1.866
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 3.859 SNIP 1.897
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 4.094 SNIP 1.765
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 3.7 SNIP 1.981
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 3.41 SNIP 1.924
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 3.703 SNIP 1.918
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 3.401 SNIP 1.794
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 1.974 SNIP 1.003
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 0.885 SNIP 0.403
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 0.526 SNIP 0.253
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 0.534 SNIP 0.341
Scopus rating (1999): SJR 0.641 SNIP 0.494

Original language: English
Model visualization, Nonlinear modeling, Support vector machine, Neuroimaging, Multivariate analysis, Sensitivity map, Kernel methods, Machine learning, Pattern analysis

DOIs:
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Source: orbit
A Fast Kernel Based Searchlight Heuristic for Real-time fMRI

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State: Published
Organisations: Cognitive Systems, Department of Informatics and Mathematical Modeling
Authors: Hansen, T. J. (Intern), Hansen, L. K. (Intern), Madsen, K. H. (Intern)
Publication date: 2010
Main Research Area: Technical/natural sciences
Electronic versions:
poster.pdf
Source: orbit
Source-ID: 270611
Publication: Research - peer-review › Poster – Annual report year: 2010

Modelling Strategies for Functional Magnetic Resonance Imaging
This thesis collects research done on several models for the analysis of functional magnetic resonance neuroimaging (fMRI) data. Several extensions for unsupervised factor analysis type decompositions including explicit delay modelling as well as handling of spatial and temporal smoothness and generalisations to higher order arrays are considered. Additionally, an application of the natural conjugate prior for supervised learning in the general linear model to efficiently incorporate prior information for supervised analysis is presented. Further extensions include methods to model nuisance effects in fMRI data thereby suppressing noise for both supervised and unsupervised analysis techniques.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Cognitive Systems
Authors: Madsen, K. H. (Intern), Sidaros, K. (Intern), Hansen, L. K. (Intern)
Publication date: Jul 2009

Publication information
Original language: English
Series: IMM-PHD-2008-203
ISSN: 0909-3192
Main Research Area: Technical/natural sciences
Electronic versions:
phd203_khm-net-uden_artikler.pdf
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Source-ID: 220839
Publication: Research › Ph.D. thesis – Annual report year: 2009

From ecstasy to agony: chronic effects of MDMA use on emotional processing

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics, University of Copenhagen
Authors: Ramsøy, T. (Ekstern), Madsen, K. H. (Intern), Wegener, J. (Ekstern), Gelskov, S. (Ekstern), Erritzøe, D. (Ekstern), Knudsen, G. (Ekstern), Skimminge, A. J. M. (Intern)
Publication date: 2009
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 258563
Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2009

Unified ICA-SPM analysis of fMRI experiments: Implementation of an ICA graphical user interface for the SPM pipeline
We present a toolbox for exploratory analysis of functional magnetic resonance imaging (fMRI) data using independent component analysis (ICA) within the widely used SPM analysis pipeline. The toolbox enables dimensional reduction using principal component analysis, ICA using several different ICA algorithms, selection of the number of components using the
Bayesian information criterion (BIC), visualization of ICA components, and extraction of components for subsequent analysis using the standard general linear model. We demonstrate how the toolbox is capable of identifying activity and nuisance effects in fMRI data from a visual experiment.

**General information**
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, Department of Electrical Engineering, Cognitive Systems
Authors: Bjerre, T. (Intern), Henriksen, J. (Intern), Nielsen, C. H. (Ekstern), Rasmussen, P. M. (Intern), Hansen, L. K. (Intern), Madsen, K. H. (Intern)
Pages: 316-321
Publication date: 2009

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Title of host publication: Biosignals 2009: Proceedings Of The International Conference on Bio-Inspired Systems and Signal Processing
Publisher: Springer Publishing Company
Main Research Area: Technical/natural sciences
Conference: International Conference on Bio-Inspired Systems and Signal Processing, 01/01/2009
Links:
http://www.biosignals.org
Source: orbit
Source-ID: 233474
Publication: Research - peer-review › Article in proceedings – Annual report year: 2009

**Approximate L0 constrained Non-negative Matrix and Tensor Factorization**

Non-negative matrix factorization (NMF), i.e. \( V = WH \) where both \( V, W \) and \( H \) are non-negative has become a widely used blind source separation technique due to its part based representation. The NMF decomposition is not in general unique and a part based representation not guaranteed. However, imposing sparseness both improves the uniqueness of the decomposition and favors part based representation. Sparseness in the form of attaining as many zero elements in the solution as possible is appealing from a conceptional point of view and corresponds to minimizing reconstruction error with an L0 norm constraint. In general, solving for a given L0 norm is an NP hard problem thus convex relaxatin to regularization by the L1 norm is often considered, i.e., minimizing \( \frac{1}{2} ||V-WHk||^2 + \lambda |H|_1 \). An open problem is to control the degree of sparsity imposed. We here demonstrate that a full regularization path for the L1 norm regularized least squares NMF for fixed \( W \) can be calculated at the cost of an ordinary least squares solution based on a modification of the Least Angle Regression and Selection (LARS) algorithm forming a non-negativity constrained LARS (NLARS). With the full regularization path, the L1 regularization strength \( \lambda \) that best approximates a given L0 can be directly accessed and in effect used to control the sparsity of \( H \). The MATLAB code for the NLARS algorithm is available for download.

**General information**
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Organisations: Cognitive Systems, Department of Informatics and Mathematical Modeling
Authors: Mørup, M. (Intern), Madsen, K. H. (Intern), Hansen, L. K. (Intern)
Publication date: 2008

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Title of host publication: 2008 IEEE International Symposium on Circuits and Systems : ISCAS 2008 (Special Session on Non-negative matrix and Tensor Factorization)
Publisher: IEEE
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Main Research Area: Technical/natural sciences
Conference: 2008 IEEE International Symposium on Circuits and Systems, Seattle, WA, United States, 18/05/2008 - 18/05/2008
Electronic versions: fullregpathSNMFLKH.pdf
DOIs: 10.1109/ISCAS.2008.4541671

**Bibliographical note**
Copyright: 2008 IEEE. Personal use of this material is permitted. However, permission to reprint/republish this material for advertising or promotional purposes or for creating new collective works for resale or redistribution to servers or lists, or to reuse any copyrighted component of this work in other works must be obtained from the IEEE.
Bayesian model comparison in nonlinear BOLD fMRI hemodynamics

Nonlinear hemodynamic models express the BOLD (blood oxygenation level dependent) signal as a nonlinear, parametric functional of the temporal sequence of local neural activity. Several models have been proposed for both the neural activity and the hemodynamics. We compare two such combined models: the original balloon model with a square-pulse neural model (Friston, Mechelli, Turner, & Price, 2000) and an extended balloon model with a more sophisticated neural model (Buxton, Uludag, Dubowitz, & Liu, 2004). We learn the parameters of both models using a Bayesian approach, where the distribution of the parameters conditioned on the data is estimated using Markov chain Monte Carlo techniques. Using a split-half resampling procedure (Strother, Anderson, & Hansen, 2002), we compare the generalization abilities of the models as well as their reproducibility for both synthetic and real data, recorded from two different visual stimulation paradigms. The results show that the simple model is the better one for these data.
Cortical neuroplasticity in patients recovering from acute optic neuritis

Patients with optic neuritis (ON) undergo cortical and subcortical neuroplasticity as revealed by functional magnetic resonance imaging (fMRI). However, the effect of the heterogeneity of scotomas has not been adequately addressed previously. We introduce a new method of modelling scotomas in fMRI, to reveal a clearer pattern of neuroplasticity, across a mixed patient population. A longitudinal fMRI-study of visual function in 19 ON patients examined at four timepoints between presentation and 6 months was performed. Four different models were compared. The first model included the four different examination timepoints as separate explanatory variables without adjustment for Visual field defects. The second model also included covariates reflecting subject-specific deviations in Visual field defect from the average group value of the Humphrey mean deviation (HMD) at each examination timepoint. In the third and fourth models the four examination timepoints were not modelled explicitly, but entered vicariously through the associated changes in the HMD for each subject that marked their individual recovery. The results show that the third and fourth models were more sensitive to geniculate and Visual Cortical neuroplasticity during recovery. Moreover, inferences from the fourth model can be extended to the general Population of patients recovering from ON. In Conclusion, we present a method of accommodating subject-specific differences between patients with acute ON by inclusion of an HMD-index. This method is sensitive to the processes of neuroplasticity whilst the generalisation of inferences makes the method suitable for future studies of treatment.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Manufacturing Engineering, Department of Mechanical Engineering
Authors: Korsholm, K. (Ekstern), Madsen, K. H. (Intern), Frederiksen, J. L. (Ekstern), Rowe, J. B. (Ekstern), Lund, T. (Intern)
Pages: 836-844
Publication date: 2008
Main Research Area: Technical/natural sciences

Publication information
Journal: NeuroImage
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BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 6.31 SJR 3.823 SNIP 1.752
Web of Science (2016): Indexed yes
Shift Invariant Multi-linear Decomposition of Neuroimaging Data

We present an algorithm for multilinear decomposition that allows for arbitrary shifts along one modality. The method is applied to neural activity arranged in the three modalities space, time, and trial. Thus, the algorithm models neural activity as a linear superposition of components with a fixed time course that may vary across either trials or space in its overall intensity and latency. Its utility is demonstrated on simulated data as well as actual EEG, and fMRI data. We show how shift-invariant multilinear decompositions of multiway data can successfully cope with variable latencies in data derived
from neural activity—a problem that has caused degenerate solutions especially in modeling neuroimaging data with instantaneous multilinear decompositions. Our algorithm is available for download at www.erpwavelab.org.

**General information**

**State:** Published

**Organisations:** Department of Informatics and Mathematical Modeling, Cognitive Systems, University of California at Berkeley, Copenhagen University Hospital

**Authors:** Mørup, M. (Intern), Hansen, L. K. (Intern), Arnfred, S. M. (Ekstern), Lim, L. (Ekstern), Madsen, K. H. (Intern)

**Publication Date:** 2008

**Main Research Area:** Technical/natural sciences

**Publication information**

**Journal:** NeuroImage

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- BFI (2017): BFI-level 2
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- BFI (2016): BFI-level 2
- Scopus rating (2016): CiteScore 6.31 SJR 3.823 SNIP 1.752
- Web of Science (2016): Indexed yes
- BFI (2015): BFI-level 2
- Scopus rating (2015): SJR 4.48 SNIP 1.84 CiteScore 6.71
- Web of Science (2015): Indexed yes
- BFI (2014): BFI-level 2
- Scopus rating (2014): SJR 4.201 SNIP 2.029 CiteScore 6.9
- Web of Science (2014): Indexed yes
- BFI (2013): BFI-level 2
- Scopus rating (2013): SJR 4.376 SNIP 2.026 CiteScore 7.06
- ISI indexed (2013): ISI indexed yes
- Web of Science (2013): Indexed yes
- BFI (2012): BFI-level 2
- Scopus rating (2012): SJR 3.922 SNIP 1.937 CiteScore 6.86
- ISI indexed (2012): ISI indexed yes
- Web of Science (2012): Indexed yes
- BFI (2011): BFI-level 2
- Scopus rating (2011): SJR 3.626 SNIP 1.81 CiteScore 6.31
- ISI indexed (2011): ISI indexed yes
- Web of Science (2011): Indexed yes
- BFI (2010): BFI-level 2
- Scopus rating (2010): SJR 3.573 SNIP 1.866
- Web of Science (2010): Indexed yes
- BFI (2009): BFI-level 2
- Scopus rating (2009): SJR 3.859 SNIP 1.897
- Web of Science (2009): Indexed yes
- BFI (2008): BFI-level 2
- Scopus rating (2008): SJR 4.094 SNIP 1.765
- Web of Science (2008): Indexed yes
- Scopus rating (2007): SJR 3.7 SNIP 1.981
- Web of Science (2007): Indexed yes
- Scopus rating (2006): SJR 3.41 SNIP 1.924
- Web of Science (2006): Indexed yes
- Scopus rating (2005): SJR 3.703 SNIP 1.918
- Web of Science (2005): Indexed yes
Recovery from optic neuritis: an ROI-based analysis of LGN and visual cortical areas

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Copenhagen University Hospital
Authors: Korsholm, K. (Ekstern), Madsen, K. H. (Intern), Frederiksen, J. L. (Ekstern), Skimminge, A. J. M. (Intern), Lund, T. (Ekstern)
Pages: 1244
Publication date: 2007
Main Research Area: Technical/natural sciences

Publication information
Journal: Brain
Volume: 130
Issue number: 5
ISSN (Print): 0006-8950
Ratings:
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Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): SJR 5.472 SNIP 2.732 CiteScore 7.31
BFI (2015): BFI-level 2
Web of Science (2015): Indexed yes
Shifted Independent Component Analysis

General information
State: Published
Organisations: Cognitive Systems, Department of Informatics and Mathematical Modeling
Authors: Mørup, M. (Intern), Madsen, K. H. (Intern), Hansen, L. K. (Intern)
Pages: 89-96
Publication date: 2007

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Title of host publication: 7th International Conference on Independent Component Analysis and Signal Separation: ICA2007
Main Research Area: Technical/natural sciences
Shifted Independent Component Analysis (SICA)
Electronic versions:
SICA.pdf
Source: orbit
Source-ID: 209046
Publication: Research - peer-review › Article in proceedings – Annual report year: 2007
Shifted Non-negative Matrix Factorization

Non-negative matrix factorization (NMF) has become a widely used blind source separation technique due to its part-based representation and ease of interpretability. We currently extend the NMF model to allow for delays between sources and sensors. This is a natural extension for spectrometry data where a shift in onset of frequency profile can be induced by the Doppler effect. However, the model is also relevant for biomedical data analysis where the sources are given by compound intensities over time and the onset of the profiles have different delays to the sensors. A simple algorithm based on multiplicative updates is derived and it is demonstrated how the algorithm correctly identifies the components of a synthetic data set. Matlab implementation of the algorithm and a demonstration data set is available.

General information
State: Published
Organisations: Cognitive Systems, Department of Informatics and Mathematical Modeling
Authors: Mørup, M. (Intern), Madsen, K. H. (Intern), Hansen, L. K. (Intern)
Pages: 139-144
Publication date: 2007

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Title of host publication: 2007 IEEE International Workshop on MACHINE LEARNING FOR SIGNAL PROCESSING : MLSP2007
Publisher: IEEE
ISBN (Print): 978-1-4244-1565-6
Main Research Area: Technical/natural sciences
Non-negative Matrix Factorization (NMF), Shift invariance
Electronic versions:
ShiftNMFupdated.pdf
Madsen.pdf
DOIs:
10.1109/MLSP.2007.4414296

Bibliographical note
Copyright: 2007 IEEE. Personal use of this material is permitted. However, permission to reprint/republish this material for advertising or promotional purposes or for creating new collective works for resale or redistribution to servers or lists, or to reuse any copyrighted component of this work in other works must be obtained from the IEEE
Source: orbit
Source-ID: 209047
Publication: Research - peer-review › Article in proceedings – Annual report year: 2007

Adaptive regularization of noisy linear inverse problems

General information
State: Published
Organisations: Cognitive Systems, Department of Informatics and Mathematical Modeling
Authors: Hansen, L. K. (Intern), Madsen, K. H. (Intern), Lehn-Schiøler, T. (Intern)
Publication date: 2006

Host publication information
Title of host publication: Eusipco
Main Research Area: Technical/natural sciences
Electronic versions:
imm4417.pdf
Links:
http://www2.imm.dtu.dk/pubdb/p.php?4417
Source: orbit
Source-ID: 191538
Publication: Research - peer-review › Article in proceedings – Annual report year: 2006

An fMRI study of the neural correlates of graded visual perception

General information
State: Published
Organisations: Cognitive Systems, Department of Informatics and Mathematical Modeling
Authors: Christensen, M. S. (Ekstern), Ramsoy, T. (Ekstern), Lund, T. (Ekstern), Madsen, K. H. (Intern), Rowe, J. (Ekstern)
Functional magnetic resonance imaging corresponds to

Identification of non-linear models of neural activity in fMRI

Non-linear hemodynamic models express the BOLD signal as a nonlinear, parametric functional of the temporal sequence of local neural activity. Several models have been proposed for this neural activity. We identify one such parametric model by estimating the distribution of its parameters. These distributions are themselves stochastic, therefore we estimate their variance by epoch based leave-one-out cross validation, using a Metropolis-Hastings algorithm for sampling of the posterior parameter distribution.
Images of illusory motion in primary visual cortex

General information
State: Published
Organisations: Cognitive Systems, Department of Informatics and Mathematical Modeling
Authors: Larsen, A. (Ekstern), Madsen, K. H. (Intern), Lund, T. (Ekstern), Bundesen, C. (Ekstern)
Pages: 1174-1180
Publication date: 2006
Main Research Area: Technical/natural sciences

Publication information
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Volume: 18
Issue number: 7
ISSN (Print): 0898-929X
Ratings:
Web of Science (2017): Indexed Yes
Scopus rating (2016): SJR 2.414 SNIP 1.014 CiteScore 3.44
Scopus rating (2015): SJR 2.704 SNIP 1.175 CiteScore 3.83
Scopus rating (2014): SJR 3.129 SNIP 1.404 CiteScore 4.63
Scopus rating (2013): SJR 3.649 SNIP 1.709 CiteScore 5.44
Web of Science (2013): Indexed yes
Scopus rating (2012): SJR 3.601 SNIP 1.546 CiteScore 5.39
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 3.93 SNIP 1.774 CiteScore 5.71
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 3.572 SNIP 1.758
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 4.031 SNIP 1.853
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 3.618 SNIP 1.658
Scopus rating (2007): SJR 3.857 SNIP 1.748
Scopus rating (2006): SJR 3.381 SNIP 1.693
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 3.761 SNIP 1.881
Scopus rating (2004): SJR 3.834 SNIP 1.833
Scopus rating (2003): SJR 4.336 SNIP 2.095
Non-white noise in fMRI: Does modelling have an impact?
The sources of non-white noise in Blood Oxygenation Level Dependent (BOLD) functional magnetic resonance imaging (fMRI) are many. Familiar sources include low-frequency drift due to hardware imperfections, oscillatory noise due to respiration and cardiac pulsation and residual movement artefacts not accounted for by rigid body registration. These contributions give rise to temporal autocorrelation in the residuals of the fMRI signal and invalidate the statistical analysis as the errors are no longer independent. The low-frequency drift is often removed by high-pass filtering, and other effects are typically modelled as an autoregressive (AR) process. In this paper, we propose an alternative approach: Nuisance Variable Regression (NVR). By inclusion of confounding effects in a general linear model (GLM), we first confirm that the spatial distribution of the various fMRI noise sources is similar to what has already been described in the literature. Subsequently, we demonstrate, using diagnostic statistics, that removal of these contributions reduces first and higher order autocorrelation as well as non-normality in the residuals, thereby improving the validity of the drawn inferences. In addition, we also compare the performance of the NVR method to the whitening approach implemented in SPM2.

General information
State: Published
Organisations: Cognitive Systems, Department of Informatics and Mathematical Modeling
Authors: Lund, T. E. (Ekstern), Madsen, K. H. (Intern), Sidaros, K. (Intern), Lou, W. L. (Ekstern), Nichols, T. (Ekstern)
Pages: 54-66
Publication date: 2006
Main Research Area: Technical/natural sciences

Publication information
Journal: Neuroimage
Volume: 29
Issue number: 1
ISSN (Print): 1053-8119
Ratings:
BFI (2018): BFI-level 2
BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 6.31 SJR 3.823 SNIP 1.752
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 4.48 SNIP 1.84 CiteScore 6.71
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 4.201 SNIP 2.029 CiteScore 6.9
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 4.376 SNIP 2.026 CiteScore 7.06
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 3.922 SNIP 1.937 CiteScore 6.86
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 3.626 SNIP 1.81 CiteScore 6.31
ISI indexed (2011): ISI indexed yes
Sparse PCA, a new method for unsupervised analyses of fMRI data

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics
Authors: Sjöstrand, K. (Intern), Lund, T. E. (Ekstern), Madsen, K. H. (Intern), Larsen, R. (Intern)
Publication date: 2006

Host publication information
Publisher: ISMRM
Main Research Area: Technical/natural sciences
Conference: 14th Scientfic Meeting and Exhibition of International Society for Magnetic Resonance in Medicine, Seattle, WA, United States, 06/05/2006 - 06/05/2006
Electronic versions:
imm4407.pdf
Links:
http://www2.imm.dtu.dk/pubdb/p.php?4407
Source: orbit
Source-ID: 191595
Publication: Research - peer-review › Article in proceedings – Annual report year: 2006
Simultaneous acquisition of polar and eccentricity mappings of the human visual cortex using fMRI

Projects:

Prospective Motion Correction in Magnetic Resonance Imaging

Department of Electrical Engineering
Period: 01/08/2017 → 31/07/2020
Number of participants: 4
PhD Student: Laustsen, Malte (Intern)
Supervisor: Madsen, Kristoffer Hougaard (Intern)
Xue, Rong (Ekstern)
Main Supervisor: Hanson, Lars G. (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD

Causal fingerprints of brain connectivity

Department of Applied Mathematics and Computer Science
Period: 01/07/2017 → 30/06/2020
Number of participants: 4
PhD Student:
A Probabilistic Framework for Tensor Methods with Applications in the Life Sciences
Department of Applied Mathematics and Computer Science
Period: 01/01/2017 → 31/12/2019
Number of participants: 3
Phd Student:
Hinrich, Jesper Løve (Intern)
Supervisor:
Madsen, Kristoffer Hougaard (Intern)
Main Supervisor:
Mørup, Morten (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD

Decreasing the spatial uncertainty in non-invasive brain stimulation, EEG and MEG based on advanced head modelling
Department of Applied Mathematics and Computer Science
Period: 15/10/2015 → 14/10/2018
Number of participants: 4
Phd Student:
Nielsen, Jesper Duemose (Intern)
Supervisor:
Madsen, Kristoffer Hougaard (Intern)
Thielscher, Axel (Intern)
Main Supervisor:
Hansen, Lars Kai (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD

Modeling Temporal Dynamics in Functional Brain Connectivity
Department of Applied Mathematics and Computer Science
Period: 15/08/2015 → 14/08/2018
Number of participants: 4
Phd Student:
Nielsen, Søren Føns Vind (Intern)
Supervisor:
Madsen, Kristoffer Hougaard (Intern)
Schmidt, Mikkel Nørgaard (Intern)
Main Supervisor:
Mørup, Morten (Intern)

Financing sources
Bayesian Modelling of Functional Whole Brain Connectivity

Department of Applied Mathematics and Computer Science
Period: 01/02/2014 → 14/06/2017
Number of participants: 7
Phd Student:
Rege, Rasmus (Intern)
Supervisor:
Madsen, Kristoffer Hougaard (Intern)
Schmidt, Mikkel Nørgaard (Intern)
Main Supervisor:
Merup, Morten (Intern)
Examiner:
Hansen, Lars Kai (Intern)
Penny, William D. (Ekstern)
Särkkä, Simo (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet

Relations
Publications:
Bayesian Modelling of Functional Whole Brain Connectivity
Project: PhD

Motion-insensitive Magnetic Resonance Imaging

Department of Electrical Engineering
Period: 01/12/2012 → 16/03/2016
Number of participants: 6
Phd Student:
Andersen, Mads (Intern)
Supervisor:
Madsen, Kristoffer Hougaard (Intern)
Main Supervisor:
Hanson, Lars G. (Intern)
Examiner:
Thielscher, Axel (Intern)
Bowtell, Richard William (Ekstern)
Ringgaard, Steffen (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: ErhvervsPhD-ordningen VTU
Project: PhD

Mapping the functional integration in the human basal ganglia by means of multi-modal magnetic resonance imaging

Department of Applied Mathematics and Computer Science
Period: 01/12/2010 → 26/05/2014
Number of participants: 8
Phd Student:
Andersen, Kasper Winther (Intern)
Supervisor:
Dyrby, Tim Bjørn (Intern)
Madsen, Kristoffer Hougaard (Intern)
Siebner, Hartwig R. (Ekstern)
Main Supervisor:
Hansen, Lars Kai (Intern)
Examiner:
Winther, Ole (Intern)
Heskes, Tom (Ekstern)
Thirion, Bertrand (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU) Samf.
Project: PhD

Integrative multimodal brain imaging
Department of Informatics and Mathematical Modeling
Period: 15/12/2008 → 30/04/2012
Number of participants: 6
Phd Student:
Rasmussen, Peter Mondrup (Intern)
Supervisor:
Lund, Torben E. (Ekstern)
Madsen, Kristoffer Hougaard (Intern)
Main Supervisor:
Hansen, Lars Kai (Intern)
Examiner:
Larsen, Jan (Ekstern)
Siebner, Hartwig R. (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
Project: PhD

Funktionelle hjernebilleder - Modellering og data-analyse
Department of Informatics and Mathematical Modeling
Period: 01/09/2004 → 17/06/2009
Number of participants: 8
Phd Student:
Madsen, Kristoffer Hougaard (Intern)
Supervisor:
Larsen, Axel (Ekstern)
Lund, Torben E. (Ekstern)
Sidaros, Karam (Intern)
Main Supervisor:
Hansen, Lars Kai (Intern)
Examiner:
Larsen, Jan (Ekstern)
Adali, Tulay (Ekstern)
Kjær, Troels Wesenberg (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: DTU-lønnet stipendie
Project: PhD