平成16年度生理研研究会「神経科学の道具としての機能的MRI研究会」

機能的磁気共鳴画像法（機能的MRI）の技術的ならびに生理学的な諸課題について議論・情報交換をおこなう。

開催日　平成16年11月25日(木) 13：00～26日（金）12：10
会場　自然科学研究機構・生理学研究所1階会議室
内容　研究テーマに関する講演発表と質疑
提案代表者　程　康（理化学研究所）
所内世話人　定藤規弘

11月25日（木）

		演題番号			
1300	～ 1335	1	Experimental design of event-related FMRI	河内山　隆紀	香川大学工学部
1335	～ 1410	2	Innovation Approach to detecting connectiity in multivate time series	Galka　Andreas	統計数理研究所
1410	～ 1430		コーヒーブレイク		
1430	～ 1505	3	Fusing　EEG　and fMRI based on a bottom-up model:Inferring activation and effective connectivity in neural masses	Riera J., Aubert E., Iwata K., Kawashima R., Wan X., Ozaki T.	NICHe,Tohoku University
1505	～ 1540	4	Linear vs nonlnear influences of EEG ryhthms on the fMRI	Fumikazu Miwakeichi(1), Pedro A. Valdes-Sosa(2), Jorge Bosch(2), Hiroaki Mizuhara(1), Yoko Yamaguchi(1)	(1)　RIKEN Brain Science Institute, Lab. For Dynamics of Emergent Intelligence (2)　Cuban Neuroscience Center
1540	～ 1615	5	Rhythm networks for cognitive processing revealed by a simultaneous fMRI and EEG	Hiroaki Mizuhara1, Li-Qun Wang2, Koichiro Kobayashi3,1,4, Yoko Yamaguchi1,4	[1]RIKEN Brain Science Institute, [2]Tokyo Denki University, [3]Iwate University, [4]CREST, JST
1615	～ 1650	6	MRIにおける中心周波数（f0）の役割とその変動のfMRIへの影響	島田育廣1), 藤本一郎1), 赤土裕子1), カラン明子1), 正木信夫1), 村瀬研也2)	1)(株) 国際電気通信基礎技術研究所 脳活動イメージングセンタ 2)大阪大学大学院　医学系研究科 医用物理工学講座
1650	～ 1725	7	機能的MRIを用いた小児中枢性聴覚障害スクリーニング法の開発	中井昭夫、川谷正男、眞弓光文(1),柏倉健一(2),藤原康博、石森佳幸(3),米倉義晴(4),定藤規弘(5)	(1)福井大学（2）群馬県立医療短期大学（3）福井大学医学部付属病院放射線科（4）福井大学高エネセン（5）生理学研究所
1800	～		懇親会(5F談話室)		

11月26日（金）

		演題番号			
900	～ 1000	8	Decoding the perceptual and subjective contents of the human brain	Yukiyasu Kamitani	Computational Neuroscience Laboratories
1000	～ 1020		コーヒーブレイク		
1020	～ 1055	9	Seeing a dreaming brain -Brain activation preceded rapid eye movements during REM sleep-	Satoru Miyauchi, Masaya Misaki, Takahide Fukunaga, Shigeyuki Kan	Brain Information Group, Kansai Advanced Research Center, National Institute of Information and Communications Technology
1055	～ 1130	10	fMRIにおける指部への空気圧刺激を用いた系列運動課題実験	堀江亮太(1), 平田智秋(1), R. Allen Waggoner(2), 上野賢一(2), 田中啓治(2), 程康(2), 谷淳(1)	独立行政法人理化学研究所, 脳科学総合研究センター, 動的認知行動研究チーム(1), 認知機能表現研究チーム(2)
1130	～ 1205	11	Capillary level imaging of local cerebral blood flow in epileptic foci	Hajime Hirase	RIKEN Brain Science Institute Hirase Reserch Unit
1205	～ 1210		閉会		

1.Experimental design of event-related FMRI

河内山隆紀
香川大学工学部

近年、**fMRI** 実験における **event-related design** の利用が増えている。**Event-related design** は、刺激に対する血流動態の応答関数を推定できるだけでなく、刺激のシークエンスを自在に組むことができるので、特に高次認知機能に関する実験において慣れや予測の影響を抑えた実験が可能である。**Event-related design** は、脳機能画像法において非常に有用な実験計画法であるが、設計や解析に関して多くの注意点も存在する。中でも課題･刺激呈示のシークエンスは、その選択によって、興味ある脳活動に対する計画行列の検出能力が大きく変わるため、実験前に何らかのシークエンス最適化の作業を行うことが推奨されている。先行研究では、あるコントラストに対して最適化された計画行列は、別のコントラストに対しては必ずしも最適ではないことが報告された。本研究では、(1) 複数のコントラストに関心がある場合の計画行列最適化に関する新しい評価関数と (2) 最適化された計画行列が、統計的第一種と第二種過誤をどの程度制御できるかを検証した。

2. Innovation Approach to detecting connectiity in multivate time series

Andreas Galka
Institute of Statistical Mathematics
Department of Prediction and Control

This talk presents a new approach to inferring the connectivity structure of spatially extended dynamical systems (such as brain) by estimating mutual information between pairs of sites, based on spatiotemporal data sets (such as fMRI). This approach is based on explicit temporal and spatial modelling steps which aim at removing approximately all spatial and temporal correlations, i.e.\ at whitening the data, such that it is replaced by spatiotemporal innovations; thereby a link to the maximum-likelihood method is provided and, for appropriately chosen models, the problem of having to estimate probability distributions of unknown shape is removed. Consequently mutual information can be reinterpreted in the framework of dynamical model comparison, since it is shown to be equivalent to the difference of the log-likelihoods of coupled and uncoupled models for a pair of sites. The practical application of this methodology is demonstrated by employing a simulated data set generated by a stochastic coupled-map lattice.

3. Fusing EEG and fMRI based on a bottom-up model: Inferring activation and effective connectivity in neural masses

Riera J., Aubert E., Iwata K., Kawashima R., Wan X., Ozaki T.
NICHe,Tohoku University

The elucidation of the complex machinery used by the human brain to segregate and integrate information while performing high cognitive functions constitutes a subject of imminent future consequences. The most significant contributions in this field, named cognitive neuroscience, have been achieved up today by using innovative neuroimaging techniques (such as EEG and fMRI), which measure variations in both time and space of some interpretable physical magnitudes. Extraordinary maps of the cerebral activation involving function-restricted brain areas and their graphs of functional connectivity have been obtained from EEG and fMRI data by solving some sort of spatio-temporal inverse problems, in which constitutes a top-down approach. However, in many cases, a natural bridge between these maps/graphs and the causal physiological processes is lack, originating some misunderstandings in their interpretation. The recent advances in the comprehension of the underlying physiological mechanisms associated to different cerebral scales have provided to researchers with an excellent scenario to develop sophisticated biophysical models that permit an integration of these neuroimage modalities, which must share a common etiology. In this paper, a bottom-up approach, involving physiological parameters in specific mesocopic dynamical equations, is proposed. Further observation equations encapsulating the relationship between the meso-states and the EEG/fMRI data are obtained on the basis of the physical foundations of these techniques. A methodology for the estimation of parameters from fused EEG/fMRI data is also presented. In this context, the concepts of activation and effective connectivity are carefully revised. This new approach permited us to examine some future prospects for the integration of multimodal neuroimages

4.Linear vs nonlinear influences of EEG rhythms on the fMRI

Fumikazu Miwakeichi(1), Pedro A. Valdes-Sosa(2), Jorge Bosch(2),
Hiroaki Mizuhara(1), Yoko Yamaguchi(1)
(1) RIKEN Brain Science Institute, Lab. For Dynamics of Emergent Intelligence
(2) Cuban Neuroscience Center

Concurrent EEG/fRMI offers the potential for achieving information about brain function with simultaneous high spatial and temporal resolution. One approach takes advantage of the temporal fluctuations of the EEG frequency spectrum by using its envelope as a reference signal in order to identify that portion of the BOLD signal related to oscillatory networks [Goldman et al.(NeuroReport 2002); Laufs et al.(NeuroImage 2003)]. We have recently shown that multi-linear statistical methods allow a fruitful exploration of these EEG/fMRI relations. Miwakeichi et al.[NeuroImage 2004] showed that Parallel Factor Analysis (PARAFAC) can perform a time/frequency/spatial (T/F/S) atomic decomposition that identifies fundamental modes of oscillatory EEG activity. Martinez et al.[NeuroImage 2004] then went on to relate these modes to spatial components of BOLD signal changes. A limitation of all these studies is the assumption of a linear relation of the EEG with a "standard" hemodynamic response function (HRF) modeled as a sum of gamma functions. This study will examine these assumptions.

The EEG of a subject was obtained for every 30 seconds during two conditions: resting and mental arithmetic task; and then transformed into a three dimensional T/F/S data set by a Morlet wavelet transform. The temporal signatures of the alpha and theta atoms were used to predict the BOLD signal. The model used for prediction was a semi-parametric auto-regression [Speckman(J. Roy Stat. Soc. B 1988)],. This allows the separation of the HRF into purely linear and nonlinear portions and to test which parts are present in the data. Additionally the nonlinear part is estimated non-parametrically, which allows examination of the type of nonlinearity that underlies the HRF. A segmentation of the brain into regions in which the HRF is linear and nonlinear will be shown.

5. Rhythm networks for cognitive processing revealed by a simultaneous fMRI and EEG

Hiroaki Mizuhara[1], Li-Qun Wang[2], Koichiro Kobayashi[3,1,4], Yoko Yamaguchi[1,4]
[1]RIKEN Brain Science Institute, [2]Tokyo Denki University, [3]Iwate University, [4]CREST, JST

A number of electrophysiological and noninvasive brain measurement studies in rodents and humans have suggested the importance of phase synchronization in theta rhythm, local field potential oscillation in 4- to 8-Hz, in cognition, behavior and memory. Theta rhythm activities known to distribute over various cortices might integrate distant regions into a task-dependent coherent ensemble. In this paper, we hypothesize that phase synchronization of scalp electroencephalography (EEG) theta rhythm can index distant regional activities integrated with theta oscillations measured by functional magnetic resonance imaging (fMRI). By using simultaneous EEG and fMRI, we developed a method to abstract blood oxygen level dependent (BOLD) signals associated with the EEG phase synchronization. Firstly we identified phase synchronization indexes (PSI) of each pairs of EEG electrode by computing the angular dispersions of the phase differences, and tested the task-dependent increase of phase synchronizations during a mental arithmetic task relative to that during the eye close resting. Based on the EEG PSI, we estimated the BOLD responses (expected BOLD) by convoluting the hemodynamic response function (HRF) to the time series of the EEG PSI. Thus, here we assumed that the long-range phase synchronization accompanied the local neuronal activities in the distant cortical regions, and the BOLD responses occurred after the proper neuronal activities with a time delay, which was decided by HRF. The regression values were computed between the measured BOLD and the expected BOLD. The results showed that long-range theta synchronization concerns with integration of a distant cortical network for cognitive task processing where positive and negative BOLD responses cooperate together.

6.MRI における中心周波数(f0)の役割とその変動の fMRI への影響

島田育廣 1), 藤本一郎 1), 赤土裕子 1), カラン明子 1), 正木信夫 1), 村瀬研也 2)

中心周波数 (f0) は MRI 画像の基本となる情報である. この変動が画像の位置ズレを生じることは良く知られているが, 信号ドリフトとの関係についてはほとんど論じられてこなかった. fMRI データでしばしば報告される低周波の信号ドリフトは, この中心周波数の変動によって引き起こされると考えられる. 試作 Phantom を用いた時系列信号変動の再現実験を行ったところ, 信号ドリフトはスキャンボリュームの全スライスで同一パターンを示さなかった. この結果は, fMRI 解析において, 中心周波数変動の影響を補正するためには, 位置ズレ補正のみでは不十分であり, 脂肪抑制パルスの波形特性の影響を考慮する必要があることを示唆する。

所属=1)(株) 国際電気通信基礎技術研究所 脳活動イメージングセンタ
2)大阪大学大学院 医学系研究科 医用物理工学講座

7.機能的 MRI を用いた小児中枢性聴覚障害スクリーニング法の開発

福井大学医学部病態制御医学講座小児科学　中井昭夫、川谷正男、眞弓光文
群馬県立医療短期大学診療放射線学科　柏倉健一
福井大学医学部附属病院放射線科　藤原康博、石森佳幸
福井大学高エネルギー医学研究センター　米倉義晴
自然科学研究機構生理学研究所　大脳皮質機能研究系心理生理学研究部門　定藤規弘

【はじめに】
先天性難聴に対し新生児スクリーニングが行われているが、一次聴覚中枢障害は ABR でも見落とされ、後にコミュニケーション・知能障害につながる。fMRI は強力な脳機能画像法だが、聴覚については機器からのノイズが問題となる。我々はこのノイズを利用し聴覚野の反応を画像化する方法を開発、中枢性聴覚障害のスクリーニング法として有用か検討した。
【方法】
本研究は倫理委員会の承認を得、文書による同意の得られたもののみを対象とした。健常成人による基礎的検討の後、ハイリスク新生児の頭部MRIの際 fMRI を施行した。磁場コイルへの電流を一時的に停止し音圧を変化させ、これを聴覚刺激とした。
【結果】
健常成人では一次聴覚野を含む両側聴覚野に賦活が観察され、同様の賦活は乳児でも認められた。
【考案】
本法は従来困難であった中枢性聴覚機能を簡便に検出可能でスクリーニング法として有用であると思われる。

本研究は JST/RISTEX「脳科学と教育」、21 世紀 COE、森永奉仕会の補助を受けた

8.Decoding the perceptual and subjective contents of the human brain

Yukiyasu Kamitani
ATR Computational Neuroscience Laboratories

The conventional approach of neuroimaging examines how the brain "encodes" stimuli or cognitive states by mapping brain activity induced by experimental conditions. Here, I present a "decoding" approach where neuroimaging signals are used to predict, or decode, internal states of the subject. Unlike the conventional mapping approach, which localizes brain functions in an anatomically meaningful way using univariate statistics, our approach aims to extract information from apparently meaningless patterns of signals from multiple channels using statistical learning algorithms. I show that functional magnetic resonance imaging (fMRI) can measure reliable patterns of visual cortical activity that accurately predict the orientation of stimulus gratings, even though the representation of orientation in the human visual cortex (in monkeys, < 1 mm interval between iso-orienation columns) is thought to be beyond the resolution of fMRI voxels (~3 mm cube). Next, I demonstrate an example of "mind-reading" where the fMRI activity patterns learned with single gratings can be used to predict the orientation to which the subject is paying attention in two overlapping gratings. These results indicate that fMRI signals in the human visual cortex allow for accurate prediction of detailed perceptual and subjective contents of our visual experience. I will also discuss possible sources of orientation information, and applications of this approach to other domains.

9.Seeing a dreaming brain -Brain activation preceded rapid eye movements during REM sleep-

Satoru Miyauchi, Masaya Misaki, Takahide Fukunaga, Shigeyuki Kan

At the first meeting held two years ago at NIPS, we introduced "Be-fMRI (Brain event-related fMRI)" as a new method of fMRI experiments. In a Be-fMRI experiment, no stimuli are presented, and subjects are required to perform no specific tasks. Instead, other physiological indices (e.g. EEG, eye movements and so on) are simultaneously recorded with fMRI data. Also explored is brain activation that accompanies spontaneous events defined by the physiological indices. A key point in Be-fMRI is that events are not experimentally defined stimuli or tasks, but spontaneously occurring events in the brain. It implies that the fMRI activation does not necessarily follow but may precede the event. As an example of such activation, we introduce brain activation that starts before the onset of rapid eye movements during REM sleep.

所属=Brain Information Group, Kansai Advanced Research Center, National Institute of Information and Communications Technology

10.fMRI 内における指部への空気圧刺激を用いた系列運動課題実験

堀江亮太(1), 平田智秋(1), R. Allen Waggoner(2), 上野賢一(2), 田中啓治(2), 程康(2), 谷淳(1)

Serial reaction time (SRT) tasks, in which subjects respond to sequential stimuli by pressing corresponding buttons as fast and accurately as possible, are widely used in psychophysics experiments and imaging studies for investigating motor learning. It is known from previous psychophysics experiments that motor sequence learning is partially represented by the positions of responding digits. To exclude the cognitive processes involved in the visuo-motor transformation in the SRT task, we use tactile stimuli and deliver them to the corresponding digits directly. One difficulty in implementation is to deliver the stimulus to a digit and detect the response from that digit simultaneously. Additional difficulties in fMRI studies arise from the fact that metal and electrical devices cannot generally be used inside the magnet. To solve these problems, we have developed a non-metal and non-electrical apparatus with air-puffs as stimuli. The apparatus has four cylinders (corresponding to the four digits of the right hand) attached to spring-like silicon rubbers. Air-puffs are delivered to a digit through a hole in the corresponding cylinder. When the cylinder is pressed in responding to an air-puff, it moves to block the light-path so the response timing can be recorded. Subjects were trained in an SRT task, in which sequences of stimuli were generated by a simple artificial grammar, for an extended period (15 to 29 days). Subjects were scanned before and after the training. In this presentation, we will report the design and configuration of the apparatus, along with some preliminary behavioral and fMRI results.

所属：独立行政法人理化学研究所, 脳科学総合研究センター, 動的認知行動研究チーム(1), 認知機能表現研究チーム(2)

11.Capillary level imaging of local cerebral blood flow in epileptic foci

Hajime Hirase
RIKEN Brain Science Institute Hirase Reserch Unit

Vascular and neuronal activity coupling was predicted more than a century ago and is the basis of modern functional imaging techniques such as positron emission tomography (PET) and functional magnetic resonance imaging (fMRI). Despite the importance of local regulation of the blood flow, capillary level quantification of cerebral blood flow has been limited by the spatial resolution of functional imaging techniques and the depth penetration of conventional optical microscopy. Two-photon laser scanning microscope (2PLSM) has the necessary spatial resolution to image capillary red blood cell (RBC) flow in the depth of the cerebral cortex, when the serum is loaded with a dextran conjugated fluorescent dye (FITC). Using this technique, RBC flow in capillaries in layer 2/3 of the mouse somatosensory cortex was examined in vivo. Basal capillary flux was quantified as ~30 RBCs/sec. When focal interictal (epileptiform) activity was induced by local infusion of bicuculline methchloride, the average RBC flux in the epileptic foci increased by approximately 50%. The increase of RBC flux decayed monotonically with the distance from the epileptic focus and reached the control level at ~300 micrometer from the center of the epileptic focus. These results indicate that hyper-synchronized neural activity is associated with increased capillary perfusion in a localized cortical area. Notably, the spatial spread of the RBC increase associated with the focal epileptic events is smaller than currently available spatial resolution of fMRI.