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Poster Presentations

No. 1 Modelling the laminar GRE-BOLD signal: integrating anatomical, physiological and methodological determinants

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Spatially accurate high resolution measurements of the laminar BOLD signal may offer insights into the layered functional organization of grey matter. However, their specificity is limited by anatomical, physiological and methodological features affecting the functional point spread function (fPSF). In order to examine these, an integrated model of the laminar GRE-BOLD signal is proposed, that combines a vascular model of the cortex with a model describing the relationship between underlying physiological parameters and R2* changes. Using the new detailed model we are able to characterize the laminar GRE-BOLD signal dependency on physiological and partial volume effects.

No. 2 An approach to Layer-specific functional imaging of human primary somatosensory cortex

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Layer-specific functional imaging of contralateral primary somatosensory cortex (S1) is challenging due to its microcircuitry-related smaller layer thickness, its receptive field distribution and input-dependent signaling behavior. We characterized signal changes in layers of S1 and primary motor cortex (M1) for two conditions: one input task (electrical finger nerve stimulation) and one input/output task (finger tapping). High resolution fMRI data (0.8 × 0.8 × 1.8 mm3) were acquired with concomitant BOLD and VASO contrasts for 14 participants using a SS-SI-VASO sequence with a 3D readout (Huber et al. 2018, NeuroImage). Data of seven participants were not considered due to poor S1 BOLD responses. For the remaining participants, we observed robust activation in BOLD and VASO during finger tapping in S1 and M1, with layer-dependent differences in amplitude, as reported before by (Huber et al. 2017, Neuron). For the electrical stimulation we found layer-dependent BOLD activation in S1, while M1 displayed strong intersubject variability in the BOLD response shape. The amplitude of the response in S1 is strongly task-dependent. The VASO data showed no significant layer profiles for finger stimulation. The response to somatosensory stimulation is highly subject-specific. Nonetheless we show the feasibility to approach layer-dependent functional imaging in S1.

No. 3 True laminar resolution fMRI of the human visual cotex at 7T

Sriranga Kashyap [1,2], Dimo Ivanov [1,2], Shubharthi Sengupta [1,2], Benedikt A. Poser [1,2], Kamil Uludag [1,2]

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Current laminar BOLD fMRI studies at ultra-high field are typically carried out at sub-millimetre spatial resolution (~0.7mm isotropic), which, however, results in each voxel covering more than one cortical layer. Thus, layer-resolved activation profile can only be obtained if such data is analysed with post-processing algorithms at a super-resolution. In this study, we demonstrate a novel functional mapping approach by acquiring fMRI data at true laminar resolution (~100µm in humans at 7T, compare it to the conventional high-resolution GE-EPI and analyse the depth-dependent BOLD signal change to visual stimulation.

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No. 4 Mapping color-selective columns in V2 across cortical depth using GE-EPI and SE-EPI

Daniel Hänelt [1], Robert Trampel [1], Shahin Nasr [2,3], Jonathan Polimeni [2,3], Roger Tootell [2,3], Martin Sereno [4], Nikolaus Weiskopf [1]

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Using ultra-high field fMRI makes in vivo examinations of columnar and laminar structures in the human cerebral cortex feasible. However, it is still under debate which acquisition technique is optimal for high-resolution fMRI. Typical acquisition protocols at lower field strengths use GE-EPI , which possesses high BOLD sensitivity but lacks specificity due to large draining veins. Because of the anisotropic macrovascular distribution in the cortex, the needed specificity towards microvascular contributions also depends on whether columnar or laminar structures are of interest. Here, we compare single-shot 2D GE-EPI and SE-EPI at 7 T in their ability and specificity to delineate colour-selective stripes in extrastriate cortex V2. Participants performed multiple sessions on different. In single sessions, stimuli consisted either of chromatic or achromatic sinusoidal moving gratings shown in different blocks. Data acquisition technique only differed in sessions between days. V2 was defined based on retinotopy and layers were estimated according to the equi-volume approach. With both sequences, stripes can be reliably identified. The column width across cortical depth is used as a measure for tangential spread. The analysis shall shed light on the issue if GE-EPI is significantly affected in tangential blurring towards the pial surface by delineating cortical columns.

No. 5 Laminar activity in the hippocampus and entorhinal cortex related to novelty and episodic encoding

Anne Maass [1], Hartmut Schütze [2], Oliver Speck [1,3,4], Andy Yonelinas [5], Claus Tempelmann [6], Hans-Jochen Heinze [1,4,6], David Berron [1], Arturo Cardenas-Blanco [1], Kay Brodersen [7], Klaas Enno Stephan [7], Emrah Düzel [1,2]

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The ability to form long-term memories for novel events depends on information processing within the hippocampus (HC) and entorhinal cortex (EC). The HC–EC circuitry shows a quantitative segregation of anatomical directionality into different neuronal layers. Whereas superficial EC layers mainly project to dentate gyrus (DG), CA3 and apical CA1 layers, HC output is primarily sent from pyramidal CA1 layers and subiculum to deep EC layers. Here we utilize this directionality information by measuring encoding activity within HC/EC subregions with 7 T high resolution functional magnetic resonance imaging (fMRI). Multivariate Bayes decoding within HC/EC subregions shows that processing of novel information most strongly engages the input structures (superficial EC and DG/CA2–3), whereas subsequent memory is more dependent on activation of output regions (deep EC and pyramidal CA1). This suggests that while novelty processing is strongly related to HC–EC input pathways, the memory fate of a novel stimulus depends more on HC–EC output.

No. 6 Vascular point spread function in real cortical vessel networks

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No. 7 Laminar profiles dissociate attentional and crossmodal influences in sensory cortices

Remi Gau [1], Pierre-Louis Bazin [2,3,4], Robert Trampel [2], Robert Turner [2,4,5], Uta Noppeney [1]

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Where and how the human brain integrates information from different senses is critical for our understanding of the cortical organization of sensory processing. In given sensory cortical area, non-stimuli of non-preferred sensory modalities can induce cross-modal deactivations when presented alone, or modulate the neural response to the preferred modality when the two sensory modalities are simultaneously presented. Yet, the neural mechanisms remain unknown. Multisensory influences on BOLD-responses in sensory cortices may rely on sensory-driven mechanisms with direct inputs from the thalamus or from other sensory cortices and/or on top-down attentional with influences from higher order cortical areas. To dissociate sensory from attentional mechanisms we presented participants with auditory, visual or audiovisual looming stimuli under selective auditory or visual attention and measured their BOLD-response using high-resolution fMRI at 7T. Combining laminar and multivariate pattern analyses, we observed different laminar profiles for cross-modal deactivation and modulation by attention in the primary auditory area and the planum temporale, whereas cross-modal deactivations and attentional effects showed similar profiles (on average) but differed in their spatial topography in the primary and higher order visual areas. These results suggest that multisensory and attentional influences in early sensory cortices rely on partly distinct neural mechanisms.

No. 8 Layer-dependent cortical myelin and iron in younger and older adults

Juliane Döhler [1,2], Pierre-Louis Bazin [2,3], Arno Villringer [2], Daniel Hänelt [2], Thomas Wolbers [1,4], Esther Kühn [1,2,4]

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There are substantial changes in human brain anatomy over the adult lifespan. Lately, advances in ultra-high field magnetic resonance imaging (MRI) at 7 Tesla offer the possibility to study age-related changes in human cortical microstructure in vivo. In the present investigation, we targeted the question of how aging shapes myelin levels across cortical depth in human primary somatosensory and motor cortex. In particular, we ask how myelin levels interact across cortical laminae, and how age-related changes in myelin levels occur in laminar profiles. For this purpose, ultra-high resolution in-vivo laminar myelin profiles were compared between two different age groups (young adults: mean age 25 years, and old adults: mean age 70 years). Here, we present first single subject datasets that indicate changes of the laminar myeloarchitecture with advancing age.

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No. 9 Colum- and layer-specific profiles of visually-driven maps in area 3b

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For a long time, the multisensory response properties of human primary somatosensory cortex (area 3b) have been unclear. Recently, we shed light on this issue by showing topographically arranged visually-driven maps in human area 3b using ultra-high field imaging at 7T that overlapped with the tactile maps of the native modality (Kuehn et al. 2018 J Neurosci). Here, we asked whether the visually-driven (non-primary) and tactile (primary) maps activate the same or different layer profiles in the same tangential map area. We show a preferential activation of superficial cortical layers by tactile maps, and a preferential activtaion of deep cortical layers by visual maps. This shows two distinct but overlapping topographic maps in area 3b. Our results question some of the current concepts on multisensory integration, cortical coding, and the multisensory response properties of early sensory cortex.

No. 10 Beyond high resolution: A glimpse into the future

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Higher field strength allows greater signal-to-noise ratio (SNR) and, in return, enables increased spatial resolution. Increased spatial resolution of anatomical data may lead to superior depiction of cortical and subcortical substructures as well as their vascularization. However, high spatial resolution imaging with sufficient SNR leads to prolonged time of acquisition. This increases the likelihood of subject motion, which limits the effective resolution. Here, we addressed such limitations by utilizing prospective motion correction, allowing to correct even subtle rigid motion during the acquisition of MR images induced by the heart beat and breathing cycle. By correcting the subject's motion we were able to acquire T1w and angiography data with an isotropic resolution of up to 250 µm and 150 µm, respectively. Besides detailing the acquisition and processing, potential use cases of such data are discussed.

No. 11 High resolution in vivo diffusion weighted imaging of the human occipital cortex: anabled by 300mt/m gradients and flexible radio-frequency surface coils

Evgeniya Kirilina [1,2], Fakhereh Movahedian Attar [1], Luke J. Edwards [1,2], Kerrin S. Pine [1], Nikolaus Weiskopf [1]

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No. 12 Alterations of feedforward and feedback characteristics of intracortical crossmodal connections due to the loss of early sensory experience

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The nervous system integrates information from multiple senses. This multisensory integration already occurs in primary sensory cortices and is substantially mediated by corticocortical connections across modalities. Sensory loss from birth results in functional recruitment of the deprived cortical territory by the spared senses but the underlying cortical circuit changes are not well known. By using tracer injections into primary auditory, somatosensory and visual cortex after first postnatal month of life in a rodent model (Mongolian gerbil) we investigated anatomical changes of the crossmodal intracortical connectivity patterns due to early auditory, somatosensory or visual deprivation. Since these connections can originate in infra- (IGL) or supragranular layers (SGL), the different pathways might also signal different aspects of the sensory stimulus. Thus, we calculated a layer index (L), which provides basic information about the type of a projection, such as feedback (majority of labeled cells in IGL), feedforward (majority of labeled cells in SGL), or lateral (also termed intrinsic; equal numbers in IGL and SGL).
Our results demonstrate that after early sensory deprivations, many intracortical connections are more formed by SGL neurons indicating that the crossmodal intracortical connections switch back to a more premature, feedforward-like stimulus-driven status.

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