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Module:	Techniques & Physics
Lecture:	Functional Imaging Basics 3 Applications
Description:	Review of MEEG and fMRI/PET applications
Author:	Dr Cyril Pernet

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Objectives:

- Identify the key areas in which functional imaging can be used

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Prerequisites:

Functional Imaging Basics 1 & 2

Which areas of research

- Functional imaging is mainly used in three areas of science and medicine.

- Basic science where the goal is to understand how the brain works, in particular where, when and how different functions are performed.

- Clinical science where the goal is to gain understanding of diseases pathology and mechanisms

- Clinical application where the goal is to help to diagnose or treat individuals.

Basic science

- Nowadays mostly non-invasive tools are used in healthy individuals.
- MEEG and fMRI research are most often associated with the field of cognitive neuroimaging.
- The main aims of this strand of research is to understand where, when and how perception (of object, sounds, emotions, intend), action and decision are performed in young, mature or old participants.

- A standard fMRI experiment could for instance ask **where in the brain something happens** – e.g. Pernet et al. 2005 ask where are letters categorized (i.e. recognized as letters). The key to such experiment is to contrast the condition of interest with others – here letters were contrasted with geometrical figures (known objects) and Korean letters (unknown) in both a categorization and a discrimination task revealing a selective response of the left fusiform gyrus.

Basic science

- fMRI can also be used to better understand **how information is processed** – and this is typically achieved using (effective) connectivity analyses. In a follow-up experiment, Levy et al. tested how reading related regions process stimuli from single Korean characters to full words. Results indicated an optimal information flow within this network that reflected individual reading performances.

- MEEG is best used to understand **when things happen**, and with appropriate design also **what is happening**. For instance, Salvia et al. looks at the perception of emotional vocal sounds (e.g. crying) and found MEG variations as early as ~100ms after onset. By manipulating the acoustical structure of sounds and regressing these variable out on the MEG signal, they showed that there early variations reflect mainly specific acoustic properties related to arousal, while affective valence only appears latter in time.

Clinical science

- Just as it is used in healthy patients, MEEG and PET/fMRI is used in patients to understand better disease related mechanisms

- **To understand the symptoms** of e.g. schizophrenia, the reward system of the brain (dopamine) as been investigated using PET and ‘model based’ fMRI. In such research there is a mathematical model of the behaviour and the parameters of such model are used to analyses brain images, revealing the dopamine network and possible defect in patients (see e.g. Deserno et al. 2013 for an overview)

Clinical application

- MEEG and fMRI have not yet fully bridge the gap between clinical research and application. The 3 main applications are:

- Using EEG as a tool for brain computer interface – measuring surface activity is used to control robotic legs or arms to help patients.
- MEG used in pre-surgical evaluation of patients with epilepsy. Recordings of neural activity are obtained at rest, ‘waiting’ for interictal spikes or seizures (usually small ones as patients with large seizures with behavioural effect cannot be imaged). Once enough events are obtained, source imaging is performed to find out where the discharges are coming from.
- fMRI is mainly used for pre-surgical mapping, being brain tumour or epilepsy. It consists in using paradigms known to activate brain areas involved in processing different types of information (motor, reading, repeating, counting, visual attention, etc) and examine how close tumours are located – therefore defining safety margins for surgery.

End of presentation

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Module Resources: Imaging Basics

- Journal Articles

- Pernet, C., Celsis, P. & Demonet, J-F. 2005 **Selective response to letter categorization within the left fusiform gyrus.** NeuroImage . 15, p. 738-744
- Levy, J., Pernet, C., Treserras, S., Boulanouar, K., Aubry, F., Démonet, J-F. & Celsis, P. 2009 **Testing for the dual-route cascade reading model in the brain: an fMRI effective connectivity account of an efficient reading style** PLoS One. 4, 8, p. e6675
- Salvia, E., Bestelmeyer, P. E. G., Kotz, S. A., Rousselet, G. A., Pernet, C. R., Gross, J. & Belin, P. 1 2014 **Single-subject analyses of magnetoencephalographic evoked responses to the acoustic properties of affective non-verbal vocalizations** Frontiers in Neuroscience. 8, DEC, 10 p., 422

Module Resources: Imaging Basics

- Journal Articles

- Decerno et al. 2013. **Reinforcement Learning and Dopamine in Schizophrenia: Dimensions of Symptoms or Specific Features of a Disease Group?** Front in Psychiatry, 4
- Ray, A & Bowyer S.M. 2010 **Clinical applications of magnetoencephalography in epilepsy.** *Annals of Indian Academy of Neurology*. 2010;13(1):14-22. doi:10.4103/0972-2327.61271.
- Zaca, D et al. 2014 **Special considerations/technical limitations of blood-oxygen-level-dependent functional magnetic resonance imaging**. Neuroimaging clinics of North America, 24(4):705-15. doi: 10.1016/j.nic.2014.07.006