DOWNLOAD PDF MAGNETIC RESONANCE NEUROIMAGING

Chapter 1 : Neuroimaging - Wikipedia

Magnetic resonance imaging (MRI) is a medical imaging technique used in radiology to form pictures of the anatomy and the physiological processes of the body in both health and disease.

X-ray images of the ventricular system within the brain were obtained by injection of filtered air directly into one or both lateral ventricles of the brain. Dandy also observed that air introduced into the subarachnoid space via lumbar spinal puncture could enter the cerebral ventricles and also demonstrate the cerebrospinal fluid compartments around the base of the brain and over its surface. This technique was called pneumoencephalography. In Egas Moniz introduced cerebral angiography , whereby both normal and abnormal blood vessels in and around the brain could be visualized with great precision. In the early s, Allan McLeod Cormack and Godfrey Newbold Hounsfield introduced computerized axial tomography CAT or CT scanning , and ever more detailed anatomic images of the brain became available for diagnostic and research purposes. In the early s MRI was introduced clinically, and during the s a veritable explosion of technical refinements and diagnostic MR applications took place. Scientists soon learned that the large blood flow changes measured by PET could also be imaged by the correct type of MRI. Functional magnetic resonance imaging fMRI was born, and since the s, fMRI has come to dominate the brain mapping field due to its low invasiveness, lack of radiation exposure, and relatively wide availability. In the early s, the field of neuroimaging reached the stage where limited practical applications of functional brain imaging have become feasible. The main application area is crude forms of brain-computer interface. Indications[edit] Neuroimaging follows a neurological examination in which a physician has found cause to more deeply investigate a patient who has or may have a neurological disorder. One of the more common neurological problems which a person may experience is simple syncope. Typically used for quickly viewing brain injuries , CT scanning uses a computer program that performs a numerical integral calculation the inverse Radon transform on the measured x-ray series to estimate how much of an x-ray beam is absorbed in a small volume of the brain. Typically the information is presented as cross-sections of the brain. The technique measures the optical absorption of haemoglobin , and relies on the absorption spectrum of haemoglobin varying with its oxygenation status. High-density diffuse optical tomography HD-DOT has been compared directly to fMRI using response to visual stimulation in subjects studied with both techniques, with reassuringly similar results. Whereas techniques such as diffuse optical imaging DOT and near-infrared spectroscopy NIRS measure optical absorption of haemoglobin, and thus are based on blood flow, EROS takes advantage of the scattering properties of the neurons themselves and thus provides a much more direct measure of cellular activity. EROS can pinpoint activity in the brain within millimeters spatially and within milliseconds temporally. Its biggest downside is the inability to detect activity more than a few centimeters deep. EROS is a new, relatively inexpensive technique that is non-invasive to the test subject. Gabriele Gratton and Dr. Magnetic resonance imaging[edit] Main article: Magnetic resonance imaging MRI uses magnetic fields and radio waves to produce high quality two- or three-dimensional images of brain structures without the use of ionizing radiation X-rays or radioactive tracers. Functional magnetic resonance imaging fMRI and arterial spin labeling ASL relies on the paramagnetic properties of oxygenated and deoxygenated hemoglobin to see images of changing blood flow in the brain associated with neural activity. This allows images to be generated that reflect which brain structures are activated and how during the performance of different tasks or at resting state. According to the oxygenation hypothesis, changes in oxygen usage in regional cerebral blood flow during cognitive or behavioral activity can be associated with the regional neurons as being directly related to the cognitive or behavioral tasks being attended. Most fMRI scanners allow subjects to be presented with different visual images, sounds and touch stimuli, and to make different actions such as pressing a button or moving a joystick. Consequently, fMRI can be used to reveal brain structures and processes associated with perception, thought and action. The resolution of fMRI is about millimeters at present, limited by the spatial spread of the hemodynamic response to neural activity. It has largely superseded PET for the study of brain activation patterns. PET, however, retains the significant advantage of being able to identify specific brain receptors or transporters associated with particular neurotransmitters through its ability to image radiolabelled receptor "ligands" receptor ligands are any chemicals that stick to receptors. As well as research on healthy subjects, fMRI is increasingly used for the medical diagnosis of disease. Because fMRI is exquisitely sensitive to oxygen usage in blood flow, it is extremely sensitive to early changes in the brain resulting from ischemia abnormally low blood flow , such as the changes which follow stroke. Early diagnosis of certain types of stroke is increasingly important in neurology, since substances which dissolve blood clots may be used in the first few hours after certain types of stroke occur, but are dangerous to use afterward. Brain changes seen on fMRI may help to make the decision to treat with these agents. MEG offers a very direct measurement of neural electrical activity compared to fMRI for example with very high temporal resolution but relatively low spatial resolution. The advantage of measuring the magnetic fields produced by neural activity is that they are likely to be less distorted by surrounding tissue particularly the skull and scalp compared to the electric fields measured by electroencephalography EEG. Specifically, it can be shown that magnetic fields produced by electrical activity are not affected by the surrounding head tissue, when the head is modeled as a set of concentric spherical shells, each being an isotropic homogeneous conductor. Real heads are non-spherical and have largely anisotropic conductivities particularly white matter and skull. This makes it likely that MEG is also affected by the skull anisotropy, [18] although probably not to the same degree as EEG. There are many uses for MEG, including assisting surgeons in localizing a pathology, assisting researchers in determining the function of various parts of the brain, neurofeedback, and others. Positron emission tomography[edit] Positron emission tomography PET and brain positron emission tomography , measure emissions from radioactively labeled metabolically active chemicals that have been injected into the bloodstream. The emission data are computer-processed to produce 2- or 3-dimensional images of the distribution of the chemicals throughout the brain. The labeled compound, called a radiotracer, is injected into the bloodstream and eventually makes its way to the brain. Sensors in the PET scanner detect the radioactivity as the compound accumulates in various regions of the brain. A computer uses the data gathered by the sensors to create multicolored 2- or 3-dimensional images that show where the compound acts in the brain. Especially useful are a wide array of ligands used to map different aspects of neurotransmitter activity, with by far the most commonly used PET tracer being a labeled form of glucose see Fludeoxyglucose 18F FDG. The greatest benefit of PET scanning is that different compounds can show blood flow and oxygen and glucose metabolism in the tissues of the working brain. These measurements reflect the amount of brain activity in the various regions of the brain and allow to learn more about how the brain works. PET scans were superior to all other metabolic imaging methods in terms of resolution and speed of completion as little as 30 seconds when they first became available. The improved resolution permitted better study to be made as to the area of the brain activated by a particular task. The biggest drawback of PET scanning is that because the radioactivity decays rapidly, it is limited to monitoring short tasks. Single-photon emission computed tomography[edit] Single-photon emission computed tomography SPECT is similar to PET and uses gamma ray -emitting radioisotopes and a gamma camera to record data that a computer uses to construct two- or three-dimensional images of active brain regions. These properties of SPECT make it particularly well-suited for epilepsy imaging, which is usually made difficult by problems with patient movement and variable seizure types. SPECT provides a "snapshot" of cerebral blood flow since scans can be acquired after seizure termination so long as the radioactive tracer was injected at the time of the seizure. Tomographic reconstruction , mainly used for functional "snapshots" of the brain requires multiple projections from Detector Heads which rotate around the human skull, so some researchers have developed 6 and 11 Detector Head SPECT machines to cut imaging time and give higher resolution. These must be made in a cyclotron, and are expensive or even unavailable if necessary transport times are prolonged more than a few half-lives. SPECT, however, is able to make use of tracers with much longer half-lives, such as technetiumm, and as a result, is far more widely available. Cranial ultrasound[edit] Cranial ultrasound is usually only used in babies, whose open fontanelles provide acoustic windows allowing ultrasound imaging of the brain. Advantages include the absence of ionising radiation and the possibility of bedside scanning, but the lack of soft-tissue detail means MRI is preferred for some conditions. BOLD-contrast is a naturally occurring process in the body so fMRI is often preferred over imaging methods that require radioactive markers to produce similar imaging. The magnetic resonance MR emitted from the equipment can cause failure of medical devices and attract metallic objects in the body if not properly screened for. Currently, the FDA classifies medical implants and devices into three categories, depending on MR-compatibility:

Chapter 2 : Search results for ` Magnetic Resonance Imaging` - PhilPapers

Perhaps the most significant reason for the new advances in magnetic resonance (MR) has been the rapid development of magnet and field gradient designs at higher field strengths of 3 tesla (T) and more recently, 7 T. 1 - 5 From its beginning in the s, MR as an imaging method suffered from.

Imaging Brain Activity Courtesy of Dr. David Shin, UC San Diego In your brain the activity of the neurons constantly fluctuates as you engage in different activities, from simple tasks like controlling your hand to reach out and pick up a cup of coffee to complex cognitive activities like understanding language in a conversation. The brain also has many specialized parts, so that activities involving vision, hearing, touch, language, memory, etc. Even when you rest quietly with your eyes closed the brain is still highly active, and the patterns of activity in this resting state are thought to reveal particular networks of areas that often act together. Functional magnetic resonance imaging fMRI is a technique for measuring and mapping brain activity that is noninvasive and safe. It is being used in many studies to better understand how the healthy brain works, and in a growing number of studies it is being applied to understand how that normal function is disrupted in disease. It works by exploiting the fact that the nucleus of a hydrogen atom behaves like a small magnet. Using the phenomenon of nuclear magnetic resonance NMR , the hydrogen nuclei can be manipulated so that they generate a signal that can be mapped and turned into an image. When you lay in the strong magnetic field of an MRI system all of the hydrogen nuclei in your body, most of which are in water molecules, tend to align with that magnetic field. When a radio frequency RF magnetic pulse is applied at the right frequency, these hydrogen nuclei absorb energy and then create a brief, faint signal the MR signal that is detected by the RF coils in the MRI system. The MR image is a map of the distribution of the MR signal, and by manipulating the timing of the RF pulses and the delays before detecting the signal MRI is a sensitive tool for detecting subtle changes in brain anatomy. However, mapping brain structure is not the same as mapping brain function. Spontaneous fluctuations in brain activity observed with functional magnetic resonance imaging. The discovery that MRI could be made sensitive to brain activity, as well as brain anatomy, is only about 20 years old. The essential observation was that when neural activity increased in a particular area of the brain, the MR signal also increased by a small amount. In the simplest fMRI experiment a subject alternates between periods of doing a particular task and a control state, such as 30 second blocks looking at a visual stimulus alternating with 30 second blocks with eyes closed. The fMRI data is analyzed to identify brain areas in which the MR signal has a matching pattern of changes, and these areas are taken to be activated by the stimulus in this example, the visual cortex at the back of the head. Instead, the MR signal change is an indirect effect related to the changes in blood flow that follow the changes in neural activity. The picture of what happens is somewhat subtle, and depends on two effects. The first effect is that oxygen-rich blood and oxygen-poor blood have different magnetic properties related to the hemoglobin that binds oxygen in blood. This has a small effect on the MR signal, so that if the blood is more oxygenated the signal is slightly stronger. The second effect relates to an unexpected physiological phenomenon. For reasons that we still do not fully understand, neural activity triggers a much larger change in blood flow than in oxygen metabolism, and this leads to the blood being more oxygenated when neural activity increases. Blood Flow Dynamics Provides a Sensitive Window on Brain Function Blood flow to an area of the brain is remarkably sensitive to changes in neural activity. For this reason, blood flow changes are a sensitive indicator of underlying neural activity changes. However, these large blood flow fluctuations still result in a BOLD signal change that is only a few percent. Nevertheless, this makes it possible to map changes in activity associated with a wide range of motor, sensory and cognitive tasks. In addition, in recent years it has become clear that there is a great deal of information on how the brain is organized just in the way different brain regions continue to fluctuate together even when you are not doing a particular task. The strength of these resting state networks RSN also changes with disease, and an important goal is to investigate whether psychiatric disease can be understood in terms of disorders of these basic networks. One of the limitations of the BOLD signal is that it is always a signal change between two conditions, such as tapping your fingers compared to resting. For this reason, BOLD imaging can tell us nothing about the actual level of blood flow before the task started. With ASL it is possible to measure the absolute level of blood flow in any condition. ASL works by manipulating the MR signal of arterial blood before it is delivered to different areas of the brain. By subtracting two images in which the arterial blood is manipulated differently, the static signal from all the hydrogen nuclei in the rest of the tissue subtracts out, leaving just the signal arising from the delivered arterial blood. ASL and BOLD imaging can be used together to provide a more quantitative probe of brain function, including assessment of oxygen metabolism changes, and this potential synergy is a primary motivation for ongoing research at the CFMRI in developing the next generation of fMRI methods. Lawrence Frank, UC San Diego Brain function depends on the wiring between brain regions, the complex web of axons carrying signals from one neuron to another. In addition to methods for detecting brain activation with fMRI, MRI also provides a way to measure these anatomical connections. The white matter of the brain consists of bundles of these axonal fibers, so that within a small region the fibers are all aligned, and diffusion tensor imaging DTI is able to measure the direction of this alignment. Knowing the orientation of the fibers at each point it is possible to trace paths through the brain that map the fiber tracts. The method exploits the sensitivity of the magnetic resonance signal to the small random motions of water molecules. This diffusion of water molecules is analogous to a drop of ink slowly expanding in a pool of water as the ink molecules diffuse. In white matter fiber tracts the displacements of water molecules due to diffusion are much greater along the direction of the fibers than in a perpendicular direction, making it possible to map the fiber orientation with DTI. In addition to mapping white matter fiber tracts, these methods are useful for detecting and characterizing disorders of white matter in disease. MR Microscopy Courtesy of Dr. Miriam Scadeng, UC San Diego Using our 7 Tesla scanner and special purpose coils designed for high resolution imaging, it is possible to image mice and even zebrafish with a resolution well below one tenth of a millimeter. While many of these studies also target the brain, these studies also extend outside the brain and include detailed identification of anatomical structures such as the airways of the mouse lung in this image for a variety of experiments. The insights into anatomy and physiology made possible by high resolution imaging in small animals provides a critical complement to the human studies on our 3 Tesla scanners. Since brain function depends to some extent on the integrity of brain structure, measures that characterize the underlying tissue integrity allow one to examine the impact of tissue loss or damage on functional signals. Furthermore, structural MRI provides anatomical reference for visualization of activation patterns and regions of interest to extract functional signal information. Many pulse sequences are available, emphasizing different aspects of normal and abnormal brain tissue. By modifying sequence parameters such as repetition time TR and echo time TE , for example, anatomical images can emphasize contrast between gray and white matter e. Information from structural MRI can be used to describe the shape, size, and integrity of gray and white matter structures in the brain. Morphometric techniques measure the volume or shape of gray matter structures, such as subcortical nuclei or the hippocampus, and the volume, thickness, or surface area of the cerebral neocortex. The volume of normal and abnormal white matter also can allow inference of macrostructural white matter integrity, providing indications of inflammation, edema, and demyelination; complementary microstructural studies using diffusion imaging can help to provide a more comprehensive picture of white matter integrity. Combining structural MRI, functional MRI and diffusion imaging may more broadly characterize normal and abnormal brain function, supporting biomarker studies of neurodegenerative or psychiatric disorders to determine risk, progression, and therapeutic effectiveness.

Chapter 3 : Magnetic Resonance Imaging (MRI)

Magnetic Resonance Imaging Brain MRI has been used more extensively in recent years among preterm infants, both for research and for clinical indications. MRI provides a more comprehensive and detailed picture of the brain, with better delineation of deep structure and cortical injury.

There are a number of accepted, safe imaging techniques in use today in research facilities and hospitals throughout the world. It works by detecting the changes in blood oxygenation and flow that occur in response to neural activity â€” when a brain area is more active it consumes more oxygen and to meet this increased demand blood flow increases to the active area. CT Computed tomography CT scanning builds up a picture of the brain based on the differential absorption of X-rays. During a CT scan the subject lies on a table that slides in and out of a hollow, cylindrical apparatus. An x-ray source rides on a ring around the inside of the tube, with its beam aimed at the subjects head. Images made using x-rays depend on the absorption of the beam by the tissue it passes through. Bone and hard tissue absorb x-rays well, air and water absorb very little and soft tissue is somewhere in between. Thus, CT scans reveal the gross features of the brain but do not resolve its structure well. When the material undergoes radioactive decay a positron is emitted, which can be picked up be the detector. Areas of high radioactivity are associated with brain activity. EEG Electroencephalography EEG is the measurement of the electrical activity of the brain by recording from electrodes placed on the scalp. The resulting traces are known as an electroencephalogram EEG and represent an electrical signal from a large number of neurons. EEGs are frequently used in experimentation because the process is non-invasive to the research subject. The EEG is capable of detecting changes in electrical activity in the brain on a millisecond-level. It is one of the few techniques available that has such high temporal resolution. These measurements are commonly used in both research and clinical settings. There are many uses for the MEG, including assisting surgeons in localizing a pathology, assisting researchers in determining the function of various parts of the brain, neurofeedback, and others. NIRS Near infrared spectroscopy is an optical technique for measuring blood oxygenation in the brain. It works by shining light in the near infrared part of the spectrum nm through the skull and detecting how much the remerging light is attenuated. How much the light is attenuated depends on blood oxygenation and thus NIRS can provide an indirect measure of brain activity. Types of Brain Imaging Techniques. Retrieved on November 10, , from https:

Chapter 4 : Types of Brain Imaging Techniques

magnetic resonance neuroimaging brain The phenomenon of nuclear magnetic resonance (NMR) was first observed in 1, 2 It was the injection of radiofrequency engineering expertise and the availability of stable new frequency sources, both byproducts of the wartime development of radar, which probably made the demonstration of NMR possible.

Interacting With Computers â€" Using computers and computer systems including hardware and software to program, write software, set up functions, enter data, or process information. Getting Information â€" Observing, receiving, and otherwise obtaining information from all relevant sources. Performing for or Working Directly with the Public â€" Performing for people or dealing directly with the public. This includes serving customers in restaurants and stores, and receiving clients or guests. Communicating with Supervisors, Peers, or Subordinates â€" Providing information to supervisors, co-workers, and subordinates by telephone, in written form, e-mail, or in person. Updating and Using Relevant Knowledge â€" Keeping up-to-date technically and applying new knowledge to your job. Identifying Objects, Actions, and Events â€" Identifying information by categorizing, estimating, recognizing differences or similarities, and detecting changes in circumstances or events. Evaluating Information to Determine Compliance with Standards â€" Using relevant information and individual judgment to determine whether events or processes comply with laws, regulations, or standards. Handling and Moving Objects â€" Using hands and arms in handling, installing, positioning, and moving materials, and manipulating things. Making Decisions and Solving Problems â€" Analyzing information and evaluating results to choose the best solution and solve problems. Monitor Processes, Materials, or Surroundings â€" Monitoring and reviewing information from materials, events, or the environment, to detect or assess problems. Inspecting Equipment, Structures, or Material â€" Inspecting equipment, structures, or materials to identify the cause of errors or other problems or defects. Processing Information â€" Compiling, coding, categorizing, calculating, tabulating, auditing, or verifying information or data. Organizing, Planning, and Prioritizing Work â€" Developing specific goals and plans to prioritize, organize, and accomplish your work. Establishing and Maintaining Interpersonal Relationships â€" Developing constructive and cooperative working relationships with others, and maintaining them over time. Performing General Physical Activities â€" Performing physical activities that require considerable use of your arms and legs and moving your whole body, such as climbing, lifting, balancing, walking, stooping, and handling of materials. Analyzing Data or Information â€" Identifying the underlying principles, reasons, or facts of information by breaking down information or data into separate parts. Performing Administrative Activities â€" Performing day-to-day administrative tasks such as maintaining information files and processing paperwork. Interpreting the Meaning of Information for Others â€" Translating or explaining what information means and how it can be used. Training and Teaching Others â€" Identifying the educational needs of others, developing formal educational or training programs or classes, and teaching or instructing others. Coaching and Developing Others â€" Identifying the developmental needs of others and coaching, mentoring, or otherwise helping others to improve their knowledge or skills. Thinking Creatively â€" Developing, designing, or creating new applications, ideas, relationships, systems, or products, including artistic contributions. Controlling Machines and Processes â€" Using either control mechanisms or direct physical activity to operate machines or processes not including computers or vehicles. Judging the Qualities of Things, Services, or People â€" Assessing the value, importance, or quality of things or people. Developing and Building Teams â€" Encouraging and building mutual trust, respect, and cooperation among team members. Guiding, Directing, and Motivating Subordinates â€" Providing guidance and direction to subordinates, including setting performance standards and monitoring performance. Scheduling Work and Activities â€" Scheduling events, programs, and activities, as well as the work of others. Provide Consultation and Advice to Others â€" Providing guidance and expert advice to management or other groups on technical, systems-, or process-related topics. Coordinating the Work and Activities of Others â€" Getting members of a group to work together to accomplish tasks. Resolving Conflicts and Negotiating with Others â€" Handling complaints, settling disputes, and resolving grievances and conflicts, or otherwise negotiating with others.

Communicating with Persons Outside Organization â€” Communicating with people outside the organization, representing the organization to customers, the public, government, and other external sources. This information can be exchanged in person, in writing, or by telephone or e-mail.

Chapter 5 : What Is FMRI? - Center for Functional MRI - UC San Diego

In Magnetic Resonance Neuroimaging: Methods and Protocols, expert researchers in the field provide a comprehensive collection of experimental MRI protocols that can be used to non-invasively interrogate the healthy and diseased brain.

This gives a temporal resolution of 20â€”30 ms for images with an in-plane resolution of 1. Interventional magnetic resonance imaging The lack of harmful effects on the patient and the operator make MRI well-suited for interventional radiology , where the images produced by an MRI scanner guide minimally invasive procedures. Such procedures use no ferromagnetic instruments. Some specialized MRI systems allow imaging concurrent with the surgical procedure. More typically, the surgical procedure is temporarily interrupted so that MRI can assess the success of the procedure or guide subsequent surgical work. This technology can achieve precise ablation of diseased tissue. MR imaging provides a three-dimensional view of the target tissue, allowing for the precise focusing of ultrasound energy. The MR imaging provides quantitative, real-time, thermal images of the treated area. This allows the physician to ensure that the temperature generated during each cycle of ultrasound energy is sufficient to cause thermal ablation within the desired tissue and if not, to adapt the parameters to ensure effective treatment. However, any nucleus with a net nuclear spin could potentially be imaged with MRI. Such nuclei include helium -3, lithium -7, carbon , fluorine , oxygen , sodium , phosphorus and xenon Gaseous isotopes such as 3He or Xe must be hyperpolarized and then inhaled as their nuclear density is too low to yield a useful signal under normal conditions. However, potential applications include functional imaging and imaging of organs poorly seen on 1H MRI e. Inhaled hyperpolarized 3He can be used to image the distribution of air spaces within the lungs. Injectable solutions containing 13C or stabilized bubbles of hyperpolarized Xe have been studied as contrast agents for angiography and perfusion imaging. Multinuclear imaging holds the potential to chart the distribution of lithium in the human brain, this element finding use as an important drug for those with conditions such as bipolar disorder. Molecular imaging MRI has the advantages of having very high spatial resolution and is very adept at morphological imaging and functional imaging. MRI does have several disadvantages though. This problem stems from the fact that the population difference between the nuclear spin states is very small at room temperature. For example, at 1. Improvements to increase MR sensitivity include increasing magnetic field strength, and hyperpolarization via optical pumping or dynamic nuclear polarization. There are also a variety of signal amplification schemes based on chemical exchange that increase sensitivity. To date, many studies have been devoted to developing targeted-MRI contrast agents to achieve molecular imaging by MRI. Commonly, peptides, antibodies, or small ligands, and small protein domains, such as HER-2 affibodies, have been applied to achieve targeting. To enhance the sensitivity of the contrast agents, these targeting moieties are usually linked to high payload MRI contrast agents or MRI contrast agents with high relaxivities. Pre-polarizing MRI PMRI systems using resistive electromagnets have shown promise as a low-cost alternative and have specific advantages for joint imaging near metal implants, however they are likely unsuitable for routine whole-body or neuroimaging applications.

Chapter 6 : - Magnetic Resonance Imaging Technologists

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Chapter 7 : Magnetic resonance imaging - Wikipedia

Magnetic resonance imaging (MRI) is a medical imaging technique used in radiology to form pictures of the anatomy and the physiological processes of the body in both health and disease. MRI scanners use strong magnetic fields, radio waves, and field gradients to generate images of the inside of the.

Chapter 8 : Foundation Text | Neuroimaging: Visualizing Brain Structure and Function

Functional magnetic resonance imaging, or fMRI, is a technique for measuring brain activity. It works by detecting the changes in blood oxygenation and flow that occur in response to neural.