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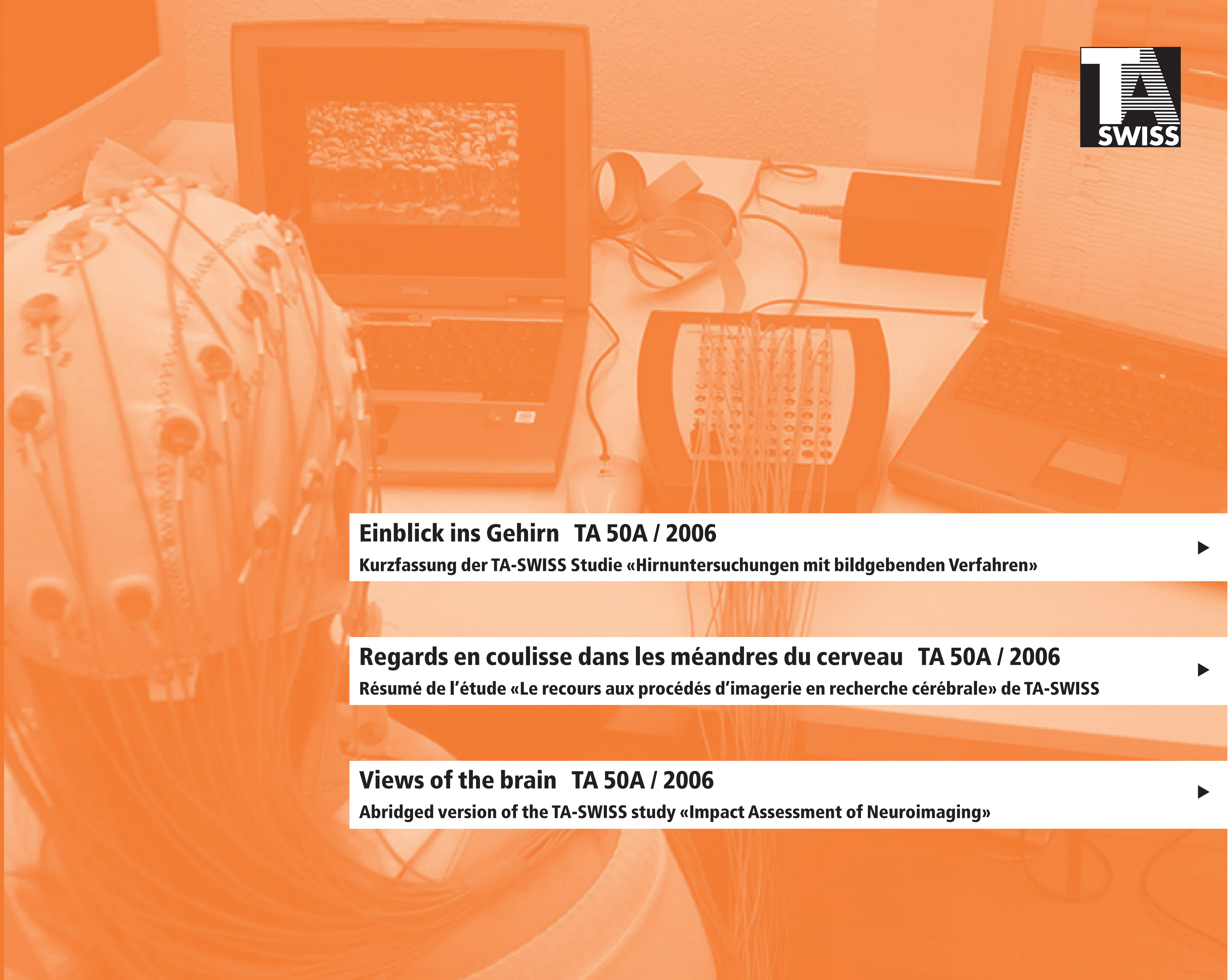

Einblick ins Gehirn TA 50A / 2006

Kurzfassung der TA-SWISS Studie «Hirnuntersuchungen mit bildgebenden Verfahren»

Regards en coulisse dans les méandres du cerveau TA 50A / 2006

Résumé de l'étude «Le recours aux procédés d'imagerie en recherche cérébrale» de TA-SWISS

Views of the brain TA 50A / 2006

Abridged version of the TA-SWISS study «Impact Assessment of Neuroimaging»

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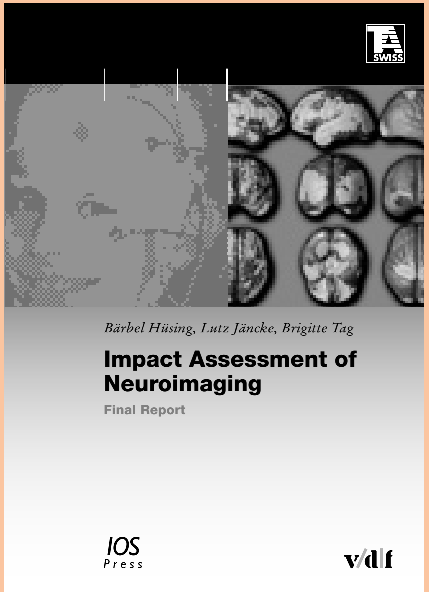


Views of the brain – abridged version of the TA-SWISS Study «Impact Assessment of Neuroimaging»

What is the purpose of the TA-SWISS Study «Impact Assessment of Neuroimaging»?

Language, intelligence, creativity, feelings – it is our brains that make these and many other human characteristics possible. Because the human brain is no ordinary organ, doctors are not the only ones interested in it. Psychologists, economists and lawyers are also attempting to unlock the secrets of the brain. In recent years, the methodology of brain research has become much more efficient. The techniques known as «neuroimaging» now enable us to see how the brains of test subjects function, without resorting to operative surgery. Corresponding findings are now resulting in statements that relate to the psychological characteristics of the test subjects; in the view of TA-SWISS, this is a significant development, but one that needs to be carefully monitored. The interdisciplinary study should make a timely contribution to the broadly based debate on the application of neuroimaging in brain research. For this study, TA-SWISS has benefited from the financial support and personal commitment of the Swiss Academy of Medical Sciences (SAMS).

What is neuroimaging?

Even those who never read medical journals have presumably seen «images of the brain» in their daily newspapers that serve to illustrate new findings in brain research. Although these images often look like cross-sectional recordings of the brain, no-one has been at work with a scalpel. The images are generally taken from living people – from patients or test subjects who have submitted themselves for examination. It is neuroimaging that gives us these views of the brain. Measuring equipment generates huge amounts of data, from which powerful computer programs create the images. So these are not photographic recordings; the results of the examinations depend rather on which physical measurements are recorded, and how these measurements are processed in the computer evaluation. This means that, depending on how the data are evaluated, it is possible to obtain different representations or to pick out particularly interesting details.

What are the possibilities and limits of neuroimaging?

With the aid of neuroimaging, it is possible to investigate both the structure and functioning of the brain. Computer tomo-graphy (CT) and the more efficient but technically more expensive Magnetic Resonance Imaging (MRI) are extensively used to confirm whether or not a suspected tumour or haemorrhaging is present in the brain. The most important methods of investigating the activity of the brain are Positron Emission Tomography (PET) and functional Magnetic Resonance Imaging (fMRI). Each of these methods gives us an insight into metabolic processes in the brain. It is here that the limits of neuroimaging also become apparent: what insights can we expect from measurements of brain metabolism for educational research, marketing or for judging potential criminals? It is not the measurements themselves that are questionable here, but there is much controversy about the extent to which we should allow the results of those measurements to form the basis of statements about personality traits.

What needs to be done?

The use of neuroimaging in brain research can reveal the personal characteristics of an individual. The knowledge that this represents can have grave consequences for the people concerned, and for the way they are perceived by others. In order not to jeopardise the undisputed benefits of brain research, and to keep the risks as small as possible, the authors of the TA-SWISS study have formulated a number of recommendations, including the following:

- Informing patients and test subjects. The possibility that examinations of the brain might produce some unexpected and psychologically harmful findings cannot be ruled out. The objectives and possible consequences of any such examination must therefore be explained to the people concerned. Only people who are well informed can decide which results they want to be told about.
- Quality assurance. This should cover both the people and the institutions which use neuroimaging, as well as the equipment they use. Only competent users who are sensible of the possibilities and limits of investigative methods can use the equipment safely and deal responsibly with the results.
- Legislative framework. The findings of the study underline the necessity of having a uniform system within Switzerland for regulating research on human beings, as proposed in the corresponding draft legislation. Particular consideration should be given here to the protection of the individual.

Watching the brain at work

All neuroimaging is based on the same principle: the measurement of a large number of data, from which images are constructed by means of sophisticated calculations. With ever greater clarity, they show how our organ of thought is constructed, and how it functions. For researching brain function, images such as these give us an insight, for example, into which areas of the brain are especially active when someone is lying, recognises a face or is solving a mathematical problem.

Neuroimaging covers a range of investigative methods, all of which enable us to see into the brain. This view is actually based on images that can be observed on a computer screen; nevertheless, such images are produced, not by a camera, but from a vast number of measurements that are recorded on highly sensitive equipment. The devices used for this are technically sophisticated and expensive. They were used originally in the field of diagnostics, for instance in showing up even very small brain tumours. Since the mid-1990s, neuroimaging has also been increasingly used to research the brains of healthy test subjects. For this purpose, volunteers lie in a tomograph, while researchers watch a screen to see which areas of the brain are active when the volunteers are performing a specific task.

This chapter briefly presents some of the most important examination methods (see also Table «Neuroimaging methods»). Of these, magnetic resonance imaging is the method that enables the most precise investigation of the structure of the living brain. It then describes three methods that are also used for cognitive research in the neurosciences. In psychological terms, «cognition» means actions of the brain such as attentiveness, memory, language, learning and reasoning skills; or problem solving, in which feelings or environmental factors – stress, for example – can also play a part.

The desire to establish personality traits using exact measurement methodology is a well known phenomenon of brain research. One example of this, from the history of science, is described in the first Box.

Magnetic Resonance Imaging (MRI)

Even in the German-speaking countries, magnetic resonance tomography is generally known by the shortened English form MRI, which stands for magnetic resonance imaging. This method, developed in the 1980s, measures signals in the body that are generated by an extremely strong magnetic field combined with radio waves. The strength of magnetic fields is measured in «tesla» units. The MRI scanners in current use work with a field strength of between 1.5 and 3 tesla, which is equivalent to approximately 50,000 times the Earth's natural

Sizing the brain – an old story

This was not the first time that his brain had made the headlines. The method used to examine the foremost organ of thought is not usually used also to measure the brains of people long deceased. It is used more to enable modern medicine to look inside the brains of living people. But the brain in question was no ordinary one – it was that of Carl Friedrich Gauss, one of the most celebrated mathematicians of all time.

Gauss died on 23 February 1855, at the age of almost 78. The following day, his corpse was dissected, his brain removed and a plaster cast made of the inside of his skull. The brain was prepared, weighed – 1492 grams – and placed in an alcoholic solution in a glass vessel. It found its way to the Institute of Physiology at Göttingen University, where Gauss had been Director of the observatory. His brain had been removed at the request of the physiologist Rudolf Wagner, on the premise that it would enable the scientists of the future to be able to determine genius from specific features of the brain. The idea was not new, but it was the first time that respected researchers had begun to take a systematic interest in the brains of extraordinarily gifted people. While it had long been assumed that the brain was the seat of the personality, at that time it was not the brain itself, but the skull – which does, certainly, provide a likeness of the upper surface of the brain – that was the chosen object of the examination. At the high point of this cranial doctrine, known as phrenology, the upper surface of the cranium was divided into 35 so-called phrenological organs. A personality trait was allocated to each of these areas, such as affection, conscientiousness or analytical understanding – bringing localisation of characteristics down to the bare bones, as it were.

Modern investigative techniques allow deeper insights than this superficial characterisation: on 25 November 1998, Gauss's brain in Göttingen was placed in a magnetic resonance tomograph. Within a very short time the MRI scanner produced 526 data sets, enabling the brain to be viewed in the form of cross-section images. However, it was no longer a question of looking for signs of genius in the brain of the celebrated mathematician. That line of research was abandoned in the middle of the 20th century, as it had not been possible to make any conclusive links between brain features and genius. Unlike other prominent brains, such as those of Lenin, which was cut into thousands of ultra-thin slices, and Einstein, which was cut up into 240 small blocks, Gauss's organ of thought was spared from all invasive attacks by researchers of elite brains. The prominent object was carefully examined in 1998, in order to record as many data as possible and to keep them safe for posterity in digital form. Following the examination, it was returned to its glass container with preserving fluid, so that the original could be kept safe for decades to come.

In view of what we know about the brain today, it would be easy to describe the historical example of studying skulls as «false doctrine». But a certain amount of critical distance is also appropriate in respect of the findings of modern neurological research. It is precisely the «graphic» results of investigations using neuroimaging that might tempt us into drawing hasty conclusions. It is a question of carefully weighing up which well-founded statements based on these results are admissible and which are not.

magnetic field. Even more powerful scanners are being developed for research.

If someone is exposed to such a strong magnetic field, the nuclei of the hydrogen atoms are aligned in a certain way. Hydrogen is a component of all tissues in the human body. Radio waves also cause these nuclei to emit signals. These signals depend, among other things, on how strongly the magnetic field has deflected the nuclei from their original position. A scanner records the signals. From the measurement data, computers use highly sophisticated mathematical models to calculate the spatial distribution and the magnetic properties of the hydrogen nuclei that have been activated during the examination. These data are used, in turn, to construct highly detailed images of the tissue being examined; even structures just 1 or 2 millimetres in size can be picked out.

Based on current knowledge, the magnetic field strengths applied today are not harmful to the human body. Whether that is also true of the even stronger magnetic fields that could well be used for MRI examinations in the future has yet to be proved. There is, however, a risk for certain people: objects that contain metal components (implants or cardiac pacemakers, for example) can heat up in strong magnetic fields, or emit electrical currents, which may result in serious injury. It is the job of the medical experts conducting an MRI examination to obviate such risks by checking carefully the situation of the person being examined. Up to now, radio waves have not been shown to have any harmful effect, either. But as with other applications of electromagnetic waves, such as mobile communication systems, there is some controversy about whether this type of radiation really is harmless in the long term.

Functional Magnetic Resonance Imaging (fMRI)

In the early 1990s, MRI technology was broadened in such a way that it has now become possible to investigate not just the structure, but also the function of the brain. Hence the abbreviation fMRI, which stands for «functional magnetic resonance imaging». In recent years, fMRI has become one of the most important methods used in the cognitive neurosciences. Measurement is done on the same principle as that used in MRI, but the scanners are set up in such a way that other signals are recorded; now it is not the hydrogen nuclei that are targeted, but a key constituent of blood – haemoglobin. Haemoglobin transports oxygen from the lungs to the place in the metabolism where it is needed, the brain cells for instance. By releasing oxygen, the haemoglobin alters its magnetic properties. And that is precisely what forms the basis of the fMRI measurement: the scanner can measure the distribution of oxygen-saturated, as well as unsaturated, haemoglobin in the brain.

It is possible to draw conclusions from events in the brain, because every area of the brain that is particularly active is supplied with an abundance of oxygen-rich blood. By means of fMRI, it is therefore possible to determine which areas of the brain are used in connection with language, visual or acoustic perception, movement or memory. There has even been some success in investigating the activity of the brain when test subjects are in certain moods. The significance of the results is somewhat reduced by the indirect nature of the measurement; the flow of oxygen in the brain is just one consequence of brain activity, but not the brain activity itself. Linking the activity of the brain cells with the oxygen content of blood is, however, regarded as a sufficient basis for making reliable statements.

Source: Jäncke 2006

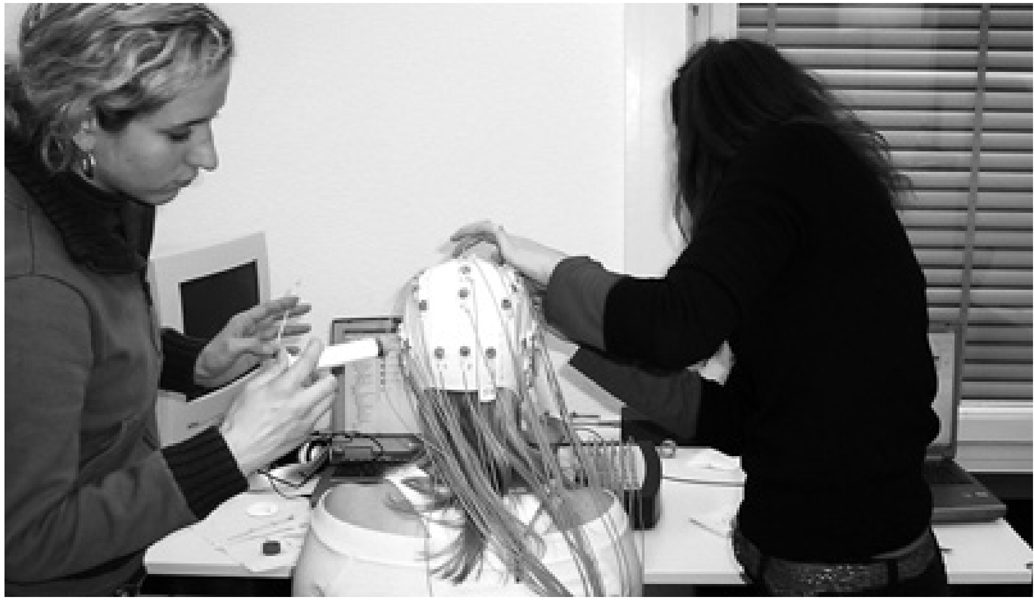


Table: Neuroimaging methods (selection)

Method	Examination of the structure of the brain	Examination of the function of the brain	Smallest identifiable brain structure	Medium used for the measurement
MRI	Yes	No	1 mm	Magnetic field and radio waves
fMRI	No	Yes	1 mm	Magnetic field and radio waves
PET	No	Yes	2 mm	Radioactively marked substances
EEG	No	Yes	10 mm	None [1]

[1] This method measures the electrical current generated by the brain itself

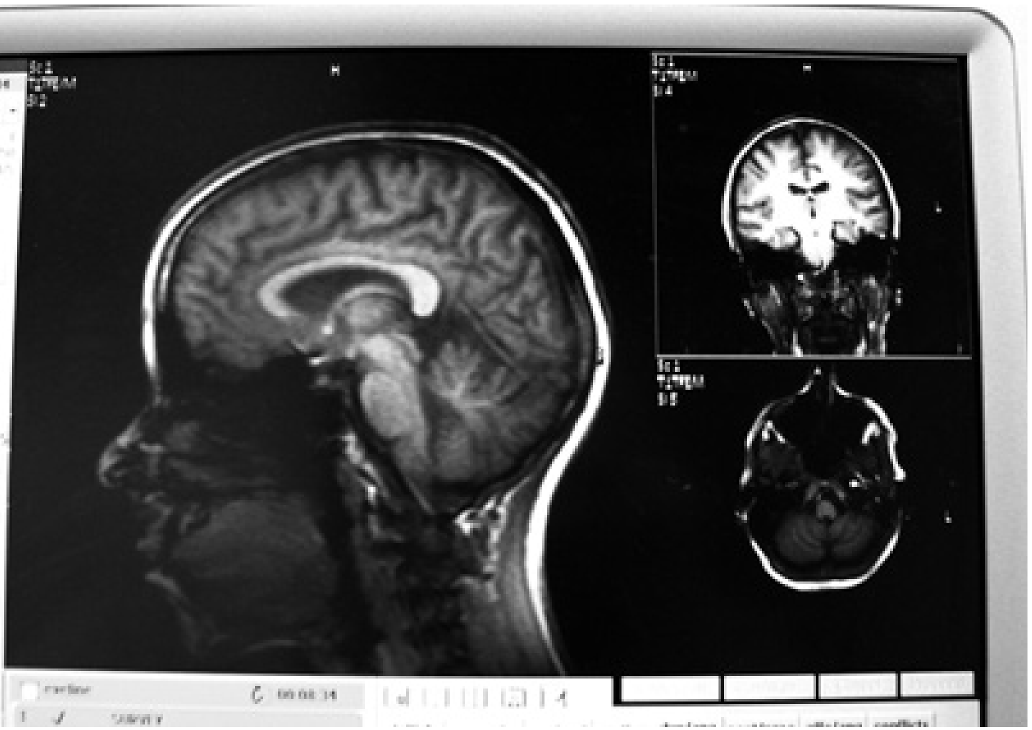
«(But) investigating the brain won't lead us to a full understanding of what the spirit is. Man is more than just a brain.»
Michael Hagner, science sociologist

english

The reactions of patients or test subjects to being enclosed in the narrow tubes for the examination may cause unpleasant sensations, or even cause claustrophobia. Because the medical examinations only last for a relatively short time, this is not usually a problem. But experiments that are used in cognitive research can last up to one and a half hours. Researchers therefore have to take into account the fact that any feelings of anxiety that are caused solely by the experimental environment could falsify the results.

Positron Emission Tomography (PET)

PET shows up metabolism activities in the tissue. For this purpose, signals given off by radioactively marked substances are measured. These may be specially manufactured variants (isotopes) of «normal» molecules such as water or oxygen, or compounds manufactured specifically for brain examinations whose purpose is to target and mark specific sites in the brain. Such substances are administered prior to measurement to test subjects by injection or inhalation. Through the blood circulation, they take about 30 seconds to reach the brain. Their radioactive disintegration produces radiation that is recorded on a measuring device. The measurement data can be used to calculate sectional images or three-dimensional views of the tissue in which the marked substance has been circulating. PET makes it possible to identify structures in the brain that are larger than 2 millimetres in size.



Source: Jäncke 2006

Safety precautions are imperative when using radioactivity. Care is taken to use as low a dose of radiation as possible. In general, no substances are used that might accumulate in the body. The preferred compounds are those whose radiological emission quickly subsides. Only substances whose toxicity is as low as possible are used for examining healthy test subjects. For the test subjects, as well as for the personnel involved, limits are imposed in Switzerland on the maximum permitted level of radiation exposure. For women under 45 years of age, there are particularly strict conditions, and children are generally only examined using PET if there is a clinical reason for doing so.

Electroencephalogram EEG

The brain «at work» constantly produces electrical signals, as stimuli are transmitted between the nerve cells electrically. With the aid of electrodes affixed to the scalp, these signals can be recorded and rendered visible by sensitive measuring equipment. Corresponding measurements of brain activity have been carried out for decades, and the tracing of what are known as brainwaves by electroencephalogram, or EEG, is a well-tried investigative method.

However, the signals measured on the scalp allow only an indirect conclusion as to which area of the brain actually triggered them. Only in the last few years has the EEG been further developed into a method that also enables statements to be made about which point in the brain a particular activity occurs at. This localisation requires the use of a large number – several dozen – of electrodes, from whose measurements powerful computers can calculate an image of the spatial distribution of the brain activities measured. This is now possible with increasing precision, which is why the EEG is regarded as a highly promising method.

One major advantage of the EEG lies in the fact that there are virtually no risks involved in using it. The signals measured are those that the brain has produced itself, without the need for any outside influence – be it radiation or chemical compounds. The only precautionary procedure relates to the safety of the measuring equipment. As with all electrotechnical medical equipment that comes into direct contact with test subjects, the possibility must be excluded of anyone being harmed by unintentional flows of current.

Major benefits in clinical applications

In modern medicine, neuroimaging is an indispensable tool. In clinical practice, it makes it possible to diagnose diseases of the brain reliably, to localise even small brain tumours accurately, and to achieve very great precision in surgical procedures in the brain.

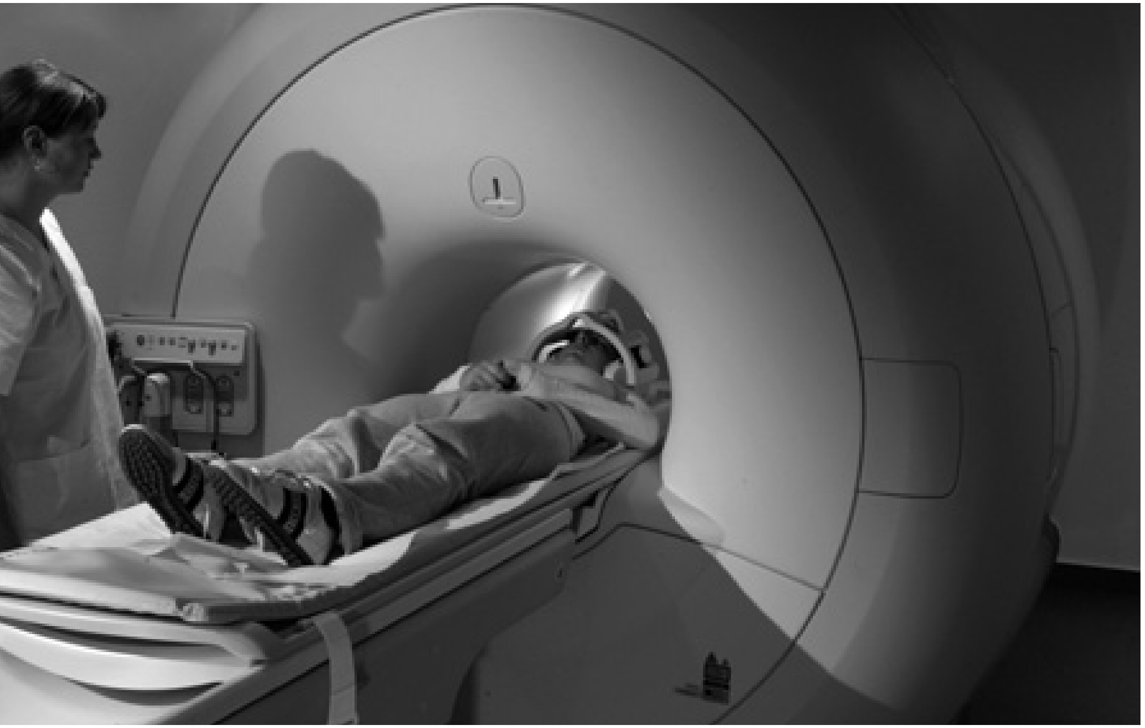
Neuroimaging today has a broad range of applications in clinical practice. That is why the expensive scanning equipment is no longer in use solely in university hospitals, but in regional

hospitals, too. In Switzerland, for example, there are some 100 MRI scanners in use today. In terms of total population size, this means that Switzerland is one of the best provided-for countries in the world. Scanners offer major benefits, especially in diagnostics, and for detailed investigations of diseases of the brain, as well as in neurosurgery. In view of the considerable, and still rising, incidence of Alzheimer's disease, the TA-SWISS Study also investigated the extent to which neuroimaging could help to improve the situation of those people affected.

Neurosurgery

Operating on the brain is one of the riskiest surgical procedures. In certain cases, brain tumours are simply not sufficiently accessible to be removed surgically, because the risk of damaging key parts of the brain during the operation is too great. Today, with the aid of neuroimaging – MRI in particular – doctors are able to establish very precisely how large a tumour is, and where it is located. This is important when preparing for any surgical intervention, and for assessing the risks associated with it. On the basis of the patient's individual image data, it is possible to check different variations of the operation «virtually» – that is, on the screen – and then to select the variation that will have the least damaging effect on the healthy tissue.

The latest development actually goes one step further; «image-guided neurosurgery» supports the surgeon not only before, but also during the operation. MRI data recorded before the operation can be processed during the procedure, so that the surgeon has the most accurate supplementary data available. Alternatively, a special MRI system can generate instant images during the operation. Even in those cases where surgery is considered too risky, neuroimaging can play a part in treatment; the method known as the «Gamma Knife» makes it possible very selectively to irradiate tumours and deformed blood vessels that have been precisely localized by neuroimaging beforehand. In this case, the radiation hits more or less only the diseased tissue, and the healthy parts of the brain are unharmed. This means that compara-



Source: Philips Medizin Systeme GmbH

«It is completely absurd, only wanting to use MRI images to see whether or not some advertising slogan is likely to catch on.»
Ernst Pöppel, brain researcher

tively high doses of radiation can be used, increasing the chances of the treatment being a success.

Example – Alzheimer's disease

In industrialised countries, the proportion of elderly and very elderly people in the population is constantly increasing. As a result, the incidence of old-age related diseases is also higher. Neurodegenerative diseases in particular – diseases that are concomitant with a decline in mental capacity – pose a considerable challenge to society. It is not only the actual persons with the disease, but also their relatives who are affected. Palliative and nursing care require a great deal of individual commitment and are very expensive once the patients can no longer be cared for by their families. This could be one reason why research into neuro-degenerative diseases has been considerably expanded over the past ten years.

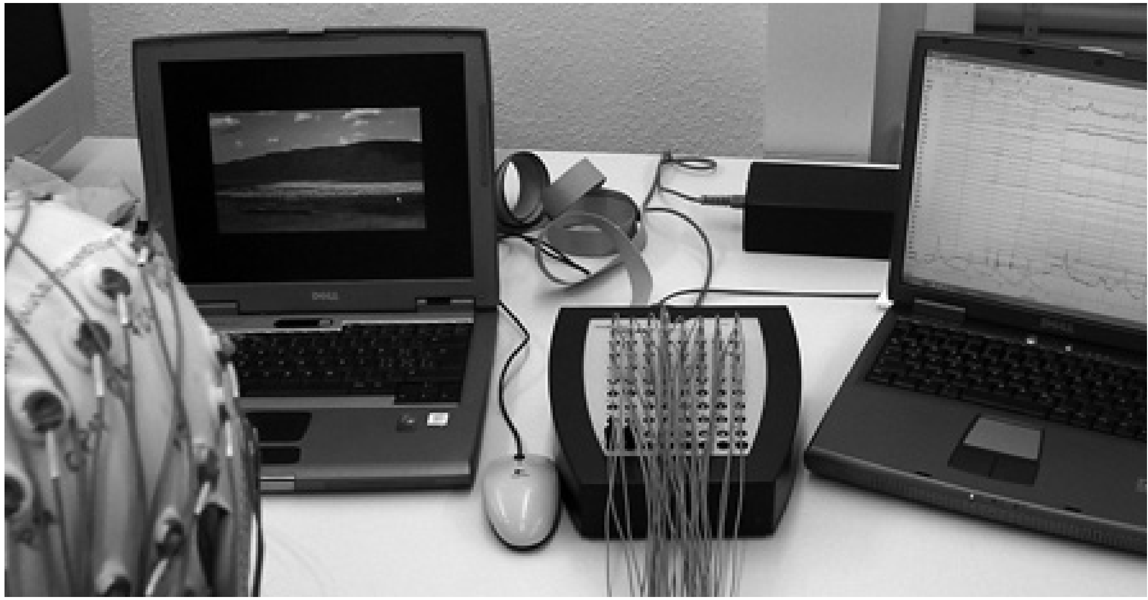
The most common form of dementia is Alzheimer's disease. In Switzerland, there are currently around 70,000 people suffering from it, and it is projected that by 2020 the number of patients will have risen to 113,000. The drugs available today only have the effect of slowing the disease down somewhat. The primary objective of research is to make early, reliable diagnosis possible, and also to achieve a better understanding of the causes of the disease and the processes in the patient's brain tissue. Only then will it be possible to develop substances that – if they prove to be safe and effective in further trials – can be used as drugs. Neuroimaging is also used in all these aspects of research.

The example of Alzheimer's disease shows that early diagnosis is of limited use while there is no effective treatment. There is even a risk of costly investigative methods being used extensively, even though it is also possible to identify the disease early on using current diagnostic methods, based on memory tests. Even earlier diagnosis – before any symptoms appear at all – might be psychologically damaging for the persons affected. In any case, this situation would necessitate specialist counselling for those concerned. There is no doubt that in the long term, neuroimaging is a key tool in the search for a treatment for dementia. At the moment, however, its significance in this regard should not be overestimated. Nevertheless, in the diagnosis and treatment of other neurological diseases, such as multiple sclerosis, the corresponding methods have proved to be highly effective in practice.

Unresolved questions in statements about the psyche

Reading someone else's thoughts is a popular theme in science fiction. Could brain research make this come true some time soon? Hardly likely in the near future. But there are other, albeit less spectacular, applications on which there are controversial opinions.

If by reading other people's thoughts we mean «retrieving» their thoughts and impressions, just as we can access texts or images from a computer memory or the Internet, this scenario is unlikely to become reality, even with the latest brain research methods. There are no doubt vast quantities of data stored in our brains. But these data only have any meaning for us when they are processed by the brain. In this respect, the brain functions according to



Source: Jäncke 2006

the principle of division of labour; certain areas, for example, are particularly active if someone is confronted with anxiety-inducing impressions. The situation that triggered the anxiety is irrelevant; it varies considerably from person to person. But the areas of the brain that are stimulated as a result are generally the same in all people. This forms the starting point for research into functional neuroimaging. In experiments, these can show which areas of the brain are particularly active in which situations. Presented below are three areas of research from which it is hoped to formulate new statements on the human psyche from the use of neuroimaging.

Neuroeconomics and neuromarketing

Even in economic matters, people do not always behave rationally. «Homo economi-cus», who having assessed a situation involving a choice of action always decides in favour of whatever appears to be most beneficial for him, is the ideal case in economic theory. But the way people behave in their everyday lives is also influenced by feelings, uncertainty or confidence. Neuroeconomics endeavours to develop a more comprehensive theory of decision-making, also taking into account the factors referred to. This is an area of research that has been given a new impetus by the use of neuroimaging over the last five years. It involves experiments being carried out on volunteer test subjects, who have to make decisions in game situations, with other trial partners or computers being their game partners. During such experiments, brain activity is measured by fMRI or PET. Investigations have already been done in

such simulations on topics such as cooperation, unselfish behaviour, sympathy, decision-making in uncertain or risky situations. In this type of research, it is a matter of answering fundamental questions of human behaviour; it is not about the personal situation of the people involved in the investigation. The findings, based on exact measurements, will help to expand the knowledge base in an area of research previously accessible mainly by observations.

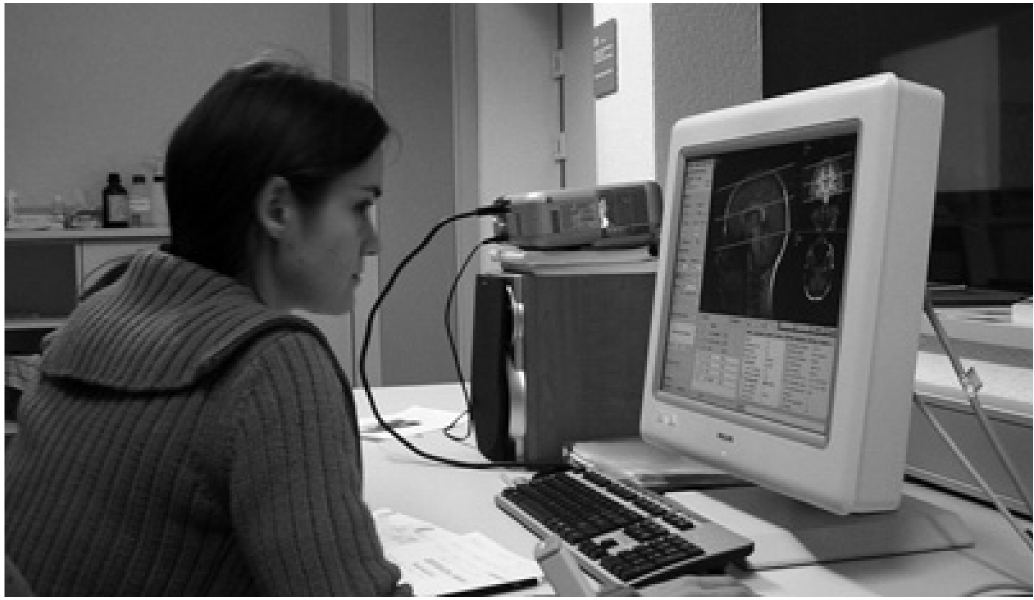
Neuromarketing is much more directly related to practice. Time and again it is taken up by the media as a worthwhile topic for speculative reports. Will advertising in the future tempt us in even more sophisticated ways than it has up to now? Are we actually losing control of our behaviour as consumers? Such fears are not entirely groundless if we know that some firms are using neuroimaging to investigate how test subjects unconsciously react in a particularly emotional or particularly rational way to advertising campaigns or product displays. This is being done on behalf of firms, but also on behalf of political parties. In the USA the citizens' initiative «Commercial Alert» has already been campaigning against one such form of influence: the risk of consumers or electors being manipulated is too great. Neuromarketing studies conducted so far have, however, produced some sobering findings. So far, there has not been a single instance where trials using neuroimaging have enabled reliable conclusions to be drawn on consumer behaviour.

Educational research

Educational research is often accused of basing its findings on opinion, rather than on reliable scientific data. Some neuroscientists are therefore suggesting that more attention be paid to the current results of brain research, because neuroimaging would deliver objective, precise data that might help to improve teaching methods. In fact, neuroimaging is currently in widespread use in investigating how people learn and what the preconditions are for encouraging the learning process. These findings often corroborate knowledge that is already available from the field of psychology, and therefore give little cause for far-reaching changes in educational research. Or they are concerned with quite basic learning processes in the brain; but there are no specific applications, in school teaching, for example, which can be deduced from these. There is even a risk of propagating new pedagogic concepts too precipitately. In a politically sensitive area, one that is already being tested enough by reforms, this would probably do more harm than good.

Nevertheless, neuroimaging has already produced numerous findings, whose effect is unlikely not to be felt in the long term. Most important of these is the discovery that the brain remains «plastic», that is, liable to change, not only during childhood but throughout a person's life, and that learning leaves a trail, not only in the form of nerve signals, but also in the structure of the brain. The intensive practice involved in learning a musical instrument, for instance, causes anatomical changes in the brain. And psychotherapy also affects the areas in the brain that are stimulated by external impressions, and therefore has a more far-reaching effect than previously assumed.

Neuroscience can also offer major impetus to the understanding of learning difficulties among children and adults, and to the encouragement of slow learners. It is, for example, very helpful to know whether children who suffer from reading difficulties (dyslexia) are just slow



Source: Jäncke 2006

«Probably the only thing worse than having people successfully reading your mind with brain imaging is having people unsuccessfully reading your mind with brain imaging and thinking that they can trust that information.»

Martha Farah, neuropsychologist

developers, or whether they actually have a reduced perceptive faculty. Knowledge gained from neuroscientific research could – together with findings of educational research studies – adopt appropriate measures in the future to provide better support for people with learning difficulties.

Criminal law

What would happen if we were unable to take any responsibility for our actions because it was not us, as people acting consciously and deliberately, but «it», our brain, that decided what we do – and we blindly followed because we were unable to do anything else? This point of view, which is represented by individual brain researchers, could bring the system of criminal law into question, a system that essentially depends on people being responsible for their own actions. There may well be mitigating circumstances if someone appears in court accused of some crime. In certain cases, a psychological disorder or an extreme situation will result in people being unable to accept full responsibility for a crime. But if free will is actually an illusion, any punishment would have to be waived. It is unlikely that it will come to that. Prominent representatives of the neurosciences, the criminal law and philosophy have already debated this issue at length – inspired not least by the findings of brain research. But not even the latest studies lead us to conclude that there is no such thing as free will, and that people are therefore not criminally liable.

Another key question for the criminal law is whether a defendant or a witness is telling the truth in court. There is already a long history of attempts to establish this beyond doubt by using a measuring device. However, all so-called lie detectors record are indirect indicators of a lie, or more precisely symptoms of stress that can be triggered by a lie. Experiments are currently being done on test subjects to ascertain the extent to which neuroimaging can be used to determine whether or not someone is lying. It has, in fact, already been established using fMRI that lying activates areas in the brain that are stimulated by particular intellectual effort, but not by «talking normally». That does not, however, mean that there will soon be fMRI lie detectors in every police station or courtroom. It has yet to be verified whether the device can actually be «outsmarted», as is possible with conventional lie detectors. Moreover, this experimental situation is very different from proper court proceedings.

An investigation has established that certain special anatomical features in the frontal area of the cerebral cortex are associated with an increased propensity for criminal behaviour. Such findings have already led to the notion of using neurological tests to assess how dangerous a criminal is, or how great the risk is that someone could reoffend after serving their sentence. In extreme scenarios, the possibility is even being mooted of people with violent tendencies being identified at an early stage by means of neuroimaging, so that therapeutic measures can be employed to prevent them actually becoming violent. But such considerations are highly speculative, and highly controversial – psychologists, at least, doubt in principle whether neuroimaging could ever allow assertions to be made about an individual's disposition. With the current state of knowledge, this is in any case excluded.

Recommendations of the TA-SWISS Study

The authors of the TA-SWISS Study recognise the considerable potential of neuroimaging, for example in diagnostics, in neurosurgery and for researching how the human brain functions. This type of research does, however, give rise to reservations similar to those expressed about genetic testing, because it too is about recording bases for personal characteristics. Unlike gene technology, where it is now normal to raise concerns about ethical, legal and social aspects, this approach is still rarely adopted in brain research.

It is therefore especially important to adopt an interdisciplinary approach for brain research as well. A broadly based, objective discussion would be an essential prerequisite for being better able to evaluate controversial research findings. Otherwise, there is a danger of the findings of brain research, graphically represented by colour «images of the brain», will be seen as opening the way for spectacular developments. Such developments are hardly realistic; they have already been labelled «neuromyths». The TA-

«The most annoying thing is that people persistently but mistakenly assume that brain researchers want to reduce mental and psychological questions to the firing of neurons, or even not talk about them at all.»
Gerhard Roth, brain researcher

SWISS Report «Impact Assessment of Neuroimaging», and this abridged version of it, should help not least to ensure that the discussion deals, not with myths, but with facts. The recommendations of the authors are presented below.

Informing patients and test subjects

The objective, and the possible consequences, of an examination must be explained to the persons concerned. Consideration must be given here to the fact that patients are not in the same situation as healthy test subjects. If symptoms are discovered in a person that lead to the suspicion that he or she has a brain disease, an examination will be carried out, with the aid of neuroimaging, to obtain a more accurate diagnosis. The affected persons should be aware of their situation, and should consent to the examination, even if it means the possibility of discovering something serious. Test subjects should be treated differently, as they are participating in an experiment to research brain functions. Such persons are generally healthy. But the possibility that measurements of their brain activity will unexpectedly discover something that indicates an illness, and that this will damage them psychologically, cannot be ruled out. A case of this type is described in the second Box. It is the case for both medical examinations, and for research using test subjects, that only fully informed persons can decide which findings they want to be told about.

Quality assurance

More and more equipment that can be used in clinical applications, but also for researching the functions of the brain, is being used in Switzerland. Not only is this extending the circle of people being tested, the number of users is also growing. To prevent inadequately trained people from working with such equipment, good specialist training, or further training, is absolutely essential. Researching the functions of the brain also requires solid, interdisciplinary cooperation between technically, medically or psychologically trained people, to ensure that the interpretation of the scan results and the – often wide-ranging – statements associated with them are reliable. Only competent users who are sensitised to the possibilities and limits of test methods can use the equipment safely and deal responsibly with the results. High quality standards are also applicable to the equipment used, to prevent harmful effects resulting from technical defects.

Source: Jäncke 2006

«You can see the activity that occurs when we think.»
Wolf Singer, brain researcher

Harmless experiment with a depressing outcome

Mr B, himself an enthusiastic brain researcher, had long wanted to see what images one of the modern MRI scanners would produce of his own brain. An opportunity arose when such a facility was opened at his university. Mr B. did not hesitate, and made himself available for tests with the new scanner – in itself a perfectly harmless undertaking. But following the test scans, he was invited to a meeting with the head of the research facility. He was shown the results of the scan, and as expected they showed cross-sectional views of his brain. But he was very shocked to notice on one of the images a brain tumour the size of a golf ball. This discovery came as a complete surprise, as Mr B. had never before shown any signs of neurological disorder. Despite being depressed about the situation, he raised his hopes; perhaps this was a tumour that had been detected early on, making it easier to deal with. Mr B. therefore accepted the offer of a referral to a neurosurgeon from the manager of the MRI facility. This was to have unforeseen financial implications.

Mr B. and his wife were expecting a child, and were therefore in the process of amending their insurance policies which would support the young family if either the father or the mother were no longer able to work because of illness or accident. But before the new insurance policies had been signed came the fatal diagnosis. Mr B. now knew from the neurosurgeon that removing the tumour would involve risks – and the possibility of him being no longer fit for work could not be ruled out. What was he to do in this situation? He chose to be honest, and told the insurance company about the results, even though the scan had not been done as part of a clinical diagnosis. The insurance company now refused to issue a new policy.

In his report of the experience, Mr B. comes to the following conclusion: «Now I sit in the uneasy position of facing surgery that could cost me and my family everything because I wanted to peep at my own brain. I understand that subject recruitment for research studies can be very difficult and every subject is precious. After my experience, however, I feel that informed consent should clearly include recognising the possibility that something of medical significance could arise and that this could have an impact on future insurance eligibility.»

Source: Anonymous, Nature Vol. 434, p. 17 (3 March 2005)

This example comes from the USA. It should illustrate the fundamental problem posed by the risk of unexpected findings. The financial implications cannot be applied directly to Europe, because private health insurance is more important in the USA than it is in most European countries.

Legal framework

In individual cantonal laws, or even scattered among federal-level decrees, there are regulations that are significant for the field of neuroimaging in Switzerland. There is, however, a need for uniform Swiss regulation, adapted for the present state of the technology. An opportunity has now presented itself. The comprehensive legislation on human research also covers the field of brain research; the bill for this law on human research was issued in February 2006. The Swiss Parliament will be called upon over the next few years to discuss the law. It is hoped that this will lead to the regulation of key points, such as protection of the individual and quality assurance as it relates to the needs of patients or test subjects.

Further recommendations

The authors further recommend

- stimulating the public dialogue on the objectives, findings, possibilities and limits, as well as the consequences of neuroimaging;

- improving the conditions for interdisciplinary research in the area of cognitive neurosciences and for transferring research findings to clinical applications;

- researching possible health risks that might be linked to certain applications of MRI, and adapting safety regulations to current findings;

- carefully tracking developments in the field of neuroimaging, and in the area of neurosciences generally, and taking action as appropriate.

«A lot of what is likely to be produced in this field won't stand the test of time.»
Wolf Singer, brain researcher

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