Winston Churchill Travel Fellowship Report

Dr Tom Ziessen - 2010 Churchill Fellow

Detecting Lies In The Brain: Exploring the implications

Being prepared for Brain Electrical Oscillation Signature profiling (or BEOS) at the Institute of Behavioral Sciences at Gujarat Forensic Sciences University in India.
Introduction and aims

Through my travelling fellowship I wanted to explore what evidence there was that either EEG- or fMRI-based truth or lie detection techniques actually worked and also to determine the current status of their use in the real world to inform legal cases.

I planned to meet and interview the scientists, lawyers and ethicists both for and against the use of EEG-based lie detection in India and fMRI-based lie detection in the USA technology. I aimed to document my progress through a blog whilst travelling. I also planned to film the interviews to create a film on my return to be used to promote debate and discussion both through online distribution and by showing the film at events with post-screening discussions. I wanted to investigate the claims being made by proponents of the technology to discover whether they stand up to scrutiny and bring my findings back to a UK and European public to further raise societal debate about this important and timely subject.

Background to EEG-based lie detection

In January 2008 in India a shop employee Amin Bhoi was convicted by the Sewri sessions court for hammering his colleague to death and robbing the shop. On 12 June 2008 in Pune, India Aditi Sharma, was convicted of murdering her ex-fiancee. According to the Times of India both convictions largely rested on evidence from Forensic Psychologists who claimed they could read the accused’s minds and detect ‘experiential knowledge’ of the crime. There is little detail of the case of Amin Bhoi, but the case of Aditi Sharma was to make international news. It made 2008 the first year that brain scan evidence was used to convict anyone of murder and the implications were huge.

Evidence used to convict Aditi largely came from a brain scan using Electoencephalography (EEG), which measures brain wave activity via electrodes placed on the scalp. The consideration of the EEG evidence took up almost ten pages of the judge’s ruling when he jailed Sharma for life. The Forensic Psychologists, based at the Directorate of Forensic Sciences in Mumbai asserted that when Aditi was presented with ‘probes’, which were short statements consistent with the prosecution’s version of events, her brain wave activity gave a signature consistent with someone who had committed the crime, and that this was distinguishable from the brain activity who had no knowledge of the crime or someone who simply knew the details of the case (conceptual knowledge) without having committed the act.

This was far from the first time that technology had been used to try and determine whether someone was telling the truth or telling a lie. The polygraph test was invented in 1921 and put forward as a means of detecting lies by Dr. John A. Larson of the University of California and it was first applied in law enforcement work by the Berkeley Police Department. The polygraph device recorded blood pressure and galvanic skin response, which is a measure of how conductive (i.e. sweaty) the skin is, the idea being that both would go up when a person was stressed and that lying caused stress. Ignoring the significant questions about whether the test was accurate it was aiming to detect a secondary response to lying. However the primary processes involved in lying happen in the brain and the technology used in the Aditi Sharma case was trying to detect these processes by directly measuring brain wave activity.

The technique, called Brain Electrical Oscillation Signature profiling (or BEOS) had been ‘invented’ by clinical psychologist Dr C. R. Mukundan, a former Professor at the National Institute of Mental Health and NeuroSciences (NIMHANS) in Bangalore.

According to a 2003 article in The Hindu, a leading national newspaper in India, Dr. Mukundan stated of EEG-based experiential knowledge detection that “Larry Farewell first used it and then standardized it,” and that “You can’t hide something that you know just too well, for long. Experiential knowledge has a different effect on the brain. And it is this quality of the brain that can be tapped.”

The BEOS system that Dr. Mukundan had ‘invented’ was based on Brain Fingerprinting, a technique invented in the USA by Dr. Lawrence Farwell. According to Lawrence Farwell’s website “In a Brain Fingerprinting test, words, pictures or sounds describing salient features of a crime are presented by a computer, along with other, irrelevant information, that would be equally plausible for an innocent subject. Items are chosen that would be known only to the perpetrator and to investigators, but not to the public or to an innocent suspect. The subject is told which features he will see (e.g., the murder weapon), but is not told which item is correct (e.g., gun, knife, or baseball bat). When a subject recognizes something as
significant in the current context, the brain emits a specific brain response. If the record of the crime is stored in the subject's brain, this response appears when the subject recognizes the correct, relevant items. If not, then the response is absent. A computerized mathematical analysis of the data determines whether or not the subject has knowledge of the salient details of the crime."

This is essentially identical to the claims made of BEOS. It is also based on scientific claims that are unsubstantiated. I am only aware of a single peer-reviewed paper in a quality scientific journal on the efficacy of Brain Fingerprinting published by Farwell – Farwell, L. A., & Donchin, E. (1991) "The truth will out: Interrogative polygraphy ("lie detection") with event-related potentials." Psychophysiology, 28, 531–547. There was a second article in the Journal of Forensic Sciences in 2001 entitled "Using Brain MERMER [Memory and Encoding Related Multifaceted Electroencephalographic Response]"Testing To Detect Concealed Knowledge Despite Efforts To Conceal". This journal is not a peer-reviewed or leading journal in psychology, neuroscience, or psychophysiology.

Back in 2003 Farwell’s website was claiming “Farwell Brain Fingerprinting is a revolutionary new technology for investigating crimes and exonerating innocent subjects, with a record of 100% accuracy in research on FBI agents, research with US government agencies, and field applications”

His website currently makes a rather more modest claim that “Scientific studies, field tests and actual criminal cases involving over 175 individuals described in various scientific publications and technical reports by Dr. Lawrence A. Farwell have verified the extremely high level of accuracy, utility, cost-effectiveness, and overall credibility of the Brain Fingerprinting system.”

Farwell’s website also claims that "Brain Fingerprinting Ruled Admissible in Court". This is not generally the case. Brain Fingerprinting evidence was admitted into an appeal hearing in Iowa in 2000 as evidence that Terry Harrington, convicted of murder 24 years earlier, however the case rested on the fact that some police evidence was not disclosed in the original trial rather than on this new ‘Brain Fingerprinting’ evidence. The Iowa Supreme Court ruling states that "Nonetheless, we briefly review the evidence introduced by the defendant at the PCR [Post-conviction relief] hearing with respect to various witnesses’ recantation of their incriminating trial testimony, as it gives context to our later discussion of the materiality of the police reports. Because the scientific testing evidence [i.e., Brain Fingerprinting] is not necessary to a resolution of this appeal, we give it no further consideration." This is the only case in which Brain Fingerprinting evidence has been heard in the USA and it was not considered to be relevant to the judge’s decision.

A 2005 critical review of Farwell’s Brain Fingerprinting claims by J. Peter Rosenfeld, Professor of Brain, Behavior, and Cognition Psychology at Northwestern University, who has published his own research on using EEG for lie detection, can be read here: http://www.srmhp.org/0401/brain-fingerprinting.html. It concludes "with the hope that the baby will not be thrown out with the bathwater: just because one person is attempting to commercialize brain-based deception-detection methods prior to completion of needed peer-reviewed research (with independent replication) does not imply that the several serious scientists who are now seriously pursuing this line of investigation should abandon their efforts. On the contrary, brain activity surely forms a substrate for deception which patient investigation may elucidate. It appears that detecting deception will continue to be of interest to various agencies and institutions. If it is to be done, it may as well be done well."

So it seems that there may be some merit to the idea that EEG data may be able to detect experiential knowledge or deception in controlled laboratory situations, but how accurately can the truth be detected and how translatable is this work from the lab to real world situations? Also how does BEOS differ from Brain Fingerprinting? What exactly had Dr. Mukundan invented?

According to the Government of India Controller General of Patents Designs and Trademarks website Dr Mukundan filed a patent application in February 2007 entitled “Electronic Investigative Device for Identifying Truth” (patent number 304/CHE/2007). According to the Indian Patent Office website this patent has not yet been granted, though it states it was requested to be examined by February 2009. The status on the website currently states that it is awaiting examination. The abstract for the patent application states "The present invention provides a novel electronic investigative device for identification of truth from individuals who have committed an act of offence. The invention also provides a method for identification of truth based on bio-electric responses that are elicited by presentation of a unique design of nested probes. The method advantageously utilizes the experiential knowledge present in a subject’s brain that elicits a bioelectric response to the presentation of probe. The invention is completely non-invasive and does not require an active participation of the subject. Further, the method is fully automated to enable tamper proof results."
Dr Mukundan also filed the patent with the World Intellectual Property Organization in July 2008. Their International Preliminary Report on Patentability was published on 30 November 2010 (sadly after my visit). It states the system "does not meet the criteria ... because the subject matter of claims is not new" referring back to patent applications from both Lawrence Farwell and one from J. Peter Rosenfeld. It further states that "The terms "means for providing tamper proof neuro signatures" is unclear and leaves the reader in doubt as to the meaning of the technical features to which it refers, thereby rendering the definition of the subject matter of said claim unclear.'

So currently it looks like the BEOS system is not novel, but I wanted to find out if there was any further evidence to support Dr. Mukundan's claims of it's reliability or any proof that it worked any better than Lawrence Farwell's much criticized technique.

In September 2008 the New York Times reported on the Aditi Sharma case saying that leading North American psychologists and neuroscientists called the Indian use of brain-based lie detection variously "fascinating," "ridiculous," "chilling" and "unconscionable."

The same month The Hindu reported that a year-long expert review of the technology headed by the director of NIMHANS (the institution that Dr. Mukundan worked at before leaving to set up his BEOS system) concluded that the technique was unscientific and should be discontinued as an investigative tool and as evidence in courts. The review was led by the NIMHANS Director D. Nagaraj who said "there was a need to thoroughly examine the procedure and bring it to established standards." The release of this report led to a swift response also published in The Hindu in which Dr Mukundan stated that the committee had not properly understand the BEOS profiling technique and that he was "ready to share the technical details with the committee members provided they agree not to publicize them. Neither I nor the manufacturer of the tool were given the opportunity to present before the committee the technology in detail." The article also stated that one of the committee members, M.S. Rao, Director-cum-Chief Forensic Scientist at the Directorate of Forensic Science Services at the Ministry of Home Affairs had been critical of the report saying "The committee members had failed to visit Forensic Science Laboratories in Gujarat and Mumbai to actually access the software and other factors in respect of working of the tools." and that the techniques had shown "encouraging results."

So despite criticism there was still a lack of consensus in India about whether there was any basis for the claims made about the accuracy of BEOS as a method of detecting experiential knowledge.

In May 2010 the Indian Supreme Court made a ruling on the use of BEOS, narcoanalysis and polygraph tests as evidence in courts "We hold that no individual should be forcibly subjected to any of the techniques in question, whether in the context of investigation in criminal cases or otherwise. Doing so would amount to an unwarranted intrusion into personal liberty," a bench of chief justice KG Balakrishnan, and justices RV Raveendran and JM Panchal said. The inclusion of the word 'forcibly' was to mean the ruling would have little impact, as we will see.

**Background to fMRI-based lie detection**

In 2001 Professor Sean Spence, from the University of Sheffield's School of Medicine and Biomedical Sciences, published the first scientific paper suggesting that functional Magnetic Resonance Imaging (fMRI) could be used to detect brain activity associated with deception: "The behavioural and functional anatomical correlates of deception in humans." NeuroReport 2001; 12: 2849 – 2853. Whilst it was a small study with only 10 volunteers being scanned it concluded that the brain's "Ventrolateral prefrontal cortex may be engaged in generating lies or withholding the truth." Since this study was published there have been around 50 further papers that demonstrate that deception can be detected with fMRI technology in lab studies with volunteers.

Magnetic Resonance Imaging (MRI) is a technique that allows the visualization of internal structures of the body. fMRI is a 'functional' version of MRI scanning and takes as its basis the fact that increased neural activity causes an increased demand for oxygen in that part of the brain. Changes in the amount of oxygen in the blood cause changes in the magnetic resonance signal (called the Blood Oxygen Level Dependent or BOLD effect) and so if parts of the brain are particularly active during a cognitive task (such as lying) then the scanner is able to identify the regions that are active and can overlay the active regions on the structural image of the brain created by MRI giving results such as the example below.
In the USA two companies have been set up to capitalize on the potential of fMRI-based lie detection. In 2004 Dr. Steven Laken founded Cephos, based near Boston, Massachusetts. The other company, No Lie MRI™ founded by Joel Huizenga and based in San Diego, California has been offering fMRI based lie detection services since 2006.

**Itinerary October - December 2010**

- London to Mumbai: 26th October
- Mumbai to Ahmedabad: 1st November
- Ahmedabad to Mumbai: 3rd November
- Mumbai to Bangalore: 12th November
- Bangalore to New York (via London): 19th November
- New York to Boston: 25th November
- Boston to Los Angeles: 1st December
- Los Angeles to San Francisco: 4th December
- San Francisco to San Diego (via Santa Barbara): 8-9th December
- San Diego to Los Angeles: 11th December
- Los Angeles to London: 15th December

**Summary of my fellowship**

**Mumbai and Ahmedabad**

My first week in Mumbai was spent acclimatizing and contacting Forensic Science Laboratories where BEOS profiling had been reportedly taking place. Prior to arriving in India I had not wanted to contact these labs or police as I was not travelling under a journalistic Visa and I did not want to risk being turned away on arrival!

I had identified the Institute of Forensic Science, based in the Colaba region of Mumbai, but on arrival I found this was not where the Directorate of Forensic Sciences (DFS, where the BEOS profiling had taken place) was based. I started contacting the Directors of these organizations via email and whilst I received no response from the Mumbai department, Dr. S.L. Vaya, Director of the Institute of Behavioral Science at Gujarat Forensic Sciences Laboratory agreed to meet me. She has a wealth of relevant experience for my project including working as Assistant Director in the lie detector division for fifteen years. Dr Vaya trained at NIMHANS under Dr. Mukundan, the inventor of BEOS. She also presented on “Indian scenario in Polygraph and brain electrical oscillation signature profiling tests” at the British Psychological Society in July 2008. I spent two days at the Institute of Behavioural Science with Dr Vaya and her staff. They were very generous with their time and showed me their facilities, including the BEOS system, their polygraph machines, their narcoanalysis rooms (all of which they informed me were still very much in use and had not been effected by the Supreme Court ruling that year) and their ‘Suspect Detection System’ (SDS). Unfortunately they were not
so helpful in providing me with any evidence that any of these techniques had a reliable scientific basis. In fact they inadvertently showed that the systems were extremely dubious by subjecting me to testing with the BEOS system, the polygraph and the SDS to demonstrate that they worked. I 'failed' all three tests!

Gujarat Forensic Sciences University, home of the Institute of Behavioural Science and Gandhinagar's Directorate of Forensic Sciences near Ahmedabad

The BEOS system has been used in a validation study to determine whether it works. The trial 'Normative data for brain electrical activation profile' was funded by the Technology Information Forecasting and Assessment Council (TIFAC) and I was told by Dr Vaya that the full results were available on the TIFAC website. I have searched for the results on the website and have contacted TIFAC by email, but I have not had a response and have not been able to find any verifiable details elsewhere. The basic idea of the test is that the person hooked up to the system is read a series of statements. The person does not need to respond, but if they have 'experiential' knowledge of that statement then the system will detect the brain activity showing they have this knowledge.

The trial involved half of the subjects reading a script where they steal some money. The other half of the subjects have to enact the robbery according to the script and the claim is that the BEOS test can distinguish between the former subjects 'conceptual knowledge' of the crime from the latter's 'experiential knowledge'. The department claims that the validation exercise was conducted on 120 subjects showed an accuracy rate of 95%. I took the procedure for the 'conceptual knowledge' group, so the BEOS system should have shown I had no experiential knowledge of the crime having not done it, however the system mistakenly categorized me as having experiential knowledge for some of the parts of the story. Hardly a convincing demonstration!

Dr Vaya did not provide me with the report from the TIFAC funded study or show me any of the raw data, so I was unable to conclude that there was any evidence for their lie detection system working thus far. I did find out that the Gujarat DFS also ran training days for judges to promote BEOS, polygraphs and narcoanalysis and to convince them these techniques work. This goes some way to explaining how and why this technology was being used and accepted in courts.

I also experienced the probes used with BEOS to test a suspect in a real serial killing case, though I was not shown the results of this test. The suspect in this case was found to have guilty knowledge by the BEOS system. He also provided self-incriminating testimony while drugged (narcoanalysis) at the Gandhinagar's Directorate of Forensic Sciences. I am not aware of what other evidence there was against him, though from newspaper reports it seems these 'forensic' techniques used by Dr Vaya’s team were an important part of the court's deliberations. He has been found guilty and been sentenced to the death penalty.

I was not permitted to video any of my interviews or any of the procedures, though Dr Vaya had known that I wanted to film she did not mention that this would not be possible until I had arrived at the University. Though I was permitted a still photograph.
After Ahmedabad I returned to Mumbai where I met up with Vickram Crishna, a human rights activist and Amar Jesani, one of the founders of the Forum for Medical Ethics Society and its journal, the Indian Journal of Medical Ethics to try and get some other leads. Vickram put me in touch with ex-police officer Nandkumar Saravade, a former Indian law enforcement officer, who is now working to improve police functioning. Vickram and Nandkumar were concerned that the police was using BEOS and narcoanalysis as shortcuts to proper investigations, though they did think they were preferable to evidence from forced confessions.

Mr Saravade informed me that when it comes to technology used in investigations or presented as evidence in trials in India there is "No formal standardization process to test whether a technology works". He was also of the opinion that there was has not been much science coming into criminal investigations for a long time in India due to the lack of infrastructure and the amount of time it can take to get samples from crime scenes analyzed by forensic science laboratories. He stated that labs can take months to analyze samples and so scientific methods of solving crimes can slow down the process, whilst techniques such as BEOS and narcoanalysis can be used as a shortcut by police to get lots of information quickly.

Vickram also suggested I talk to Dr Mohan, also formerly at NIMHANS with Dr Vaya and Dr Mukundan, another advocate of BEOS and Director of the Forensic Science Laboratory in Bangalore. He also told me that in India doctors do not appear in court as witnesses for the defense, and since forensic scientists work in departments that report to the police there was nothing produced in cases to counter the claims of 'experts' stating that BEOS (as well as polygraphs and narcoanalysis) work and are evidence for the defendant being guilty (I am not aware of any case in which BEOS 'evidence' has been used to suggest someone was innocent.)

After numerous emails had been ignored over the past few months I decided to go to the Mumbai Directorate of Forensic Science to see if I could try and meet with its Director, Dr. M V Garad. Dr. Garad was last author on a 2009 paper Brain signature profiling in India: It's status as an aid in investigation and as corroborative evidence - as seen from judgments.

Parts of the above paper are cause for concern. In the case of a man accused of murdering an employee and who had taken the Brain Electrical Oscillation Signature (BEOS) profiling test (which had indicated that he was guilty) the court observed that "the tests are scientific tests, are conducted in scientific manners and with latest scientific machines and therefore, these examinations and its results cannot be discarded in this case as it corroborates with other evidence brought on record by the prosecution including oral as well as documentary and therefore, the results of the said examinations are acceptable in this case.'

Just because the test has some of the trappings of science and uses technology this is not a basis for admitting it as evidence in courts. In fact the above statement shows how bad science can fool people into thinking it has a real scientific basis due to lack of scientific understanding. A decision on whether a form of evidence is acceptable should made on the basis that it has been demonstrated to be accurate and reliable, not that it uses the latest machines.

Later in the paper it is stated that 'Being used on approximately 300 subjects suspected to be involved in criminal activities, and the increase in demand for the conduction of this test, is an indication of the usefulness of this particular test in a Forensic Set-up as an aid to investigation.' This is a circular argument. It is used, therefore it is useful and because it is useful it is used... That fact that it is used does not mean that
it provides relevant information for an investigation or criminal trial. It could instead be due to the lack of other corroborative evidence due to crimes being minimally investigated with a lack of more tried and tested forensic methods being used.

In conclusion the paper states that 'Brain Electrical Oscillation Signature Profiling (BEOS) is certainly a useful test as an aid to investigation provided it has been conducted in a scientific manner.' and 'If the tests of the results are negative, and if they are not supportive of prosecution, the courts may consider that, the purpose for which the test was taken has not been served.'

What is worrying about these conclusions is that the definition of 'a scientific manner' seems to be one in which technology is involved rather than that the test has been rigorously scientifically tested to determine whether it can do what it claims to be able to do and to what degree of accuracy and reliability. The second conclusion is particularly worrying as it shows that test results suggesting that the suspect does not have experiential knowledge of a crime are not considered exonerating evidence. Instead it shows that the reason for using the test in the first place is to provide evidence of guilt in order to convict a suspect, and not to determine whether the suspect is guilty or innocent.

I had hoped to discuss all this with Dr. Garad, but it seems that showing up on his doorstep was not to bring me any closer to a meeting with him. I did manage to get a brief interview with Dr. Daundkar, the Deputy Director, but he refused to answer most of my questions. When I asked him about the reliability of the tests and the chances of false positives he did say that it is not possible to get false positive readings with BEOS and that if a positive result suggesting that you had experiential knowledge of a crime was obtained, but that you were not the one responsible for the crime then perhaps the result was due to knowledge as an accessory to the crime. This was both extremely worrying both in terms of being extremely un-scientific and in terms of the potential for human rights violations.

Bangalore
Leaving Mumbai I had high hopes that I would achieve more in Bangalore. Bangalore is after all home to the inventor of the BEOS system, Dr Mukundan. Axxonet, the company he founded to sell BEOS products and the National Institute for Mental Health and Neurosciences (NIMHANS) where he worked for 20 years as a clinical psychologist and the organization which more recently provided a damning expert review of the technology.

I had hoped to be able to meet Dr. Mukundan, in Bangalore to get further information to support the claim that this system can detect experiential knowledge. Dr Mukundan had agreed to meet me before I left the UK, but whilst I was in Mumbai he withdrew this offer and said that Axxonet would also not be able to talk to me about there work. I suspected that this was due to the posts on my blog, so I stopped blogging at this point as I didn’t want the blog to damage the project. I had wanted to see some data and to understand how the system comes up with its 'verdict'.

Dr. C. R. Mukundan, after my meeting Dr. Vaya sent me a message asking for my credentials to support that I am a forensic psychologist or forensic neuroscientist, working in cognitive electrophysiology or
psychophysiology and stating that he would decide on meeting only once I had supplied this. Having been very clear about the project and my position this came from left field, but I emailed him to explain my background and interest and in response I received this email:

'I wish I had known these details early enough; I would not have asked you to meet me. There is no chance of you understanding either the electrophysiology or the cognitive neuroscience of BEOS with your background.

'Anyway BEOS was never to be used as evidence in the Court of Law and to the best of knowledge it was never advocated so by me or presented in the courts. I know from publications of the two laboratories engaged in the use of this technique, that its findings have been cited as corroborative evidence when primary evidences were present and accepted so by the court. I understand the test findings have helped as leads in many cases for solving them. However, you must collect these pieces of information from the concerned forensic scientists or laboratories. I do not have any authentic information which I can share with you.'

Even without a meeting this email was very interesting. The claim that 'BEOS never intended to be used in a Court of Law' is suspect since the first line of Dr. Mukundan's patent application for BEOS reads 'The present invention provides a novel electronic investigative device for identification of truth from individuals who have committed an act of offence.' It is possible that he only ever intended the system to be used in investigations rather than trials, but Dr Vaya, his former student, was clearly presenting evidence from BEOS for use in trials.

Since Dr Mukundan had now decided not to meet me I decided to track down his company selling the BEOS system, Axxonet, whose website claims that “BEOS is being used as an aid to Criminal Investigation in hundreds of cases (including murders, terrorism, fraud, poaching, theft), by the Police and the reports have been presented in Court as supporting documentation,” and that “Extensive ecological validation studies and laboratory studies have already been completed which have validated the usefulness of the test for forensic and intelligence applications. The Government of India performed its own independent Validation study with over 110 subjects, and found the system provides a accuracy level of 95%.” This presumably refers to the TIFAC-funded trial at the Gujarat DFS mentioned above, which is unpublished in any form and which was certainly not peer-reviewed. It took some time to track down the location of the company, and when I did they were not willing to discuss any aspects of the BEOS systems they are selling and would not provide any evidence to back up their claims.

I had also hoped to meet Dr. P. Satishchandra, the Director of the National Institute for Mental Health and Neuroscience (NIMHANS) in Bangalore. He was unfortunately not available, but he put me in touch with Dr Sinha a Professor in the Department of Neurology at NIMHANS who agreed to meet me. He confirmed what I already knew about Dr Mukundan and also introduced me to Dr Kesab, from the Department of Psychology, who knew more of the history of how Dr Mukundan had come to develop BEOS. Unfortunately they asked that our discussion remain confidential.

I then met P. Chandra Sekharan who has written extensively on BEOS, narcoanalysis and the 2010 ruling by the Supreme Court banning the use of these techniques (without consent) and is on the record as stating that the ruling was inadequate to prevent use of the unproven techniques.

He informed me that Section 45 of the Indian Evidence Act recognizes the opinion of skilled persons in court when it comes to "science or art" which forms the basis for allowing the inclusion of evidence such as BEOS profiles in court. He also stated that "brain mapping [was being] done by non-medical personnel in India whose careers are, to say the least, highly questionable" referring to those promoting BEOS. He suggested that since their salaries depended on the technologies working their status as independent experts was suspect. He did however think that the use of these technologies by courts was well intentioned and that the forensic science laboratories using BEOS were simply misleading them.

He also confirmed what I had been told in Mumbai that use of independent experts (independent of the police or independent of the prosecution) testimony in court was not often used in India. He said that the DFS training of judges in Gujarat, was not wholesale however and pointed to a more independent example of the forensic science laboratories in Tamil Nadu, which he told me where independent of the police and suggested that this was a better model.

He said that some of the reason for the popularity of using BEOS and other related techniques was that the police thought along the lines of the 19th Century English lawyer Sir James Stephens, who in 1883,
rationalized "third degree" practices by the police of India: "It is far pleasanter to sit comfortably in the shade rubbing red pepper in a poor devil's eyes than to go about in the sun hunting up evidence." He suggested that this attitude also helped lead to the forensic scientists acting unscientifically by using multiple tests to corroborate the evidence from each previous test, rather than each test being independent. When asked about what he thought of the claims made by the DFS, Gujarat he said that they were flawed, as they were not independent, not blinded and not published.

Prof Chekaran also told me that the then-Central Bureau of Investigation Director Ashwani Kumar wanted the 2010 Supreme Court ruling on the use of BEOS and to be reversed as he considered these techniques to be essential to beat terrorism. It seems this is the case according to an interview for The Hindu in May 2010.

Prof Chekaran then gave me the contact details of Mr ST Ramesh, a senior police officer, who had previously been in charge of the Bangalore Forensic Science Laboratory. I met him in his office the following day. He told me that when supervising the FSL in Bangalore he had opposed the techniques of BEOS and narcoanalysis as he thought they were dubious.

Mr Ramesh stated that he had no problem with using polygraphs as part of investigative purposes, but only to lead investigators to search for concrete evidence, rather than as evidence suitable for presentation in courts. He thought that Dr Malini and Dr Mohan (the forensic scientists at the FSL in Bangalore) had overstepped their remit by promoting BEOS, polygraphs and narcoanalysis to be used in combination as useful courtroom evidence rather than as an investigative tool.

He stated that their "freedom to experiment was misused" as they started giving seminars and conferences to police to promote the techniques without proper authority. He thought that the motivation for the collaboration between Dr Mukundan, Dr Vaya, Dr Malini and Dr Mohan was based on a combination of commercial interest and desire for publicity and fame rather than a desire to apply science to lead to more robust and accurate rulings in criminal cases. He thought that their promotion of the power of the technologies had led to public, media and political pressure on police to accept them as a valid way of providing sound evidence, and thus convictions. He also said that in 2008 the promotion and take-up of these technologies meant that resources were being spent on them rather than traditional forensics, which compounded the problem.

Mr Ramesh also very generously also provided me with a copy of the report from NIMHANS 'Technical peer review of the brain electrophysiology based technologies used at forensic science labs in Bangalore & Gandhinagar.' This report concluded that there is a 'sub-optimal scientific basis' for BEOS to be used as evidence in a court of law and that the scientific claims made about them needed to be peer reviewed and published. It also recommended that the procedures needed to be standardized, and made transparent before they can be used.
To get the point of view of the other side of the argument I wanted to meet Dr Mohan, the Director of the FSL, Bangalore. I called and visited, and finally got an appointment to meet him on my last day in Bangalore.

He claimed that the use of BEOS was continuing and that the technique worked, but that they were just waiting to be able to afford a neuroscientist to analyze the data to publish it and show that it worked! This demonstrated a profound misunderstanding of how science is supposed to work since he was admitting that they had not properly validated the technology before claiming it was capable of determining guilty experiential knowledge robust enough to be used in courts to help secure convictions. His view was that the analysis and publication of existing data would answer the concerns set out in the critical review of BEOS by NIMHANS.

He claimed that the technique had been used on more than 2000 people, and that their data would show that the technique was effective once analyzed. Again this demonstrated a poor understanding of science since he was already certain of the outcome of such an analysis before it had taken place. He stated that in his opinion the Supreme Court ruling still permitted the BEOS and narcoanalysis, and that his view was that these could only be done with consent. He claimed that the NIMHANS report on the techniques was flawed and that it did not look at, or analyze the data they had gathered. Sadly I was not able to spend more time with Dr Mohan as I had to leave for the USA the next day. I would have liked to question him further and try and secure some of his data to be able to get someone to independently check his conclusions.
New York
It was great to arrive in New York, and whilst it was by far the most expensive part of my fellowship in terms of accommodation I did have amazing views from the roof of my hotel, the Affinia Shelbourne! It helped make me feel re-energized and hopeful that the US part of my trip would be more successful than the Indian part had been.

Views from my hotel in New York

My first NY meeting was with Ed Cheng, Professor of Law at Vanderbilt University in Tennessee, but who fortunately for me was working at Columbia University in Manhattan at the time. His research focuses on scientific and expert evidence, and the interaction between law and statistics.

He took me through a brief history of the use of scientific evidence in US courts, starting with the first case when polygraph evidence was considered by a court in the 1920s, Frye vs the USA, and that whilst the evidence was not considered admissible it set the standard still used in many US states to determine the criteria a scientific test needs to meet to be deemed admissible. He also told me about the Daubert standard that is used in most of the states that do not use the Frye standard.

He thought that there was a case for introducing fMRI based lie detection in US courts as with the adversarial system it would be good to see lawyers argue the merits for and against the technology in courts, though he thought that there was a deep-set cultural reluctance for lie detection to be admissible.

Ed stated that “Brain scanning technology for lie detection is important because it offers an opportunity for us to improve credibility determination in court. We know that humans are very bad detectors of credibility and so any kind of improvement in that score is going to lead to more accurate trials. It doesn’t necessarily have to be perfect but it can be an improvement and that is one of the major reasons why it’s an exciting development.” However he also said that he thought the legal system tends to be quite set in its ways, that it’s comfortable with having the jury be the lie detector and it’s quite protective of that. He suggested that unless fMRI technology can really show say a 90-95% accuracy rating then the legal system is likely to ignore and resist it’s development.

He also said that the reluctance to use it was a shame and that if he were a juror he would want to hear the fMRI lie detector results. He said that “one of the best things that juries are good at is synthesizing all of the evidence that’s available into some kind of meaningful or holistic story and if you provide them with this information I don’t think necessarily that they’re going to do bad things with it or blindly follow it.”

Prof Cheng also talked about the problem with the way courts view precedent when it comes to new technology. If they accept a technology when its accuracy is not that high and its limitations are not well documented then there is a problem that future courts could blindly accept such evidence based on precedent. Conversely if a technology is not held as admissible then that can make it much harder to introduce in future cases based on precedent even if the technology has since improved making the evidence more reliable. He stated that “the state of the art is always shifting and courts [and the] the law in general is very bad at dealing with that.”

The next person I went to see in New York was David Zevin an employment lawyer based in Brooklyn who had been Cynette Wilson’s lawyer and tried to bring fMRI based lie-detection evidence into her civil case for unfair dismissal. She had been employed by an employment agency and after complaining about sexual harassment on a job she had taken an employee at the agency had informed her that she was not offered any more jobs after the employee’s boss had told him not to place her again. David had heard about Cephos offering lie detection in Boston, and at the time it was offered free as Cephos were trying to get a test case in
which fMRI lie-detection evidence was heard in court. In this case the judge did not allow the evidence into court as he considered that lie detection was the job of the jury, not science. The judge, Justice Robert J. Miller said "Credibility is a matter solely for the jury" confirming Ed Cheng’s analysis of the current situation and the resistance of the legal system to such evidence.

David Zevin thought the decision was a shame and said that “as an aid to the jury as one piece of evidence among many I would be in favour of it coming in, just because juries by themselves are no better than 50/50” and that “we know that 1) people lie a lot and 2) juries are terrible lie detectors.” He told me that “Many social scientists have done studies showing that juries can’t tell if someone is telling the truth or not and that we know that eyewitness testimony is also unreliable. Why shouldn’t we let fMRI based lie-detection evidence in if there are reputable scientists out there who say that this could be useful especially in light of the fact that the other side can point out to the jury that there’s this study and this study and this scientist and this scientist who think it’s not reliable and shouldn’t it be let in.”

He said that, particularly in civil rather than criminal cases “So many cases involve determining who’s telling the truth whether it’s a personal injury case and somebody says that they have pain in their leg five years later from an auto accident. If you know if they’re telling the truth or not then the case would be much more fairly and quickly settled.”

I asked David what he thought about providing fMRI-based lie detection evidence even though it was imperfect and letting the judges and juries assess it through cross-examination for the evidence. He thought the reason the legal system does not allow evidence from such unproven techniques was that the technology hasn’t been around that long enough and that there hadn’t yet been enough studies to provide a consensus on how accurate it is. He said, “Until some kind of consensus is built I think it will not be allowed.”

He thought that although the current system was flawed it was unlikely to change in the near future. “We just basically just keep doing things the way we have done them until we can come up with something better because otherwise just from a very practical point of view what would we do? Disputes have to be resolved. We’ve been resolving them this way for hundreds of years and society has not fallen apart. Injustice is done regularly, but if we didn’t have a justice system what’s the alternative?

“There is a long standing doctrine in the law that no person, no new technology is allowed to usurp the function of the jury.... But that’s been a doctrine for hundreds of years and once we get to the point where we do have technology that can be used more accurately than a jury can be used it seems that it’s time for that doctrine to fall.

“The purpose of the rules of evidence are to exclude junk science, to exclude snake oil to exclude things that are hype without any substance behind them... We want to keep out inaccurate, possibly dishonest science. Yet on the other hand we want to do justice so if a scientific process is valid we want to be able to use it as quickly as possible. But the wheels of the law and the wheels of science grind slowly.”

I left with the overall impression that David was keen to see fMRI evidence admitted into court but that he wasn’t very hopeful that it would happen in the near future.

I had hoped to speak to Dr Liz Phelps, Lab Director, New York University, Department of Psychology who has written about fMRI-based lie detection in Using Imaging to Identify Deceit: Scientific and Ethical Questions, but sadly although I emailed her in August and October 2010 she was not in town when I was there. She did offer to speak to me on the phone though.
Boston
I travelled up to Boston from New York by bus on Thanksgiving Day. My first meeting after the holiday was with Steven Laken, President and founder of the fMRI-based lie-detection company Cephos. You can see Steven on a short Dateline NBC newsclip on the Cephos website showing the fMRI being used to attempt to verify or cast doubts on details of extra marital affairs.

![Image of Me with Steven Laken at the Shields MRI in Framingham, Massachusetts]

Steven was very generous with his time and showed me round the centre where his company performs the fMRI testing on his clients.

Steven talked to me about David Zevin’s case and also about a second trial in which his company had tried to provide fMRI lie detection in 2010. The case was a fraud case and the defendant Dr Lorne Cemrau was accused of submitting false and fraudulent claims to the Tennessee and Mississippi Medicaid and Medicare programs. Interestingly in this case the defendant did not deny that he had submitted the wrong claims, but he argued that this had been an innocent mistake as he thought he was using the correct claim and had simply misunderstood which claim code he should have been using.

Whilst this was a criminal case, rather than a civil one it seems it largely rested on the intent of the defendant, rather than whether the crime had been committed. In other words it was a case in which the jury’s decision would largely rest on whether they believed the defendant or not, and so one where any independent test of whether he was being truthful would be invaluable. The fMRI evidence was heard by the judge, but the evidence presented was not clear. Cephos had done the test three times, two of which concluded that Cemrau was telling the truth, however the other concluded that he was lying. Hardly compelling evidence. In addition the questions used in the test were highly technical and complicated, and as such very different from the types of questions used in the published studies on lie detection. Finally none of the studies on fMRI-based lie detection had been carried out in anyone over 55, and so it was not clear if Dr Cemrau’s responses aged 65 would be the same as in younger subjects.

In the end the judge ruled that the fMRI evidence in this case did not meet the required Daubert standard and that it was not admissible. Judge Tu Pham spent considerable time considering the evidence and whilst he did not consider the evidence strong enough in this case he provided a roadmap for how future defendants may be able to satisfy the Daubert standard. He wrote “in the future, should fMRI-based lie detection undergo further testing, development, and peer review, improve upon standards controlling the technique’s operation, and gain acceptance by the scientific community for use in the real world, this methodology may be found to be admissible even if the error rate is not able to be quantified in a real world setting.”

Steven seemed to be very keen that the lie-detection system he was promoting was as scientifically rigorous as possible and he pointed out that they published their research in peer reviewed journals, and was keen that others replicated (or refuted) the findings to move the field forward. He seemed frustrated that although new papers were being published showing that fMRI lie detection works and that these studies had been from labs in different parts of the world that opponents of the technology continued to say that more studies were needed and that it may be appropriate to be used in ‘5-10 years time’ when that research had been
done. He said that these opponents were saying the same thing five years ago, and that their views were not being updated in light of further evidence.

I asked him whether he had had any interest in the technology from investigative agencies rather than by individuals wanting to prove their innocence when accused of lying. He said that the agencies were not interested as they had a long standing tradition of using polygraphs and that even if the techniques offered a more direct measurement of lying they were happy with their existing methods.

I left Steven with a much more positive view of the potential of fMRI-based lie detection and sympathized with his wish for more neuroscientists to research the accuracy of the technique.

Whilst in Boston I had also hoped to meet Professor Nancy Kanwisher in the Department of Brain and Cognitive Science at the McGovern Institute of Brain Research at the Massachusetts Institute of Technology who had written about fMRI-based lie detection and had contributed to the publication Using Imaging to Identify Deceit: Scientific and Ethical Questions, but unfortunately she was not in Boston during my visit. She did suggest that I talk to Anthony Wagner when I visited Stanford University.

I had also emailed and called Steven E. Hyman, Provost of Harvard University and Professor of Neurobiology at Harvard Medical School, another contributor to the ‘Using Imaging to Identify Deceit’ report, but I was not able to get hold of him.

I had also hoped to meet Joshua Greene, Assistant Professor of Psychology, Harvard University who had done a very interesting fMRI study looking at deception, but unlike most other such studies the participants were unaware that the test was looking at lie detection. Participants were told they had to predict the outcome of a coin flip and then report whether their prediction was correct. The more correct predictions meant that they were financially rewarded. Some participants were dishonest and reported they had been correct more than they actually had, since they would likely only be correct around 50% of the time. The study showed brain activity in those people being dishonest similar to other lie detection studies, and an absence of such activity in those honestly reporting their predictions. This study was the first to show deception-related activity when participants were not aware that lie detection was the subject of the test. Unfortunately Josh was not able to meet me, and did not even have time to speak to me on the phone. He said that he would be happy to talk to me the following year.

California
It was great to arrive to the warm Los Angeles weather after being in freezing cold Boston. I hired a car and set off for San Francisco to meet various contacts at Stanford University. Having not driven for many years this was a scary journey, but travel around California without a car seemed almost impossible.

My first interview in Stanford (about an hour’s drive from San Francisco) was with Professor Hank Greely, Director of the Center for Law and the Biosciences, Stanford University. Hank has published extensively on bioethics and on the use of fMRI-based lie detection.

I spoke to Hank about his views of Steven Laken and one of Cephos’ scientific advisers, Frank ‘Andy’ Kozel of the Medical University of South Carolina and Ralph H. Johnson Veterans Affairs Medical Center, Charleston, South Carolina. Andy Kozel has been the lead author on a number of the fMRI-based lie detection studies supported by Cephos, though Kozel is an unpaid adviser to Cephos. Hank told me that he had talked with Kozel and liked him. He said, “I think he’s a scientist trying to genuinely figure something out.” He said he’s also talked to Steve Laken and I liked him as well although he said, “for Steve I think the clash of roles of entrepreneur on the one hand and scientist on the other may be a little difficult to manage.”

He said about Cephos and NoLieMRI that he felt “some sympathy for the companies involved, I think [answering whether fMRI-based lie detection works] is a major research project. I think you’re talking about millions of dollars or work spread over 5 years or so to get a very good sense of whether this works or not.”

I asked him what he thought of the current evidence that fMRI-based lie detection works. He said of the published articles dealing with fMRI-based lie detection that “They almost all have found some sort of statistically significant correlation between brain activation in particular regions and deception, but that doesn’t mean that it’s ready to be used, in part because most of them have found activation in different regions of the brain which is a little disconcerting, but more fundamentally none of them has actually involved ecologically realistic lie detection where it’s really somebody who is worried about whether he’s going to be guilty or not, who’s not an undergraduate or an adult knowing that he’s participating in a research project.
“Ecological realism is really quite important and to me that’s probably the biggest concern. I would like to see a lot more research here. I do think that if this turns out to be reliable, to have a very high sensitivity, specificity, and positive predictive value - all terms for measuring different kinds of accuracy then we’re likely to want to use it in various ways. And we probably should use it in some ways. But I just want to make sure that its proven to work for the people, for the kinds of people on whom its used with in really realistic situations and we haven’t seen any of that yet.”

Hank then explained more about the importance of knowing different aspects about the accuracy of any type of scientific tests in terms of needing to know, not just the sensitivity of the test, but also the specificity. He said “Sensitivity effectively tells you your false negative rate - how many people who are guilty, you are saying are innocent, how many people who are lying, you’re saying are telling the truth. Your specificity tells you your false positive rate - How many people who aren’t lying you say are lying. Both of those are important and the balance between sensitivity and specificity is a real issue in any kind of test, not just in court. It’s an issue in say diagnostic tests in medicine. You don’t want to identify people as HIV infected who aren’t HIV infected because you then put them in anxiety and expose them to dangerous drugs and a bunch of other stuff. You also don’t want to tell people who are HIV infected that they aren’t HIV infected because you put their lives and the lives of their contacts at risk. Often tests have a balance between those so you can kind of tune them up so you can improve your specificity at the expense of your sensitivity or improve your sensitivity at the expense of your specificity. I think the same would be true of these kind of tests used either in the court or for investigative purposes. There’s going to be a relationship between specificity and sensitivity and that relationship will make a difference in how we want to use it in different contexts. Until we know what those sensitivities and specificities are and how they change I don’t think we should use it at all. So again my basic theme here has been more research is needed.

“I think the most important thing for us in dealing with any kind of new technology whether it’s fMRI for lie detection or whether it’s a new transportation technology is figuring out what the consequences are likely to be. How well it’s likely to work, what the side effects are, what the costs are and get that information well understood before we start making important decisions about how we’re going to use it. All technologies can be used well and they can be used poorly. They can be used within their limits or they can exceed their limits. If we use them within their limits we can use them for good purposes or bad purposes. If we use them outside their limits I don’t see any way that any good can come from it. We need to understand the limits of the technology before we decide how to use it. Then we need to decide, if it is an effective technology, how we want to use it. For things like fMRI lie detection we need to answer both of those questions. We don’t have enough data yet to answer either of them.”

Hank then started talking about countermeasures “If what it’s measuring is how your brain works then its not at all implausible to think that changing what you’re thinking about when your telling the truth or telling lies could be a really effective countermeasure.”

I was interested in this potential for countermeasures to be used to beat the fMRI lie detection, as it is well documented that this is one of the problems with polygraph tests. Whilst there have been all these papers documenting a correlation between brain activity and deception it is still only theoretical in terms of what this brain activity represents. Hank suggested that “Let’s say your theory is it’s harder to tell a lie than to tell the truth because you’ve got to think about more things. [Then there are] two possible kinds of countermeasures you could [theoretically use. You could] study your lie very carefully and memorize it so it’s very easy to tell the lie – practice it, plan it.” He said that another theoretical countermeasure would be to make it harder to tell the truth by actively performing a complex cognitive task “so if I ask you what your name was and you were trying to beat the machine you might start counting backwards from 100 by 7s or trying to remember the winners of the last of the premier league trophy for the last 5 years, so those things might be effective countermeasures”

Hank talked about a study published on countermeasures just a couple of weeks earlier by Professor Georgio Ganis at Harvard Medical School, Boston. Unfortunately I only became aware of this study once I was in California, so had missed an opportunity to try and interview Professor Ganis when in Boston.

I asked him about whether the fact that there is already a lot of unreliable evidence and techniques used in investigations and in courts was an argument for using fMRI-based lie detection even though we know that it has significant limitations at the moment. Hank said that “The fact that something we’ve done for a long time is not very good is not an argument for adding something else that is not very good. If we’re using something that’s bad, yes in an ideal world we would go back and stop using it, but that isn’t an argument for adding something else that is bad too.” He gave examples of polygraph tests that had been wrong. There was a Russian spy, Oliver James, who worked in the CIA for many years whilst passing many polygraph tests aimed at detecting such spies. In another case Wen Ho Lee with the department of energy was suspected of
 spying for the Chinese based in part on polygraph results. It turned out the tests in both these cases were wrong. Hank said that “using something that makes mistakes will screw people’s lives up. And we shouldn’t do that as an ethical matter, we shouldn’t do that as a legal matter and neuroscience shouldn’t want to be part of something that messes up people’s lives”

Hank did talk about how useful having an effective lie detection test would be and talked of a variety of situations where it could be used ethically and to make people’s lives better. But he said that “Knowing what the accuracy is essential to figure out if it’s appropriate to use it either in a setting where the consequences are enormous, like a court case or a setting where the consequences are less important, like investigation. But the consequences in investigation are still important. In part because you wouldn’t want to risk incriminating, and certainly annoying and causing anxiety in innocent suspects, in part because you risk letting off guilty suspects. It’s not the case that just because you’re using it in investigation rather than in court we don’t care about accuracy. We can in some circumstances I think reasonably care somewhat less about accuracy than otherwise”

It was a fascinating meeting with Hank and I would have loved to have had more time with him, but as with so many other people I wanted to meet on my Fellowship he is a busy man and could only spend a limited amount of time with me.

After meeting Hank I met Emily Murphy, a bioethicist at the Stanford Centre for Biomedical Ethics, with a background as a neuroscientist and experimental psychologist. She also writes about both fMRI- and BEOS-based lie detection. One of her blog posts includes a link to the original judicial ruling convicting Aditi Sharma of murder in 2008. Interestingly whilst being rightly skeptical she thought that the claims of EEG-based experiential knowledge detection in India or fMRI-based lie detection in the US were not without some scientific merit, at least in theory. She had been to India and had managed to meet and interview Dr Mukundan. She said that he had claimed that funding was tight when he was at NIMHANS and that it was difficult under those circumstances to publish in decent international scientific journals. She also talked of the problems faced by Dr Mukundan in terms of being divorced from the rest of the scientific community and the lack of enforcement of protection of Intellectual Property in India making it difficult for him to be open about how his system worked. She said that these were valid reasons for his lack of publication and transparency, however they do mean that the techniques being used were rightly questioned. She also informed me that the ‘probes’ used in the Aditi Sharma case did not fit with the protocols set up in Dr Mukundan’s work, which fitted with the NIMHANS reports conclusion that the procedures used needed to be standardized.

Emily also told me that the first near-case of fMRI being used in US courts in a San Diego case did not get to court because the expert witness from NoLieMRI, Daniel Langleben, was not willing to testify.

I also met Kelly Lowenberg. Prior to joining the law school, Kelly worked in Dr. Jonathan Cohen’s lab at Princeton University assisting functional magnetic resonance imaging (fMRI) research on decision making. She writes for the Centre for Law and BioSciences blog. She suggested that one of the problems with fMRI lie-detection was that it is still not known whether the test is actually detecting the act of lying or whether it may in fact be detecting the difference between a memory and the lack of one, or between something that is of no consequence to the subject or something that is salient to them. She suggested I talk further about this with Anthony Wagner.

The next day I met Anthony Wagner, Professor of Psychology and Neuroscience, Co-Director of Stanford’s Center for Cognitive and Neurobiological Imaging, and Director of the Stanford Memory Laboratory. He was extremely cautious about what he would say about fMRI based lie detection. He confirmed that the different publications on the subject had used different methodologies and had identified slightly different regions of the brain active during lying, possibly as a result of this. He also confirmed Kelly’s concern that we don’t yet know if these active regions are specific enough to be considered markers of lying as there could be other cognitive processes going on during these tests that are actually leading to the signal. The signals could be due to cognitive processes involved in lying, they could be to do with memory retrieval or they could be to do with salience for example. However Professor Wagner did state that “There’s reason to be optimistic [about fMRI-based lie detection]. The field has taken great strides over the last few decades and [I] expect great additional strides over the coming decades” and that “it’s an exciting time and we’ll see where the science takes us.”

Prof Wagner suggested I should also speak to David L. Faigman, John F. Digardi Distinguished Professor of Law, Director of the UCSF/UC Hastings Consortium on Law, Science & Health Policy University of California, Hastings College of the Law. Both are members of the Research Network on Law and Neuroscience, supported by the John D. and Catherine T. MacArthur Foundation. Unfortunately Prof
Faigman was not able to meet me at such short notice. Hank Greely, Elizabeth Phelps, Emily Murphy have all published papers on fMRI-based lie detection as part of the Research Network.

Prior to travelling I had arranged to meet Michael S. Gazzaniga, Professor of Psychology and Director, Sage Center for the Study of Mind, University of California, Santa Barbara but unfortunately by the time I was in California his plans had changed and he was not able to meet me. He suggested I instead try and meet Robert T. Knight, Evan Rauch Professor of Neuroscience, Director, Helen Wills Neuroscience Institute at University California Berkeley, but by the time Prof Gazzaniga had cancelled and suggested Prof Knight it was such short notice that Prof Knight was also unable to meet me.

The last part of my journey was to San Diego to meet Joel Huizenga, Founder and CEO of California-based 'No Lie MRI'. He can be seen (back in 2007) on a PBS Wired Science feature promoting his companies' lie-detection technology. I met Joel at a café in the town, and whilst he was very personable he mainly seemed interested in talking to me about Cephos to try and get any information I had about what Steven Laken was currently working on. He talked at length about the way Cephos had not done a good job of presenting lie-detection evidence in court for the Lorne Cemrau case. I did not get much information about what he or his company were doing though, and did not get any information about what had happened in the case in San Diego where it had been reported that his company were going to be providing fMRI-based lie detection testimony. This case in 2009 would have been the first in the US where fMRI evidence was submitted (the two Cephos cases were in 2010.) No Lie MRI licensed its technology from psychiatrist Daniel Langleben of the University of Pennsylvania and it had been suggested to me that the evidence was withdrawn as Langleben was not willing to testify. I was not able to determine whether this was the case or not.

I had hoped to meet Terrence J. Sejnowski, Laboratory Head, Computational Neurobiology Laboratory, Salk Inst., University of California (Also on science board of NoLieMRI and elected to National Academy of Sciences in Apr 2010), but I received no response to my emails.

I also tried to meet Paul Ekman, Professor of Psychology at the University of California, San Francisco psychologist who has been a pioneer in the study of emotions and their relation to facial expressions. He has been named one of the 100 people who most affect our world by Time magazine. He has written extensively about lie detection using ‘micro-facial expression analysis.’ One of his colleagues responded to my request to meet him asking what I would be paying, but when I told him that I didn’t have the funds to pay a large interview fee I did not hear back. This was a shame as whilst fMRI based lie-detection has not yet gained any real traction in the US Prof Ekman’s lie-detection has been enthusiastically taken up by US border control agencies. The evidence for this ‘science’ being effective is, if anything, less convincing than fMRI-based lie detection, but it has gained political traction due to the fear of terrorism and the fact that it can be rolled out without worrying about whether it would meet any standards required for even an investigation, never mind a criminal trial.

Whilst my Fellowship was not specifically concerned with micro-facial expression analysis I feel it is worth a mention as there is a lack of convincing evidence of accuracy, particularly in real-life circumstances, and there is also a lack of understanding of what the false positive rate or false negative rate is. For courtroom situations such information would be crucial, but for border control screening uses knowledge of the false negative rate is absolutely crucial. A false negative would be when a trained micro-facial expression analyst passed a terrorist and, say, let them on a plane with a bomb. Needless to say for this ‘science’ to be of any use the false negative rate needs to be essentially zero. With millions of people travelling per year a false negative rate of 0.000001% would be useless as only one terrorist or one bomb needs to get on a plane to make the whole system worthless. Given the attacks, or attempts at attacks that have happened since this micro-facial expression analysis system was adopted the system is useless in my opinion.

For fMRI-based lie detection the false positive rate is less important as if used in courts it should only be used in combination with multiple other sources of evidence, and even then, if accepted it would have a defined margin of error that could be usefully taken into account, so given that micro-facial expression analysis has been allowed out into real world setting perhaps fMRI lie detection should be used as well. Alternatively perhaps we should not be using micro-facial expression analysis.

When with Hank Greely in Stanford I had asked his views on Paul Ekman and his ‘lie detection’ work using micro-facial expression analysis. Hank said that he thought it was frustrating that Ekman claimed he had great results, but that he wouldn’t publish them in peer reviewed literature because he didn’t want to reveal the science to America’s enemies in case they developed countermeasures against them. He concluded that if the science isn’t published then there is no reason to believe it works. He said “The fact that the transportation and security administration (TSA) has decided to experiment with [micro-facial expression analysis], the TSA isn’t terribly comforting for those of us who’ve been through TSA inspections at airports.
They don’t necessarily have the greatest reputation in the world, but there at least you’ve got some back up. All that’s being used as a screening device to pull somebody out for a metal detection or a wandering or a baggage search. You’ve got some more objective piece of evidence that would follow from it. It’s an investigative screening technique. I still wouldn’t like to see it used unless we had good confidence that it works, but that’s very different to using it in a court room where you’re using it because there isn’t solid objective next step evidence one way or the other. So I do think the settings matter and whether you’re using it for screening purposes or for some other purpose matters. Wherever and however you’re using it, if you don’t know whether it works you shouldn’t use it.”

Conclusions and recommendations

My main conclusion, perhaps predictably is that ‘more research is needed’, a phrase banned by the British Medical Journal. There are many problems with this need for more research, starting with who would do it or pay for it. Most research into understanding the brain is concerned with understanding consciousness or understanding diseases of the brain. Neuroscientists are not generally funded to develop technologies that can be used in courts to determine whether people are telling the truth or whether they have experiential knowledge of crimes as they are mostly funded by sources aimed at biomedical research rather than legal research.

There are many difficulties with such research beyond funding. There is mostly no ‘objective truth’ beyond what subjects report in real life circumstances, so it is very hard to design scientific experiments to conclusively show that brain-scanning based lie detection works in a way that is useful for legal trials. There are some clever experiments that have been done to try and get beyond the experiments where participants know that they are taking part in lie-detection research (such as the research of Josh Greene), but these are still a long way from being similar to detecting the type of lies told in real-life situations which could have a bearing on the outcome of an investigation or a trial.

Perhaps research is needed on criminals for whom there is firm objective evidence of their guilt to look at how truth or lies of the details of their crimes look in a scanner. There are considerable logistical and ethical issues involved in such experiments however!

I do not think we should be abandoning hope for the future of the fMRI-based lie detection, since papers continue to be published and all suggest that deception can be detected. Use of countermeasures could be an issue, but since these will involve subjects consciously attempting to use other cognitive processes when being scanned it should theoretically be possible to detect that they are using countermeasures. This would mean it wasn’t possible to determine whether they are lying or being truthful, but it would show they were not cooperating with the procedure.

Whilst I am hopeful for the future of fMRI-based lie detection I have seen no convincing evidence at all that EEG-based lie detection or experiential knowledge detection has any basis in sound experimental evidence that it works. I find it very worrying that India seems to be continuing to use this technique. When I was in India those using EEG techniques say that they hope to supplement the techniques with fMRI in the future. This makes me no less concerned as those promoting BEOS have clearly demonstrated poor scientific practice, so unless some better scientists were involved in validating any combination of EEG and fMRI technique it would likely just compound the existing problem. I am not suggesting there is a wholesale problem with forensic scientists in India, but it seems that a very small number of people pushing an agenda stating that BEOS works can have a huge impact on large number of potentially innocent people.

I very much hope other countries do not adopt use of BEOS evidence in courts. I would suggest that in most if not all countries the level of understanding of scientific methods by police, lawyers and judges is not particularly great (as in the rest of the population), and so pseudo-scientific methods can easily seem to provide robust evidence if suitably qualified experts do not appear in courts to explain to judges and juries the limitations of the technologies. Without experts providing critical analysis of these techniques it is all too easy for pseudoscientists to peddle their wares.

The two cases in the USA show that if lie-detection evidence is heard in courts where effective adversarial systems exist and where scientists are able to speak up against the evidence then there is an appropriate safeguard against poor science being used to undermine justice systems. In any country, or in any system legal or otherwise my message is - ask for evidence, don’t be blinded by pseudoscience, and always seek independent opinion of scientific claims.
I hope there will be more cases in which fMRI-based evidence is presented and challenged. If fMRI-based lie detection evidence is ever to be a useful tool for society we need to know it works and having such hearings in courts will help us to determine if and when it is ready to be used more widely outside the laboratory.

**Dissemination of findings**

So far since returning from my travels I have spoken about my experience and what my views on the status if the technologies are at various events. I spoke at a panel event called ‘Oi, get your grubby hands out of my brain’ on the 25th June 2011 at the Edinburgh International Film Festival. The neuroscientist joining me on the panel was University of Edinburgh Professor of Psychiatry Stephen Lawrie. The event used various fictional films to explore the commercial and ethical issues around neuro-imaging.

By autumn 2011 I had edited the interview footage I had gathered in the USA into a 11 minute film ‘The Truth is in There: Detecting lies in the brain’ which can be viewed at [https://vimeo.com/38154129](https://vimeo.com/38154129). I premiered this film as a kick of for a debate about neuroscience and lie detection at the Battle of Ideas on the 30th October 2011. The session ‘My brain made me do it’ featured Professor of law at the University of Kent, Canterbury, Michael Fitzpatrick and Professor of neurobiology at the Netherlands Institute for Neuroscience, University of Amsterdam Dick Swaab. The event was well attended and there was a lot of lively discussion, though the main conclusion was that more research is needed before we use lie detection technology outside the lab.

I also showed the film and took part in the event ‘The Legal Mindfield’ at Wellcome Collection on 8th March 2012, chaired by Claudia Hammond and with fellow panelists Professor Nikolas Rose, Professor of Sociology and Head of the Department of Social Science, Health and Medicine at King’s College London and Dr Lisa Claydon, Associate Professor in Criminal Responsibility at Bristol Law School. A podcast of this event will be available on the event page on the Wellcome Collection website later in 2012 and I will also distribute it through promotion on Twitter and Facebook.

I have now started to distribute the film via a combination of Vimeo and other social media and will approach science festivals and science centres about arranging events on the subject later in 2012 and in 2013.