INTRODUCTION

Change is the Rule of Justice

Forensic science is a continuously expanding branch of applied science and technology. The branch of Forensic Science has seen considerable growth over the years and continues to progress with further expansion in technology. Forensic Science is “The study and application of science and technology in search of truth in civil, criminal regulatory and even non-litigious matters” (B.R. Sharma, 2005). The term forensic comes from the Latin word “forum” which means the “market place”. In ancient times, justice was administered in the market place. In present scenario, Forensic Science is used to describe the role of science in solving crime. It had an impact on the world of justice, crime investigation and the use of advanced technology in this field. It encompasses several other disciplines like Forensic biology, Forensic serology, Forensic chemistry, forensic physics; Forensic toxicology etc. One of the emerging fields is Forensic Psychology/Criminal Psychology.

Forensic Psychology is a branch of applied psychology which is concerned with the collection, examination and presentation of evidence for judicial purposes’ (Haward 1981). The provision of psychological information for the purpose of facilitating a legal decision (Blackburn 1996). The first recorded example of a psychologist acting as an expert
witness in a court of law was in 1896. Forensic Psychology focuses on collection, examination and presentation of psychological evidence for judicial purposes (Haward 1981). Psychology and Law are very different disciplines with unique methods of understanding human nature and behavior. They both employ a rational approach to solve complex multifactorial problems and intersect at multiple levels. However the achievement of balance between the two is a very difficult task. Nonetheless, continued effort has been devoted to bridging the gap. Forensic Psychology has retained its focus on assessing and understanding criminal behavior intention behind the crime, diagnosing mental or personality disorders that are conducive to committing a criminal offense or which can be directly connected/attributed to the crime. However the detection of complex crimes, by connecting crime with the perpetrator is much more complex and complicated. To overcome this complex situation, new technologies/tests and methods have been developed to handle such situations tactfully with a humanistic approach. With the expulsion of traditional sources of proof and confession methods, the current scenario demands more reliable and objective techniques for providing indicators of truth suppression by the suspect. The traditional source of proof and confession has gone away, now the demand of present scenario is to rely in something more objective and concrete to establish signs that may indicate that the suspect
is telling lies by suppressing the truth. These signs are found to manifest as either behavioral or physiological when telling lies. Therefore, the association of behavior and physiology culminates in a more scientific and functional field, that is, Psychophysiology. Psychophysiology is concerned with the physiological basis of psychological processes and, further, explores their interaction with each other.

A lie is considered to be said when the individual who states it knows that the denial, commitment, or the answer does not conform to the reality. The lie is expressed as it helps one to save his self-esteem or avoid punishment, helps to conceal the truth, and thereby helps to escape the punishment. Suspects lie because they want to hide their deeds/actions; these actions are illegal or against the law, and can prove to disrupt or destabilize the society of those responsible citizens. Hence he would cover the facts and would not tell the truth. The fear of being identified and punished is the issue of anticipation of the consequences of the act committed. The ability to predict the consequences of actions is an important prefrontal lobe function used for motor programming. Estimating/ foreseeing the consequences of detection, such individuals learn to conceal and escape from detection of deception. More often than not, a large section of society falls prey to the vicious cycle of corruption, compelling them to commit certain crimes for personal benefits. Due to the majority of the population being involved in some form of subterfuge
or the other, the average individual feels insulated from punishment and considers such practices as the norm. Therefore, there is a need/we need an instrument that would assist the examiner to determine if the accused or suspect concerned is telling a truth or lie. There is a great demand for sophisticated and objective instrumentation that can assist in bringing some semblance of order into a country where crime has, over the years, escaped justice through several means of deception. Lying is perceived as a convenient alternative to telling truth rather than a conflicting alternative. Investigators attempted to develop techniques for detecting deception and finding truth. In today’s world, the scenario of justice, the traditional sources of proof, eyewitness accounts, and confessions have gone awry. Trials take place after or for a long period of time, thus resulting in manipulation and sabotage of evidence and proof. It is important that the prosecution agencies rely on something more authentic, more concrete and more productive in terms of convictions without the police having to resort to the third degree methods that not only violates fundamental human rights but also fail to bring about positive results most of the time. There has to be something that is available; objective, and hence not prove to be susceptible to the whims of the spectators. The solution that meets these requirements is scientific evidences. Scientific evidences have a variety of uses. Firstly it can identify the guilty people. Secondly, it can establish the accuracy of statements made by witnesses.
or informants. Third, is that it can eliminate suspects. Fourth use is that it can save money by shortening investigations; it is estimated that the prosecuting agency spends lakhs of rupees in each trial. Thus, not merely a dangerous criminal goes scot-free but the immense amount of public money is also wasted. These frequent acquittals also embolden the criminals and escalate crime and multiply criminals. There is urgent and widespread need for the application of forensic science in the criminal justice delivery system. The need for the application of science in the dissemination of justice is pressing. Many genes are responsible for the same, which will be included in this essay after constitutional validity. The organization is an umbrella in which lot of conventions, norms are kept to determine human behavior and for the welfare of the human mankind as well as for the upliftment of society. Today when our nation is in the 21st century we must interpret the validity of scientific evidence to follow the faith of every individual in a court of law and in the court of justice.

**Polygraph** - From a historical perspective, China used the effect of inhibition of salivary secretion for lie detection. The suspect was given rice powder to chew on and then forced to spill it. It was assumed that the guilty person would be fearful because of lies told during the interrogation and this fright interfered with the salivation so the powder
would be dry. Over 90 years ago, Munsterberg (1908) indicated that measures of Physiological reactions, like heart rate, blood pressure, skin conductance and respiration should be used in investigation as a possible help to differentiate between the innocent and the guilty person. Later, Marston, a student of Munsterberg, could attract the interest of two police officers in using physiological measures to detect deception (Kleinmuntz and Szucko, 1984). The modern Polygraph was developed by one of the police officers (Larson) and perfected by the other (Keeler). This equipment became “The Keeler polygraph”. Polygraph is based on the principle of Psychosomatic Interaction within the individual.

The scientific principal of Polygraph/lie detector has its roots in Psychology and Physiology. Physiological changes take place when a subject is caught between preponderant responses on to tell the truth and a strong desire to conceal it. Then, he attempts to inhibit the automatic true ‘yes’ response of the brain and bring forth a lie and verbalize it by saying “no”. The physiological functions which take into consideration for examination or detecting the deception are controlled by the autonomic nervous system. The polygraph test measured the autonomic variables such as respiration, heart rate, heart rate, blood pressure and skin resistance of a suspect while he is being questioned. The purpose of taking those questions is to detect physiological changes, which the examiner can identify as a sign of deceit, which is observed as a cluster of
specific physiological changes seen immediately after the question and during the period when the suspect answers, if the answer does not conform to reality known to the suspect. A response conflict takes place when a suspect answers the question asked of him. He attempts to conceal the automatic reply “Yes” to hide himself being caught and verbalize it as “No”. This is where the response conflict takes place. Measuring the physiological changes and comparing the changes to significant questions to neutral questions and in comparison with the level and nature of baselines, a decision is reached about the significance of the magnitude and nature of the physiological response. The response conflict may be for selecting from several preferred responses, when many have a preferred aspects, between a preferred response and an appropriate response, when the preferred is not the appropriate, several appropriate responses, and of incompititive responses in the absence of a preferred response” (Mukundan, 2007). However, over a period of time it has been observed and reported that the hardcore criminals and serial offenders are able to cheat the polygraph and were also able to control many of his physiological reactions. This is one of the reasons why polygraph test results for habitual criminals have not been considered authentic or valid.

There are variations in the way in which questions are put across and the manner by which the subject must respond. The very frequently
used technique in India has been **The Control Question Test (CQT)** described by Podlesny and Raskin (1977). Furedy, Davis and Gurevich (1998) criticized the CQT on the basis of differential significance between the relevant and control question since this trial compares the reactions of relevant question to control questions (Elaad, 2003). Relevant questions are specifically related to the crime and meant to the suspect, where else control questions are designed in a pretest interview and deal with similar conditions to those covered by the relevant question so that the suspect is very likely to be deceptive to them (Podlesny & Raskin, 1977, p. 786). The basic assumption behind CQT is that the innocent person will show more response on control question than the relevant question however, the sane control question is expected to elicit less response in guilty suspect than the relevant question. This In general the theory is that guilty subjects will be deceptive to relevant questions and show stronger autonomic responding than the control questions. In contrast, the control question is meant to be "a stronger stimulus for the innocent subject because he knows he is truthful to the relevant questions; (Raskin & Podlesny, 1979, p. 54). There is indeed dispute over the exact theoretical formulation underlying the CQT (Lykken, 1978, 1979, 1981; Raskin, 1978; Raskin & Podlesny, 1979), Although a number of practical and theoretical problems with the CQT have been identified by Lykken (1974, 1978, 1979), The test does not furnish an adequate scientific
control for detecting deception, because it is impossible to calculate what the relevant response would have been if the answer to the relevant question had been honest. Indeed, Raskin and Podlesny (1979) have argued that the control question is not meant as a scientific control for deception. Rather, it is meant as a stronger emotional stimulus than the relevant question for innocent subjects. Therefore, it is intended as an "emotional standard" (Barland & Raskin, 1973, p. 43) designed to enhance the innocent subject's responses to control questions.

The Guilty Knowledge Test (GKT) was developed by Lykken (1959) as an alternative to the standard CQT. The rationale is to focus on the guilty knowledge (i.e., the significance of the question) rather than the guilty person (i.e., emotional content referring to the involvement of the suspect), and therefore questions are formed to know that only the guilty can know the truthful answer. Both the rationale and the accuracy of the GKT are superior to that of the CQT (Bradley & Janisse, 1981; Lykken, 1981; Podlesny & Raskin, 1977), although from a purely psychophysiological perspective it is important to mention that it is probably not the process of deception but rather an orienting process that is being detected (Ben-Shakhar, 1977; Furedy, 1986; Heslegrave, 1981).

The GKT test is theoretically sounder and is less disputed amongst scientists than the CQT test. The Guilt Knowledge Test (GKT) was
developed by Lykken (1959, 1960). The nub of the test is to ask a question with multiple answers of which one is relevant to the crime and the others have neutral value. An innocent suspect will find all the answers of neutral value as of the same relevance to the crime, whereas one connected to the crime will find a special significance to one of the answers (Lykken 1998) which he or she alone knows to be significant. If the subject’s physiological response to the relevant answer is significantly greater than that for the other neutral ones, the matter is inferred to be associated with the crime investigated. However, if the innocent subject is aware of the relationship of the certain answer with the question, he also may get a significantly higher response. Therefore, it is important that the questions as well as the relevant answers are not yet exposed to the media and the suspects who are under investigation. Nevertheless, this is a provision of controlled methodology than an absolute method for detecting the lie or knowledge of crime only in the one related to it.

A GKT question can be applied only when confirmed information is available that the correct answer to the question is known only to the individual who has committed the crime. The greater the number of such questions, the greater is the accuracy and effectiveness of the process in identifying the subject. Nevertheless, it is important to know that the one who is examined should have had the knowledge or awareness of the specific information at the time of committing or witnessing the crime.
This task presents great responsibility on the part of the investigators to come forward with such confidential information during the process of examination of the crime scenario and its antecedents and precedents. They must also keep such details confidential so that the perpetrator does not recognize that the investigators have come to know of the details. (Elaad and Ben-Shakhar (1997).

Another used technique is the Peak of Tension Test. This test is moreover like the Guilt Knowledge test as the questions can be asked with probable alternative answers. Each option is expected to have greater tension than the former, as it conveys the issue closer to the true solution. The tension and the response increases as the alternatives become closer to the truth, if the suspect is the culprit. Tension peaks, when the correct alternative is presented. If an innocent is questioned, the choices do not have any special value and hence there is no change in the tension. Peak of tension can be made only if a gradient can be aimed across the choices based on the alternative which the examiner knows to be dependable and is tied with the offense. It is also possible to use the peak-of-tension in a searching mode when the investigator does not know the true answer but is cognizant of several possibilities of which one may be true. The suspect will show a physiological response profile indicating his knowledge of the particular alternative, supporting his participation in
the crime (Raskin, D.C., and C.R. Honts 2002, the comparison question test).

One more technique is a **Zone of Comparison Test** - the Zone Comparison test was developed by Backster (1963). The test spans over three zones of time, which are the relevant zone, questions allowing comparison of probable-lies, and the period when questions related to issues falling outside the other two zones are required. Questions of each zone are threatening to the subject and the questions of one of the zones most threatening than the other two zones. The questions used under each category are related to a single issue, in which a lie to one relevant question supports that the subject has lied to all related relevant questions in the class. In contrast, truthful reply to one relevant question means truthful response to all questions in that relevant zone.

**In Directed Lie Test (DLT)**, the subject is instructed to deliberately tell lies to all the responses even when the responses reflect the truth. Comparison of physiological responses between false negative and positive answers makes it possible to detect responses when the subject has lied to truths. Whereas in Affirmation Test the subject is presented with questions, this explicitly exonerates him and provides opportunity for him to make an affirmative answer to the question.
Since the suspect verbalizes the answer as “Yes” or “No” when a question asked of him, several studies addressed the issue of the role of verbal responses in psycho-physiological detection, but they found inconsistent results. Gustafson and Orne (1965) manipulated the verbal responses required in a card test procedure using three experimental conditions, wherein subjects were asked, respectively, to respond "no" to all questions (NO condition), give the first word that came to mind (Free association condition), or remain silent as they heard the questions (Silent condition). The frequency of correct detections as measured by GSR (skin resistance) responding varied as a function of these three conditions, with the NO condition producing the highest detection rate, and the Free association condition the lowest In both the NO and the Silent conditions, detection rates were significantly heavier than those expected by chance. Kugelmass, Lieblich, and Bergman (1967) compared the NO condition with a YES condition. In this experiment no differences were held between the two verbal conditions—in both of them the relevant information was discovered, using changes in skin resistance, at better than chance rates. This finding was not replicated in two recent studies (Elaad & Ben-Shakhar, 1989; Horneman & O'Gorman, 1985). In both of these studies the NO condition was associated with better detection efficiencies than either the YES condition or the Silent condition. However over a period of time it has been observed and reported that the
accused often cheated the polygraph and was able to control many of his physiological reactions which show variations from his normal responses whenever the person lied or gave a response contrary to what actually had taken place. This is one of the reasons why polygraph test results for professional criminals have not been considered authentic or valid. But it was assumed that deception requires conscious manipulation of the truth which leads to use of increase resources in the brain. Recent advances in technology have enabled direct observation of the activities of the human brain during various cognitive operations, including lying. Measuring changes in the brain associated with detection of familiarity with units of information drawn from a crime scenario, which is known only to the perpetrator has shown potentiality to identify the perpetrator. On the other hand, deception requires conscious manipulation of the truth recalled, which in turn results in the use of increased utilization of resources in the brain, whereas the truth could have been expressed with minimum utilization of such resources. The various techniques which have proven their potential for the use of investigation are Brain Imaging/Functional Magnetic Resonance Imaging (FMRI), Brain Fingerprinting etc. Yet another method that is developed does not depend on either detection of familiarity or deception but on retrieval of originally acquired experiential knowledge of participation without requiring expression of
such retrieved information i.e. and Brain Electrical Oscillation signature Profiling (BEOS).

**Functional Magnetic Resonance Imaging (fMRI) -** is a technique that indirectly measures the brain’s activity (Joseph Mandeville & Bruce Rosen, Functional MRI, in BRAIN MAPPING 315, 315 (Arthur Toga & John Mazziotta Eds., 2d Ed. 2002). fMRI does not directly measure neuronal activity (Raichle, supra note 61, at 767-68.) Perceiving, thinking, acting, feeling, and even resting have associated neuronal activity. A growing body of evidence suggests that mental states—such as thoughts and emotions—are represented by patterns of neuronal activation in specific regions or networks of the brain. For many such cognitive or emotional tasks, an increase in neural activity in a particular region or network is interpreted as the brain doing “more” of that particular cognitive or emotional task. For example, when the physical body is performing a particular task (finger tapping, listening to an audio stimulus, looking at changing color etc.), certain parts of the brain activates and neurons start exchanging information. Data transfer between neurons in the brain is an energy-requiring process, and because of this the places in the brain where this transfer is happening have greater demand for energy and thus a greater demand for oxygen. To meet this increased metabolic demand, neuronal activation is accompanied by increased local blood flow. It has been noted that the

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additional influx of oxygen exceeds the amount extracted, thus producing a higher concentration of oxygen in the blood locally compared to the resting state. Since oxygen is not very soluble in blood, it is transported bound to the large iron containing molecule, hemoglobin. The form other compound that contains oxygen is called oxyhaemoglobin and without oxygen is called deoxyhaemoglobin. Because neurons do not have internal reserves of energy, when they activate in response to any activity, oxygen-carrying blood must be transported to the neurons. This is called the “hemodynamic response.” Blood that is carrying oxygen behaves differently in magnetic fields than deoxygenated blood does. The difference in the magnetic properties of oxygenated blood allows fMRI to detect changes in blood flow related to the activity. This is called the Blood Oxygen Level Dependent (BOLD) response. (Seiji Ogawa et al., Brain Magnetic Resonance Imaging with Contrast Dependent on Blood Oxygenation, 87 PROC. NAT’L ACAD. SCI. USA 9868 (1990);, Marcus E. Raichle & Mark A. Mintun, Brain Work and Brain Imaging, 29 ANN. REV. NEUROSCIENCE 449, 455 (2006).

Functional neuroimaging techniques allow the study of neural processing changes during deception instead of analyzing the emotional effects experienced in the physiological functions when a crime related questions are asked. New brain-imaging techniques have reinstated interest in lie detection paradigm as the neuroimaging technique can
differentiate with great amount of accuracy between the neural processes associated with truth and deception. As in the regular lie-detection paradigm, the suspect is asked a question which he must respond affirmatively or negatively, the brain resources used to tell a lie is more than the resources used for telling the truth and the extent of participation of neural tissues are evaluated by the fMRI and compared. Some fMRI studies have concluded that a few key regions of the brain are more active during deception than in telling the truth. Results indicate that functional MRI is a reasonable tool with which to study deception and it was found that those specific areas of the brain involved in deception or truth telling can be depicted with functional MR imaging. Neuroscientists tend to have doubts about the reliability of fMRI lie detection at this stage, but many agree that the technique is worth considering. Technology appears to have been built up into a state wherein it can be straight away applied for forensic purposes. Many speculate fMRI as the equipment for all future deception detection. Despite criticism and difficulties in experimentation fMRI studies of deception detection have been on the rise. There have been widespread criticisms about the use fMRI for a lie-detection function, particularly for the use of the findings as evidence in a court of law. Since it is said that fMRI is not mind reading. Not only can it not tell us what or how a person was thinking at the time of a legally relevant act, it also cannot tell us with reliable accuracy what a person is
thinking while being scanned. In this respect, brain imaging can only provide post hoc explanations. Functional magnetic resonance imaging fMRI provides only one window to many multiple influences on behavior that can be relevant to understanding why a person acted in an that particular manner. Such influences include the complex interaction between genetic, prenatal, endocrinological, social, cultural, and economic factors; “No pixel in a brain will ever be able to show culpability or nonculpability”.

All fMRI studies conducted on violent and anti-social populations have studied group effects. Moreover, most studies have examined adult males, and the consequences cannot be generalized to females and children. Accordingly, if fMRI is to be applied to the forensic evaluation of the individual subject, a standardized set of tests, procedures, and imaging parameters are needed to achieve more valid conclusions. Correlations between fMRI and criminal behaviors are imperfect, calling into question both the diagnostic and predictive validity of brain-imaging evidence. In court proceedings, many experts have argued against the use of ambitious speculations concerning the brain (e.g., State of Tennessee v. Paul Dennis Reid Jr., 2002, No. 38887), particularly where the link between the criminal act and the neurological damage is based solely on fMRI data.
fMRI technology has tremendous potential for lie detection, however, there is still a lot of work to be done before the results of these tests can be trusted. There, there are ethical reasons to view the new technology with caution. One of the main difficulties and disadvantages of fMRI is that its output/data can be rendered useless/ unusable by moving a little, holding your breath, or even thinking about a bunch of random stuff. A trained defendant might even be able to introduce bias into the fMRI data.

The truly serious handicap of a deception detection test is that the technique required the subject to respond to a question presented, as deception gets involved while the person has to answer the question truthfully. What the test actually tells the examiner is that the answer is deceptive and hence truth is different from what one has revealed. Truth has to be deduced from the lie. Furthermore, what the test measures are a neural process; it is merely an inference that the answer a subject has given is either the truth or a lie, based on the neural process. The neural process on its own does not differentiate or refer to the content of the question or the answer. In addition, the technique fails when the subject convincingly tells a lie as if it is the truth.

**Brain Fingerprinting**- Brain fingerprinting, an EEG-based technique by Farwell (1995) using the P300 event related potential and the MERMER
hypothesis. Potentials, which are produced only when a specific cognitive process takes place in the brain, are called Event Related Potentials (ERPs). They are produced only when the individual willfully attends to the stimulus and process the information. The topic is presented with words, phrases or pictures on a computer monitor and the EEG recorded from the surface of the brain. The subject must respond familiarity with the presented stimulus with a ‘yes’ or ‘no’ by pressing a key rather than verbally answering to the question. While understanding the difference between two stimuli, the brain goes through a process of comparison, which enables it to identify the specific differences. When the conflict is detected which enables the individual to affirm that one stimulus is different from the other, a response is produced during the affirmation and it is called the P300. “P” stands for the positive nature of the response and “300” indicates the time in millisecond when the reaction is considered over the scalp. The amplitude of P300 depends on the affirmation made by the subject by pressing a key or mentally counting the occurrence of a different stimulus. Thus, the P300 is often response dependent and its detection and interpretation is difficult if the subject is not provided with a response paradigm. The P300 is elicited in the auditory, visual and somatosensory modalities. A changed P300 morphology and amplitude will indicate the perpetrator’s familiarity or knowledge of special meaning associated with that particular stimulus.
However, if such changed morphology and the amplitude is absent, indicates that the stimulus has no specific meaning to the subject. The technique came under severe criticism as it is assumed that the elicitation of the potential is a function of the relative significance of a stimulus to a subject and not a core central measure which can be labeled a fingerprint. The specificity of the P300 potential is well known to be poor as several factors could contribute to its alterations and therefore it is considered a poor diagnostic indicator.

On the other hand, its high sensitivity has merit and it has been demonstrated that appropriate experimental paradigms could make use of this advantage for deception detection. It is demonstrated that P300 can be utilized along with GKT for deception detection (Vahid Abootalebi et al., 2009). Detection of deception experimentally induced by delaying self-preference in a task could significantly alter the amplitudes of the event related potentials of (N400-700) and a positivity (P1000 – 2000), with separate generator sources elicited in a dipole analysis (Shen Tu et al., 2008). Significant difference between truthful and deceptive responses has been described in a wavelet analysis of EEG from the bilateral frontal electrodes in the beta rhythm at a time interval coinciding with the P300 response (Merzagora AC et al., 2006). Rosenfeld et al. (2008) have put up a revised methodology for P300 recording which dispenses with ‘yes’ and ‘no’ responses with a single acknowledgement.
response and they suggest that the revised method will help to overcome hitherto known impediments with P300 paradigms and it could make it an appropriate and sensitive lie-detection test (right hits were more than 90%). They have called it the Complex Trail Protocol.

Near-infrared brain scan is a test of blood flow devised by Britton Chance, a biophysicist at the University of Pennsylvania. NIRS provides a way to measure changes in blood flow—the same goal as fMRI. The basis of the technology is the measurement of how near infrared light is scattered or absorbed by neural tissues. Small devices are attached to the subject's skull, which glow when near-infrared light through the skull and into the brain. The light does not penetrate very far into the brain, only approximately half centimeters, before it scatters. This scattered laser light is collected by sensors on the subject's skull. The pattern of scattering reveals the pattern of blood flow through the outer regions of the brain. A headband containing near-infrared light emitters and detectors are placed along the subject's head, which senses changes in the prefrontal cortex, the site of decision making that is also stimulated by deception. The sensors can detect changes that occur when a person makes a decision to lie—before the lie is actually pronounced. Subjects are given a series of questions, some to be answered truthfully, others, negatively, which help to chart the changes that occur. This method could, presumably, be used in ways similar to fMRI to determine
deception, at least for regions of the brain within reach of the NIRS signal penetration. Similar galvanic skin resistance changes are used for detection of abnormal changes shown by individuals who are either interrogated or made to answer provocative questions. The Suspect Detection System is reported to employ such technique by which individuals can be scanned and suspects can be identified. Galvanic skin resistance is already employed as a polygraph measure in the lie detection test and there are ample research findings about its interpretive usefulness.

**Voice Stress Analyzer and Thermal Imaging** - Voice Stress Analysis (VSA) is yet another lie detection technology. It is based on the supposition that there are infrasonic components of human voice not audible to observers caused by a physiological phenomenon present in muscles called "microtremor". Federally funded research showed "little validity" in the technique. The voice-stress produced in response to a Relevant Question is referred to as psychological stress or 'deceptive stress'. Questions may be posed to elicit simple "yes" or "no" answers, but can be posed to produce a narrative response. Questions are developed to compare situational stress signatures with Control Question and Relevant Question signatures, in order to identify deception. The technique's accuracy remains debated. There are independent research studies that
underpin the use of VSA as a reliable lie detection technology, even as there are other studies that dispute its reliability. A review of the evidence accumulated about these devices shows that the evidence for the existence of a microtremor in the voice is problematic and that the capability of these devices in detecting stress is equally questionable. Without exception, however, the scientific evidence reported to date shows that voice stress analyzers are not effective in detecting deception; none of these devices have yet been proven to yield detection rates above chance levels in controlled situations. During the 1990s, the U.S. Department of Defense Polygraph Institute (DoDPI) carried out a series of laboratory tests comparing the role of the computer voice stress analyzer and the polygraph using the peak of tension and control question test formats. Castro and Dollins (1994) used a peak of stress test to compare with the analyzer in a standard laboratory comparison, and Cestaro (1996) and Janniro and Cestaro (1996) carried out comparisons with control question test formats for mock crime scenarios. These studies, which suffer from the same methodological deficiencies as most polygraph research, found that the computer voice stress analyzer was never significantly superior in its detection accuracy of the polygraph and that neither had exceptional high correct detection rates. The practical performance of voice stress analysis for detecting deception has not been impressive. However, the CIA and FBI both use VSA at times, in their

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own investigations. The technology is currently recognized in 43 countries. Many an intelligence agency as well as private forensic psycho physiologists worldwide utilizes VSA in preference to polygraph technology. Thermal Imaging uses a heat-sensitive camera to detect increased blood flow around the eyes. It is claimed that when people lie, their eyes give off more heat than when they are telling the truth. This technique is in the early phase of development, and how accurate it may be is still an open question.

Detection of violent intentions Vs. deception detection- Suspect detection is considered a major requirement in places where a large number of persons visit for further onward movements. The test is used to identify individuals who may have intentions to participate in violent or destructive activities and will try to blot out their intentions when pertinent questions are asked. One of the chief virtues of a deception detection test in this context is its potential ability to enable identification of the person who seeks to hide such intentions which may lead to violence and destruction. The application of the test is not to detect if a person is telling a lie about an act already committed, but to identify one who has an intention to perform a violent act.

In India, the techniques which are being used for the detection of deception are polygraph and, Brain Electrical Oscillations Signature.
Polygraph as per discussed above deals with physiological parameters which can be seen when a response conflict occurs within the body. However this test is considered to have both positive and negative merits because it is assumed that the changes seen need not always be directly related to deception. Even an innocent subject can indicate anxiety and the associated emotional arousal is always reflected in the physiological responses. There are variations in the manner in which questions are put across and for this purpose there are a number of techniques used to frame the questionnaire.

**Brain Electrical Oscillations Signature Profiling-(BEOS_P)** - There has been an overwhelming interest in developing technologies that could detect the act of deception expressed orally or through a response. A denial is therefore an important act with which the parameter that reflects deception is associated. A complete paradigm shift from deception detection has been made in the technology developed and used in India in the past one decade. It is an EEG based test, which has been extensively studied both in the laboratory and in forensic conditions and is called the Brain Electrical Oscillations Signature (BEOS) profiling technique. The technology was developed since 1999 and was used as a research tool first in the Neuropsychology Laboratory at NIMHANS, Bangalore and later in the Directorate of Forensic Sciences, Gandhinagar, since early
2003 (Mukundan 2007b). BEOS profiling does not present a question or stimulus to which the suspect must intentionally respond. On the other hand, the test expects the subject to remain silent and only listen to a narrative presented as short verbal statements in sequence, which are called probes. One hundred to 150 probes could be presented in a testing session. The scientific basis of the technique is drawn from the wide body of knowledge drawn from functional neuroimaging and clinical studies that exists which differentiates between ‘knowing’ and ‘remembering’ as dual systems of memory. Both the processes involve retrieval of information from memory. One form of retrieval is used for recognition or knowing the inputs to the brain whereas the other form of retrieval is used for bringing autobiographical episodes or ‘experiences’ already stored to current awareness (Mukundan 2007a), which is called remembrance. Yet another important aspect of the technique is based on the findings that electrical oscillations recorded from the surface of the brain reflects neural processes associated with different cognitive states. Remembrance is either intentional or automatically when it is triggered by an external cue.

BEOS profiling is a technique for extracting an electrophysiological signature of an experience during its remembrance from the electrical oscillations of the brain of a subject, whether the experience relates to the significant personal episode or participation in a
criminal activity. It is well established that remembrance takes place when the cued stimulus is presented to a subject and the retrieval is automatic and mandatory (Moscovitch 1992, 1994, 1995, 1997). In BEOS profiling, the subject is presented with a probe (stimulus, expected to provoke the remembrance of the experience), which contains references to the episode to be remembered. The awareness of the remembered episode is called “Experiential Knowledge” (Mukundan, Vaya, 2004; Mukundan 2005, Mukundan 2007a, 2007b). The test measures remembrance of the Experiential Knowledge (acquired through participation in an activity) or the concerned autobiographical episode, and the retrieval consists of recreation of sensory-motor mental imageries and emotions associated with experience triggered by the verbally encoded probes. The electrical oscillations/activity related to remembrance is called the “Signature” of the experience. As BEOS is not a test of deception, its results cannot be directly compared with that of a lie detection test. Lie-detection involves measurement of a stage of cognitive processing involving response conflict, as the subject must evaluate the consequence of choosing the right response. BEOS profiling measures the presence of awareness of personal participation in episodes, if truly present, and the retrieval may be automatic and mandatory, though one can deny the specific knowledge to others. Studies in the past several decades have reported electrophysiological changes related to
cognitive processing in the electrical oscillations of the brain. These changes may be detected as changes in the frequency characteristics of the electrical activity or seen as deflections in the potential during specific type of processing initiated by the stimuli presented to a subject. The program captures the 30/62 channels of EEG in the bandwidth of 0.016 – 100 Hz using an Electrocap, time locked to the probe and computes the frequency specific energy measures of small data segments in progression in each channel over an epoch of 7 seconds and compares the energy and phase data with the baseline scores extracted from 3 seconds of preprobe epoch. Similarly the time related positive and negative deflections are identified by the program. The positive and negative deflections are identified as they occur within the data epoch in each channel, if the amplitude, morphology, and latency are within the predefined ranges and also have a predefined topographic distribution. The program identifies changes in a stepwise manner over a period determined by the length of the probe and these changes are interpreted as different stages of neural processing associated with cognitive processing, using the data from each electrode. The single trial analysis moves from probe to probe and the program carries out the entire computations and statistical analysis automatically and finally generates an interpreted report of the statically significant changes detected, which may indicate the absence or presence of attention, encoding, accessing memory,
presence of sensory and motor mental imageries and other associated neurocognitive processing states.

An extensive normative study has already been completed by TIFAC, New Delhi and DFS, Gandhinagar and the data on the sensitivity and specificity which supports its use in the forensic scenario. The results of the normative study have been already presented in several international and national conferences. Using a cutoff score drawn from a ‘mean + SD’ formula, the participants of the normative study could be correctly classified into the experimental and control groups with sensitivity and specificity ranging from 0.86 to 0.96 with a positive predictive value reaching unity. The study has further revealed the importance of considering the presence of significant findings of probes which reflect participation in sequence of related actions, and the need for maintaining the highest degree of context specificity for the probes. The technique also provides for self validation during each profiling using control probe. The hypotheses tested are to be based on the suspicions and formulations of the investigating agency and/or to support the contentions of the suspect.

As BEOS Profiling is a new technique, its ecological validity is still being established. Though the entire technique is automatized to the extent of generating an interpreted report, the task of designing probes is complex and needs extensive understanding of human behavior and
neuropsychological principles of brain functioning, which may be hard to come by in forensic institutions in the early stages. The fact a group of persons participating in the same activity may have different experiential profiles of the same participation render the task of probe designing very intuitive and complex for a forensic examiner. The test is expected to be administered first to understand a general experiential profile of the subject and then narrow down the scope of expected findings so that the probes could reflect individual specific experiential components. There is ample need for application oriented research and understanding with the technique.

**Previous study on BEOS:** A study has been already completed using BEOS profiling and the study was conducted at the Directorate of Forensic Sciences, Gandhinagar and the project was funded by Technology Information Transfer and Forecasting & Assessment Council (TIFAC), New Delhi, Ministry of Science and Technology, Government of India (2008). The report of the task has been already accepted by TIFAC, (TIFAC-DFS Report – 2008; Mukundan 2008a, 2008b, 2005; Wagh et al. 2009; Vaya et al. 2009a, b) on 56 experimental and 54 control volunteers who took part in an experiment in which each experimental participant performed several acts using the materials provided in a tasting room, whereas the control participants had only
knowledge of these routines. Both had the opportunity to read the list of probes prior to BEOS profiling. The experiment consisted of the participant having to open a dark room, turn on the light, observe the articles inside, open an almarah, take out an iron rod from it, break a clay piggy bank kept on a table, collect the coins from it, and cleans up the place before leaving. The experimental group produced EK responses in 13.8% of the total probes (n=68) and it was 3.8% in the control group. The study did not use Control probes as they were to be individually designed after confirmation of the episodes/experiences. The accuracy of the procedure was determined by Receiver Operating Characteristics (ROC) Curve analysis comparing the EK scores in the experiential and control groups in the BEOS profiling done two weeks after the participants either took part in the experimental study or were only given details of the activities. With cutoff scores of EK equal to (Mean + 2 SD) of the control group, the mean sensitivity was reported to be 88% with specificity 96% in the ROC analysis. With increased EK cutoff scores (Mean + 3 SD) specificity increased to 100% though sensitivity fell to 82%. Nonetheless, these cutoff scores are not for use in individual forensic tests.