LITERATURE REVIEW

Literature review for polygraph

The researches in Forensic Psychology have had great interest in deception detection methods. Lie-detection using polygraph has been the most extensively used tools for extracting information from a suspect who is believed to be suppressing revealing the truth. By entering the portfolio of physiological responses, a subject makes to each successive question, the polygrapher established a baseline reaction from which the significant deviations are observed and interpreted as indicators of deception. To determine whether subjects are lying or hiding something related to the event took place, the first approach to deception detection relied on anxiety-induced autonomic indicators, using polygraphs measuring pulse, blood pressure, respiration, and galvanic skin response. The modern era of lie detection began around the turn of the 20th century. In 1885, an Italian named Cesar Lombroso measured the blood pressure of three murder suspects under questioning to determine which one was responsible. In 1914, two early precursors to the polygraph were tested, one called the pneumograph, which measured a person's breathing, and later one called the galvanometer, which measured the amount of sweat a person put off.
In the 1930s the father of the polygraph, Leonard Keeler, combined a number of these methods under the tutelage of John Larson to make the modern polygraph, which records changes in blood pressure, pulse, respiration and perspiration. The polygraphs established a baseline reaction for both truthful and deceptive answers. Later, he or she could review the responses to questions related to the crime at hand to find the subject's participation. But even as the polygraph gained popularity, its aura of infallibility began to recede. Critics stated that what the polygraph measures is changes in the blood pressure, breathing, and pulse of a subject, can be affected by a lot more than a lie. A nervous or embarrassed subject can also register a "false positive" in a lie test.

Polygraph testing conglomerates interrogation with physiological responses obtained during polygraph examination, which includes a series of yes/no questions to which the subject expected to respond verbally while connected to sensors. Physiological Phenomena that the instrument measures are assumed by polygraph practitioners to reveal the deception. The major classes of questioning techniques which are in current use are the relevant irrelevant technique; the relevant questions are very specific and hit the target under investigation. For example, “Did you murder Mr. X?” The irrelevant questions may be totally unrelated to the quarry. For example, “Are you From Delhi”. It is expected that the stronger physiological responses on more relevant than to irrelevant
questions are indicative of deception. Although this technique has plentiful limitations from a scientific viewpoint (Raskin and Honts, 2002), it is used in criminal investigations. The second class of techniques, called control question or comparison question testing (CQT), compares responses to relevant questions with responses to control/Comparison questions. The comparison questions are selected to induce a temptation to deceive. For example, “Have you ever lied in your life?”. The third class of techniques, commonly called guilty knowledge polygraph testing (GKT), looks for concealed information, that are known only to investigators and the subject. This test is also called as concealed information test. The questions are presented in a multiple-choice format. For example, in a Murder investigation: “You Killed Mr X with? Was it a: (1) Hammer? (2) Knife? (3) Pistol? (4) Axe?” (Nakayama, 2002:50). However Polygraph practice is raised on comparing physiological responses to questions that are considered relevant to the investigation, with responses to comparison questions. The responses are compared only for one individual because of individual differences (Davidson and Irwin, 1999; Cacioppo et al., 2000; Kosslyn et al., 2002). According to current theories of polygraph questioning, subjects who are being deceptive or truthful in responding to relevant questions show different patterns of physiological response when their reactions to relevant and comparison questions are compared. In the
relevant-irrelevant technique, the hypothesis is that a guilty person, who is deceptively only to the relevant questions, will react more to those questions. However, an innocent person, who is truthful, will not respond differently to the relevant questions. In the comparison question technique (CQT), a guilty person lies both to the relevant and the comparison questions while the innocent person lies in the comparison but not the relevant question. It is assumed that the innocent person will show equal or less physiological responses to relevant than comparison questions. However, the guilty person will show greater responses to relevant than comparison. In the concealed information technique (GKT), it is assumed that subjects will respond most strongly to questions related to their actual knowledge and experience, so that concealed information will be recorded by a stronger response to questions that hint on that information than to the comparison questions.

Polygraph testing is based on the opinions that deception and truthfulness reliably elicit different psychological states through subjects. According to the theory of conflict (Davis, 1961), two discordant reaction tendencies aroused at the same time produce a large physiological reaction that is greater than the reaction to either alone. At the time of answering questions directly would create one reaction tendency, and the circumstances that would motivate a subject to deny the truth would create an incompatible reaction tendency. The premise of the comparison
question technique is that a stronger reaction tendency will be produced in response to relevant than control questions in guilty subjects than in others. Ben-Shakhar (1977) noted that the conflict hypothesis have trouble accounting for responses that are seen even when subject do not respond verbally to questions (e.g., Gustafson and Orne, 1965; Kugelloss, Lieblich, and Bergman, 1967).

There have been a number of previous reviews of the validity of the polygraph and related techniques (e.g., Levey, 1988; U.S. Office of Technology Assessment, 1983; Lykken, 1981; Murphy, 1993), each of which has examined partially overlapping sets of subjects. Practitioners have always claimed extremely high degrees of accuracy, and these claims have rarely been reflected in empirical research. Levey’s (1988) analysis suggests that conclusions about the accuracy of the polygraph have not changed substantially since the earliest empirical assessments of this technique and that the prospects for improving accuracy have not brightened over many decades. From 1973, researchers and practitioners have reviewed available scientific literature to find out the validity and reliability of Lie- Detector/Polygraph test. Reviews which have conducted in past 5-10 years reported relatively positive conclusions which are based on scientific literature evaluations. In 1973, Abrams reviewed reports of Polygraphs from 1917. He said that in studies with complete verification of ground truth, diagnoses were 100% correct.
average of results of reports between 1963 and 1973, he estimated the accuracy in between 83-93%. However, these early positive reviews have been challenged by Lykken and Ben-Shakhar et al.

Lykken in 1981 challenged the control question technique (CQT), and asserted that an average 50-percent false positive rate supported his theoretical challenge. The controversy around the polygraph has been focused almost entirely on the validity and application of the "Control Questions Test" (Ben-Shakhar & Furedy, 1990; Furedy & Heslegrave, 1991; Iacono & Lykken, 1997, 1999; Lykken, 1974, 1978; Raskin, 1982, 1989; Raskin, Honts, Amato & Kircher, 1999; Raskin, Honts & Kircher, 1997; Saxe, Dougherty & Cross, 1983, 1985). However, Lykken believed that there are some particular Polygraph Techniques which are useful. That particular technique, he talked about was detection of guilt i.e. Guilt Knowledge Test (GKT) technique by measuring physiological arousal (Lykken, 1959, 1960). He started using this question technique to increase the validity and reliability of Polygraph test. He used a series of multiple-choice questions, with one relevant alternative and few control alternatives. It was being assumed that a truthful subject would not be able to distinguish relevant from control alternatives (Lykken, 1998). The Theory behind GKT was that if the information has not been leaked out about the incident/event (Concealed information) the possibility would be higher that a truthful subject would show constantly larger or equal
responses to the relevant than to the controls. Thus, the rate of false-positive errors can be controlled. On average, if the subject’s physiological responses to the relevant alternative are repeatedly larger or more equal than to the neutral alternatives, knowledge about the event is inferred. GKT is based on orienting responses (ORs) and habituation processes in humans (Siddle, 1991; Sokolov, 1963, 1966). OR is a complex of physiological and behavioral reactions triggered by any stimulus (Berlyne, 1960; Sokolov, 1963). It is believed that the guilty knowledge presented items with significance, those items will result in stronger ORs. Clearly, for subjects who do not possess the guilty knowledge, all items are equivalent and results in similar ORs.

The criticism about the technique was related to the Formulation of GKT questionnaire. It was being assumed that at least four different GKT questions are required to formulate one GKT and based on this assumption Podlesny (1993) estimated that the GKT might have been used in only 13.1% of FBI cases. GKT aimed at detecting knowledge/guilt, rather than deception. Consequently, innocent suspects failing a GKT due to leakage of any important information. (Bradley, MacLaren, & Carle, 1996; Bradley & Rettinger, 1992; Bradley & Warfield, 1984). The American Polygraph Association, states that experienced testers can see through these efforts, however, and that polygraphs — while not foolproof — are a useful tool for authorities.
The presence of conflict while telling a lie depends on many factors. The emotional state of the subject during the test, personal conviction of the righteousness of the act committed by the person, and occurrence of habitation to the questions asked in the test are same. However, if the question truly arouses a sense of conflict in telling the truth, the test is likely to pick up the physiological response associated with the emotional state of conflict. A question such as “Did you visit the Bank before reaching home?” may produce two possible mental states based on the truth and the consequence of telling the truth. At the elementary level, there is no need for a conflict between the two possibilities as only one of the alternatives is correct. The conflict arises because of the foreseen outcome of one of the answers, which suppresses its free expression because of anticipated fear of punishment. Punishment may be in the form of deprivation of life, imprisonment, loss of self-esteem and privileges in life. This evaluation normally results in the presence of knowledge of guilt in the matter. On the other hand, if the subject feels justified about the act charged, he may succeed in making clever efforts to conceal the facts, without having the guilty knowledge. The conflict therefore, is not the mere result of the presence of two or more simultaneous responses, but the result of awareness of the consequential result of choosing what one knows as the right.
Unfortunately, concerns about the accuracy of these methods, particularly the ability of people to deceive investigators by controlling their autonomic reactivity, have confined their use and acceptance in courts of law (Keckler, 2005; Stern, 2002). Fundamentally, the problem is that physiological responses are secondary to the primary central nervous system processes generating acts of deception.

**Literature review for BEOS**

In recent years, research has turned to brain imaging techniques to study deceptive processes in the brain itself. Electrophysiological methods have shown great promise, A great deal of attention is now being paid to the possibility that brain imaging will prove to be the sort of reliable lie detection technology that will be able to provide admissible evidence in courts of law (Keckler, 2005; Meegan, 2007; Tovino, 2007). A list of studies has used functional (fMRI) and positron emission tomography (PET) to identify the neural substrate supporting deceptive behavior. These have used a number of deceptive tasks and scenarios, including Guilty Knowledge tasks (GKT: Langleben et al., 2002, 2005; Phan et al., 2005), mock crime scenarios (Kozel, Padgett, & George, 2004; Kozelet al., 2005; Mohamed et al., 2006), feigned memory impairment (Lee et al., 2002, 2005), and auto biographical or experienced events (Abe et al., 2006; Abe, Suzuki, Mori, Itoh, & Fujii, 2007; Ganis, Kosslyn,
Stose, Thompson, & Yurgelun-Todd, 2003; Nun’ez, Casey, Egner, Harre, & Hirsch, 2005; Spence et al., 2001). While measuring brain activity directly through brain imaging is considered to have more scientific promise than the peripheral measures used in existing tests, this approach is also fraught with limitations (for reviews, see Appelbaum, 2007; Sip, Roepstorff, McGregor, & Frith, 2007; Wolpe, Foster, & Langleben, 2005). Across the variety of deception tasks studied, there has been a certain amount of agreement in cortical regions activated, notably anterior cingulated cortex, dorso lateral and ventro medial prefrontal cortex, and parietal cortex. However, there are also considerable differences in activated regions across studies.

Several memory models have been proposed that recognition of memory judgments can be based on two distinct forms of memory. It’s been reported from various surveys that the neural structures involved in remembrance are different from that associated with knowing (Tulving 1987, Gardiner and Java 1990; Tulving et al. 1994, LePage et al. 1998; Henson et al. 1999, 2000, Smith and Jonides 1999a, b, Aggleton and Brown 1999; Moroz 1999; Fletcher and Henson 2001; Burgess and Alil 2002; Graham et al. 2003; Schnyer et al 2004; Cabeza et al. 2004; Giloba 2004; Umeda et al. 2005). Mandler (1980) was first who had discussed the difference between knowing and remembering in his dual theory of storage and the huge amount of significant evidence supporting the same.
is subsequently available from several functional neuroimaging studies. Knowledge is a conceptual representation and is acquired through various means of communication and cognitive processing. It is not required for someone to remember that when and where he/she acquired those aspects of knowledge-based information, for their later recall and use. The knowledge bases of the individual are created by persistently accesses for recognizing a variety of entities of the world and are used for explaining various phenomenon and relationships. However; remembrance of personal or autobiographical episodes may be more complex and have many parts spread over time, place and may involve other individuals, and entities. Recall of episodes may form personal recreation of mental motor and sensory imageries, proprioceptive signals, emotions, and their transcoded details in awareness. The participation may be intentional or incidental, with or without interpersonal context. One may perform an action as a personal adventure but it may further involve emotional experience and expressions. The nature of the participation in the action makes the experience memorable for the individual.

A list of studies has focused on the Differentiation of remembrance and neurocognitive processes of recognition (Tulving 1987, Gardiner and Java 1990; Tulving et al. 1994, LePage et al. 1998; Henson et al. 1999, Smith, Jonides 1999a, b, Aggleton, Brown 1999; Fletcher, Henson 2001; Graham et al. 2003; Schnyer et al 2004; Cabeza et al. 2004; Gilboa 2004;
Umeda et al. 2005). The results of these studies helped to identify separate neural structures for the two processes. Recognition of the familiar world is a quick and effective procedure which is based on the easily accessible conceptual knowledge. However remembrance may occur even without recognition, triggered by thoughts and feelings from within (see for review and Meta analysis, Mukundan, 2007). Knowledge is a conceptual representation which is acquired through various means of communication (Mukundan 2007). All autobiographic recalls must have such references, which supply them with authenticity and reality verification effect that one has truly experienced or participated in the event recalled. When remembrance in an individual is about personal experiences, they evoke memories of the past; they recreate sensory and motor mental imageries, verb trans-coding of the experience, and emotions called forth during the experience.

Studies on knowing and remembrance, using the PET and the fMRI showed that the anterior cingulate – during remembrance, part of the ventromedial prefrontal cortex, and the limbic structures are activated. Whereas during recognition, the dorsolateral prefrontal cortex is activated (Tulving 1985; Gardiner, Java 1990; Tulving et al. 1994; Fink et al. 1996; Calabrese et al. 1996; Nyberg et al. 1995, Kapur et al. 1995; Duzel et al. 1997; LePage et al. 1998; Posner, DiGirolamo 1998; Henson et al. 1999, Smith, Jonides 1999a; Hankey, Consolian 1999; Aggleton, Brown 1999;
Fletcher, Henson 2001; Turriziani et al. 2003; Phan Luu, Posner 2003; Markowitsch et al. 2003; Horiike et al. 2004; Naghavi et al. 2004; Kosslyn et al. 2005, Herrmann et al. 2004; Schnyer et al. 2004; Cabeza et al. 2004; Giloba 2004; Umeda et al. 2005; Curran et al. 2006; Steinworth et al. 2006; Vandekerckhove et al. 2006). Graham et al. (2003) compared the cerebral blood changes during autobiographical memory and semantic memory using an extended retrieval paradigm on the PET and found the presence of increased blood flow in the bilateral middle temporal and medial frontal regions during contrasting of recall of autobiographical memory with semantic memory. A reverse contrast of the tasks showed increased blood flow in the left posterior temporal and left prefrontal cortices. They elicited increased blood flow in the right anterior temporal lobe during autobiographic recall, which they explained in terms of the need for greater conceptual knowledge in autobiographic recall. The role of the temporal lobes in autobiographic recall was investigated by Maguire and Frith (2003) and they found that bilateral hippocampal activation is present in regular autobiographic recalls, and the difference between the left and right hippocampal activation depended on the remoteness of the episode recalled. A temporal gradient was seen in the right temporal lobe activation with activation decreasing as the remoteness of the recalled information increased, indicating the greater need of the neural resources for recall of distant events. Their findings
showed that the left temporal lobe involvement is required continuously and consistently for all autobiographic recalls. Haist et al. (2001) also found a factor of temporal gradient in normal subjects using the fMRI. They found that the entorhinal cortex has a greater role to play than the hippocampus for memory consolidated over the years. Maddock et al. (2001) found that successful retrieval of autobiographic memories is associated with the activation of the caudal portion of the left posterior cingulate cortex. Apart from it, lesser intensity activation of the left anterior orbitomedial anterior middle frontal, percuneous, cuneus, and left inferior parietal cortices indicated the need for the involvement of the posterior cingulate cortex engagement in autobiographical memory retrieval. Leveroni et al. (2000) found in their event related fMRI study that during recognition of famous faces, neural activation was seen in several areas of the brain. Recognition of famous faces resulted in the activation of the prefrontal cortex, lateral temporal and mesial temporal areas consisting of hippocampus and parahippocampus in comparison with the recognition of recently encoded or unfamiliar faces seen for the first time. They understood that face recognition has an episodic memory as well as semantic components. Gorno Tempini et al. (1998) had earlier found in their study that recognition of famous faces activated extensive bilateral areas involving medial temporal lobes including the hippocampus regions. Person identification during recall has been found
to be associated with bilateral frontal and temporal engagement (Evans et al. 1995; Harris and Kay 1995; Nyberg et al. 1996; Reinkemeier et al., 1997; Steinvorth et al. 2006), whereas pure semantic recall or interpretation required mainly the left frontal and temporal involvement. Maguire and Mummery (1999) found that time reference to personally relevant recalls produced an increase in activation in the left hippocampus, medial prefrontal cortex and left temporal poles as compared to the typical personal recalls, which produced an increase in activation in the bilateral temperoparietal junctions. Fink et al. (1996) compared the blood flow changes in subjects during recall of autobiographical details with the recall of impersonal episodes known to them, and found that both the types of recalls elicited relative increase in the rCBF extensively in the bilateral temporal lobes. However, recall of personal experiences produced greater rCBF in the right hemisphere specifically in the right temperomesial, right dorsal prefrontal cortex, right cingulate areas, and the left cerebellum. Recent studies have further supported the findings of duality in the neurocognitive process of recognition of familiarity and remembrance of personal experience. Kohler et al. (2004) found an association between the activation in the left inferior prefrontal cortex during an initial experiential episode and its later remembrance; they reported that the accuracy and vividness of remembrance are a function of the efficiency with which encoding took
place during the original experience. Gilboa (2004) found it necessary to
differentiate between recalls of words, pictures, and faces at one phase,
made familiar by an initial presentation and acquaintance, and the recall
of autobiographic information. Gilboa found that in episodic memory, the
right mid dorsolateral prefrontal cortex is invariably activated, in contrast
to the activation seen in the left ventromedial prefrontal cortex during
autobiographic recalls. The two areas are considered to support different
types of mediation of the post retrieval processes. It was suggested that
autobiographical recalls require quick intuitive 'feeling of rightness' for
monitoring and verification of the remembered experience and its
personal self-reference whereas episodic recalls need verifications for the
purpose of detection of omissions, commissions, and repetitions, i.e. the
accuracy of the signal detected in relation to the knowledge schema
acquired initially. Gilboa et al. (2004) found further differentiation in the
neural activation profiles between retrieval of decades old and recent
memories as the former produced engagement of the rostrocaudal axis of
the hippocampus, whereas recalls of recent memory produced activation
in the anterior areas. A comparative study of autobiographical memory
and episodic memory by Cabeza et al. (2004) showed that a common
neural activation profile is evident in all recalls involving episodic and
autobiographic recalls, which involved the medial temporal and
prefrontal regions. However, autobiographical recall produced greater
activation of medial prefrontal cortex, visual and parahippocampal region, and hippocampus, representing self-referential processing effect, visual and spatial memory effect, and recall effect respectively. Umeda et al. (2005) compared the parts of the left and right anterior and posterior prefrontal cortical areas in the recollection of episodic memory and found that the left and right anterior prefrontal cortical areas showed significant differences based on the nature of the recall, whereas such differentiation was not present in the posterior prefrontal areas. Steinvorth et al. (2006) compared using functional neuroimaging, recent, remote autobiographical information, and remote semantic information and found that recent and remote autobiographical reminiscence produced activation of large bilateral network. The activation during reminiscence extended across the anterior and posterior parts of the middle temporal gyrus spreading into the superior temporal sulcus, temperoparietal junction, middle and superior frontal gyri, anterior paracingulate and cingulate gyri, and left inferior orbital frontal gyrus pars orbitalis. On the other hand semantic retrieval produced activation of bilateral supramarginal and inferior frontal cortices, left insular cortex, and inferior temporal gyrus. Extensiveness and intensity of activation in functional neuroimaging studies are dependent on the recruitment of neural resources for the processing assigned to a task. The presence of a greater need of neural resources and the consequent activation is indicative of greater
complexity personally encountered during processing of a job. One may be able to treat a complex task with limited attention and deployment of processing skills because of familiarity and habituation with the project. The neural activation in that individual may be comparably lower than the activation produced by a simpler task for which the same person may utilize greater neural resources because of its unfamiliarity. Therefore, the level and extent of activation is not a direct indicator of neural resource deployment. It reflects the vast resourcefulness of the neural tissues to discover and produce higher levels of processing and performance competency, which are not directly comparable across individual.

Recognition of a stimulus involves the matching of a memory trace with the external model produced by the stimulus and the subsequent identification of the stimulus as the content in the memory trace (Sokolov 1963). Perception of familiar objects, persons, entities, and words, therefore, uses the identification of matching memory traces, using only minimal information. The effect that occurs during detection of a stimulus or its feature is accompanied by neural activation, which can be identified in functional neuroimaging studies or using electrical oscillations recoding techniques. Typical time domain view of the electrical changes associated with perception consists of the electrical deflections named P1, N1, and P300, recorded from the scalp of a subject. The P1 is a positivity associated with visual sensory registration.
occurring around 100 millisecond after the stimulus input, and the N1 is a negativity occurring at 140 millisecond and associated with arousal of attention. The P300 is a positive potential seen in the scalp occurring around 300 milliseconds (within 250 – 650 milliseconds) from the onset of a stimulus (Donchin and Coles, 1988; Picton, 1992; Mukundan et al. 1999), when an unexpected stimulus is detected. In a typical standard test, the P300 is manifested when the subject detects a change in the stimulus in terms of novelty or a change in the stimulus features. Detection of any alteration in the stimulus characteristic can elicit a P300. The P300 manifests well only when the subject is instructed to acknowledge the detection by making a response to the detection of change or novelty. A typical test for eliciting the P300 uses two tones differing in frequency and presented at random, one frequently, and the other infrequently. The subject is instructed to acknowledge hearing the infrequent tone by a response. The P300 emerges every time the subject listens to the infrequent tone. The amplitude of the P300 is highest at the vortex and in the midline of the scalp. A frontal and posterior element can be differentiated in some of the experiments. The P300 amplitude is easily affected by suggestions affecting the interpretation of the signals received (Mukundan et al. 1999, Kamarajan 2000). A prior mindset created through hypnotic suggestion can affect the detection of the infrequent stimulus and inhibit the production of the P300. Hypnotic suggestion
given to a subject that he or she will hear only one type of tone causes the subject not to detect the difference in tonal quality of the infrequent tone, though it is registered and attended in the brain, as seen by the corresponding electrical activities of the brain. The effects on the P300 produced by suggestions are clear examples of how perception can be affected by various factors, which may have a suggestive influence on the interpretation involved in the perceptual process. The P300 can be seen emerging every time a change in the stimulus parameters of physical and semantic features is detected by the subject and the subject makes a response after such detection. It is considered the most sensitive, consistent and robust of the event related potentials, but with poor diagnostic specificity. Nevertheless, the P300 response in general, does not have any value or significance as a measure in forensic investigation, as it is only a measure of detection of change or novelty when different stimuli are presented to a subject. Familiarity of an object or of a piece of information is not a factor that can be used to indict or identify an individual as a perpetrator of a crime, unless such familiarity is established to be exclusively present only in one or in those who were truly involved in the crime (Fabiani, et al. 1983; Rosenfeld et al. 2005, 2004, 2003, 1991, 1988; Farwell, Smith 2001; Abootalebi et al. 2006). This is the part of the privileged information used in the “Guilty Knowledge” (Lykken 1959, 1960) test. In that sense, the P300 must be
used as a central measure in a modified lie-detection paradigm, in which the subject must respond to words, which are inferred to embed guilty knowledge, as against to a direct question reflecting the guilty knowledge in the regular lie-detection paradigm. That stimulus word must be words presumed to reflect guilty knowledge by the investigator is a disadvantage of the technique, as P300 can be extracted only by presenting words or pictures for limited duration. On the other hand, in a regular lie-detection test, questions could be framed cleverly and strategically for presenting conflict and the need for contradiction in a suspect (Ben-Shakhar, Elaad 2002). Further, the nature of participation of a suspect in crime must be inferred from the reactions to isolated words used for producing the P300. That even an innocent suspect may be grilled by the investigating team about possible involvement in a crime that is investigated may render all the words relevant to the crime traumatic to the subject, despite absence of any related experiential knowledge. The mental state and the personal involvement of a suspect cannot be compared to that of a normal person who volunteers to participate in a simulation study, in which he or she must only pretend the role of deceiving. The P300 response may be readily extracted by the emotional effects of the crime relevant words even in an innocent suspect. The rationale of using the P300 was that knowledge of being guilty could produce an oddball effect, when such words are presented along with
irrelevant or neutral words, as the subject is the only one who could have access to such information (Rosenfeld et al. 1991). For example, Rosenfeld et al. (2004) demonstrated that when the date of birth of an individual was presented along with other irrelevant dates, the date of birth elicited a significant P300 amplitude change. Vast P300 literature shows that detection of any change in the stimulus characteristic during the repeated presentation may serve as an oddball eliciting the P300. Interestingly, studies have shown that truthful responses produce significantly greater P300 response than dishonest responses (Ellwanger et al. 1999; Miller et al. 2000; Rosenfeld et al. 2003). Knowledge on the part of a suspect about the significance of recognition of words related to a crime, other than familiarity of the words also could introduce such oddball effect eliciting changes in the P300 responses, unless the suspect is made to listen to those words for the first time during the trial. Such effects may not be obviously seen in controlled simulation studies, as the subjects are not suspects.

Remembrance is the neurocognitive process of bringing personal past to the present. Studies have reported electrophysiological correlates of remembrance of episodes and autobiographic information, which differentiated the electrical profile of remembrance from that of knowing (Curran et al. 2006; Friedman and Johnson, 2000; Mecklinger, 2000; Allen et al. 1998; Duzel et al. 1997). Duzel et al. (1997) compared
remembrance and knowing using event related potentials in normal subjects. In their study, they presented narratives of events in a prior session, which they were expected to identify having heard before while the ERPs were later recorded. The ERP showed a distinct positivity in the 600 – 1000 ms range associated with remembrance, seen bilaterally predominantly in the frontal areas and lesser in the parietal areas, which was absent in the other conditions tested. They could distinguish between fake and true remembrance, whereas mere false and true recognitions did not show such differentiation in the ERPs. In their subsequent study (Duzel et al. 1999), using both the PET and the ERP, the neural profiles of recall of information related to past episodic tasks was compared with the recalls in semantic tasks. Episodic retrieval was found associated with activation in the right prefrontal cortex and posterior cingulate cortex in the PET and sustained frontopolar positivity in the ERP recordings. Semantic recall was found to be associated with the typical left frontal and temporal activation seen in other studies. Friedman and Johnson (2000) in their review of ERP and functional neuroimaging studies compared the results from the two modes of investigation in explicit memory and found good correspondence between the results of the two types of studies.

The neurocognitive processes represented by electrophysiological changes in the brain, which can be easily recorded using surface
electrodes placed on the head (Mukundan 1986a, 1986b, 1995; Khanna et al. 1989; Mukundan et al. 1989, 1990). Of these stages, the recognition of the stimulus is accompanied by the P300 event related potential (Donchin, 1981; Neville et al. 1986; Donchin and Coles 1988; Annet, Mukundan 1996; Mukundan, Rohrbaugh 1998; Sudha, Mukundan 1998; Mukundan et al. 1999; Silva et al. 2007). However, the P300 response can be produced only presentation of a brief stimulus lasting not more than 200 ms. The P300 response represents the detection or recognition of a new stimulus. The P300 potential can be produced by the infrequent stimulus in an oddball paradigm consisting of two stimuli one frequently and the other infrequently presented, every stimulus when a set of different stimuli (Mukundan, Rohrbaugh 1998) are presented one after the other, or when the same stimulus is presented with varying intertrial interval (Gonsalvez et al. 1995, 1999, 2002, 2007; Mertens, Polich 1997 Polich and Heine, 1996; Polich et al., 1994). Farwell (Farwell, Donchin 1991, Farwell, Smith, 2001) used the oddball paradigm for generating P300 potential and used two sets of stimuli assigned as Irrelevant and Target and presented them one after the other on a computer monitor, with the Target as the rare stimulus. The suspect, who knew the nature of the stimuli, was to differentially respond to two stimuli. The average P300 amplitude was greater than the average P300 amplitude to irrelevant stimuli. A third stimulus called the probe was also presented without the
knowledge of the subject. The probe contained a piece of concealed information which the examiner/investigators considered was known only to the suspect was presented along with the other two. The suspect who had guilty knowledge related to the probe produced higher P300 amplitude comparable to the Target stimuli, which were related to the crime investigated and already known to the suspect. If the suspect was innocent, he viewed it as another irrelevant stimulus and produced P300 amplitude accordingly. He interpreted the higher amplitude elicited by the probe as indication of knowledge of the crime, which he argued must render him guilty. However, it was of paramount importance that the probe was known only to the suspect other than the examiner and the investigators, as the knowledge of relationship caused greater P300 amplitude even in innocent persons. If the probe or any of the irrelevant stimuli were of any special meaning unconnected to the crime, to the suspect, they also caused higher P300 amplitude even in an innocent suspect. Further, the entire practice of relating the stimulus to the subject’s participation must be inferred and hypothetically interpreted by the examiner.

Rosenfeld et al. (2009, 2008) has developed a modified P300 paradigm in which the entire suspect’s participation was made more complex in terms of sensing and responding to the stimulations. He gave two separate sets of stimuli with a brief interval in each trial and required...
differential responses to each stimulus from the subject. The modifications were justified in terms of the need to compensate for countermeasures which a suspect may use. There are no data available about the findings in forensic cases. Practical acquaintance with forensic conditions makes it important to maintain that the suspect’s participation at a minimal level as in clinical cases. The findings that the diagnostic specificity of P300 is very poor despite its very high sensitivity may be likened to the usefulness of measuring body temperature for the diagnosis of a disease condition. Further, the effect of other variables such as differences in the intertrial interval and the mindset of a guilty suspect to ignore all stimuli are not seen in the above trials. It has been demonstrated the P300 peak can be suppressed by hypnotic suggestions though the amplitudes of the earlier components (P1 and N1) associated with sensory registration and attention are not affected (Mukundan et al. 1999). Recognition of familiarity known only to the guilty is the gist of the P300 based paradigms, which establish the link between a crime investigated and the guilty suspect. Different responses to the stimuli are only to help the examiner establish that the subject remains attentive and he has cared to notice the meaning assigned by the examiner to the irrelevant and target stimuli. On the other hand the classical Guilty Knowledge test uses the concealed information as an alternate choice to a question and the deception is detected only when the suspect intentionally
chooses the wrong answer. The Guilty knowledge test used with Polygraph recording has been utilized in several functional MRI studies for detecting the brain activation pattern linked to lying in normal volunteers who participated in laboratory simulated deception experiments.

Reading from Memory Larger areas of the brain take part in remembrance of autobiographical episodes in comparison with recognition of external entities which can produce the P300 event related potential. Recognition also requires only minimal signals from a stimulus, using which the brain can predict perception of a familiar stimulus or entity. On the other hand remembrance of autobiographical episodes or experiences often constitutes a reliving of the past episode and therefore it may involve total or near total retrieval of information from the memory (Mukundan 2007b). The experience remembered is mentally recreated as imageries and it may sensory and motor components, along with proprioceptive and emotional components, originally experienced by an individual. Such recreation of sensory and motor imageries are known to activate both primary and association cortical areas, which were activated in the real online experience. Neurocognitively remembrance must involve a process of accessing long term memory and an inward shift in attention as the individual is attending to an internal process or information retrieved. Recognition is always that of an external entity and

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therefore attention is directed outward. Recognition is the sensory modality specific, though one may be reminded of familiarity and other associated experiences. The additional information retrieved may be considered to be responsible for the higher P300 amplitudes and thus represents the additional brain resource utilization involved in the specific recognition. On the other hand, remembrances may be voluntary or provoked/triggered by external cues present in a stimulus/entity. The cue has a personal value as only a given individual(s) would have had the associated experience which is provoked by the stimulus cue. Others would recognize the same stimulus without the cue and there will be no remembrance linked to it. The remembrance may also require retrieval of encoded and transcoded information which may be used to reactivate the original sensory and motor components as imageries. Neuroimaging studies have demonstrated ample clear evidence for the extensive activation of the brain during remembrance in comparison with knowing or recognition (Steinworth et al. 2006; Vandekerckhove, et al. 2005; Umeda et al. 2005; Naghavi et al. 2005; Cabeza et al 2004; Gilboa et al. 2004; Horiike et al. 2004; Turriziani et al. 2003; Luu et al. 2003; Graham et al. 2003; Markowitsch et al. 2003; Fletcher et al. 2001; Aggleton, Brown 1999; Smith, Jonides 199a, b; Tulving et al. 1994; Gardiner, Java 1994; Tulving 1987). Remembrance of past personal events would further require activation of the source memory which provides the time and
place and contextual links for the remembered episode (Cinel et al. 2002; Marsh et al. 2002; Cycowicz et al. 2001, 1997; Hicks, Marsh 2001; Jones et al. 2001; Troyer, Craik 2000). Activation in remembrance of autobiographical episodes has been reported in bilateral middle temporal lobes including hippocampus and medial frontal regions (Graham et al. 2003; Maguire, Frith 2003; Haist et al. 2001; Leveroni et al. 2000; Reinkemeier et al., 1997; Nyberg et al. 1996; Evans et al. 1995; Harris, Kay 1995). Pure semantic recall produced activation of left frontal and temporal activation whereas person identification was found to be associated with bilateral frontal and temporal engagement (Steinvorth et al. 2006; Reinkemeier et al., 1997; Nyberg et al. 1996; Evans et al. 1995; Harris and Kay 1995). Gilboa (2004) obtained a left ventromedial prefrontal cortex during autobiographic recalls, whereas a right mid dorsolateral prefrontal activation was seen in the recall of familiar words, pictures, and faces, differentiating between routine episodic recall and recall of autobiographical events. Cabeza et al. (2004) found that autobiographical recall produced greater activation of medial prefrontal cortex, visual and parahippocampal region, and hippocampus, representing self-referential processing effect, visual and spatial memory effect, and recall effect respectively. Steinvorth et al. (2006) compared recent, remote autobiographical information with remote semantic information and found that recent and remote autobiographical
remembrance elicited activation of the large bilateral network. The activation during remembrance extended across the anterior and posterior parts of the middle temporal gyrus spreading into the superior temporal sulcus, temperoparietal junction, middle and superior frontal gyri, anterior paracingulate and cingulate gyri, and left inferior orbital frontal gyrus pars orbitalis. On the other hand semantic retrieval produced activation of bilateral supramarginal and inferior frontal cortices, left insular cortex, and inferior temporal gyrus.

The remembrance may also have components of sensory and motor imageries which need to be evoked and recreated and hence entails the activation of various primary and secondary association areas in the given sensory modalities and that of primary motor cortex and other related motor cortical areas (Fiorio et al. 2006; Kosslyn et al 2005, 1999,1997; Lacourse et al. 2005;Pineda 2005;Kelin et al.2004, 2001; Ganis et al. 2004;Sparing et al.2002;Dettmers et al.2001;Maruno et al. 2000). Only those experiences which have some emotional significance to the individual are remembered for long. The events are remembered as long as the associated emotions are important to the individual. Emotions are a subjective state of the individual accompanied by physiological and bodily responses and occurring in cognitive context, its repeat occurrence may be as real as the original emotion. Emotional significance is therefore of crucial importance for one to be able to remember personal
episodes. Remembrance of a certain experience can occur if it can be triggered by an external stimulus. But that stimulus which has a relationship known to the person with the original experience can trigger its remembrance. This effect has been called cueing (Moscovitch 1992, 1994) caused by a specific stimulus. Thus one remembers the fond memories of a certain event and the person associated with it every time one looks at a gift presented by that person. Such remembrance is considered automatic and mandatory (Moscovitch 1992, 1994) unlike strategic retrieval, in which one must make an effortful attempt to logically retrieve information in a sequential manner.

Electrophysiological Correlates of Cognition and Remembrance

Electrophysiological studies in language processing have overwhelmingly used event related potential paradigms. The contributions of Basar (1999) and his team (Basar 20089, 2006, 1999; Basar et al. 2001a, b, c: Basar et al. 2000; 1999; Schürmann, Basar 2001). In the field of EEG oscillations had a profound influence on the scope of measuring electrical oscillations of the brain for understanding various cognitive functions. They postulated that oscillations in the frequency ranges of gamma, alpha, theta, and delta are closely related to several aspects of cognitive processing. Studies have differentiated the electrical profile of remembrance from that of knowing (Friedman and Johnson, 2000; Mecklinger, 2000; Allan et al. 1998; Duzel et al. 1997). Duzel et al.
(1997) compared remembrance and knowing using event related potentials in normal subjects. They presented narratives of events in a prior session to participants, which they were expected to identify in a second session consisting of presentation of related and unrelated words, while the ERPs were recorded. The ERP showed a distinct positivity in the 600 – 1000 ms range associated with remembrance of narratives. The positivity was seen bilaterally predominantly in the frontal areas and lesser in the parietal areas, which was lacking in the other conditions tested. The ERPs differentiated between false and true remembrance, whereas mere false and true recognitions did not demonstrate such differences. In their subsequent study (Duzel et al. 1999), using both the PET and the ERP, the neural profiles of recall of information related to past episodic tasks was compared with the recalls in semantic tasks. Friedman and Johnson (2000) in their review of ERP and functional neuroimaging studies compared the results from the two modes of investigation in explicit memory and found good correspondence between the results of the two types of studies. Familiarity of recognition was detected in ERP studies by Curran et al. (2006) using recognition of words, some of which was presented in earlier sessions. They found that Medozolam, a pharmacological agent had the specific effect to produce amnesia on recall of remembered words as shown by P300 and FN400 potentials. The drug adversely affected remembrance of knowing the
words in the earlier session was adversely. Remembrance involves attending to the internal cognitive processing related to a specific retrieval and generation of its awareness with consequent acceptance of the content. This may result in total or partial withdrawal of attention from the outside world/stimuli, which may impede the perception of the external world transiently so that attention can be directed inward to the internal processing. Such inward attention is also required for awareness of the recreated mental imageries and thoughts and for selectively attending to them for further processing. Harmony et al. (1996) and Fernandez et al. (2000) found that delta band frequencies have such specific association with awareness of internal processing. Robinson (1999) reported that 4 Hz activity is related to behavioral arousal and it is negatively related to 10 Hz activity. The importance of frequencies in the theta and alpha ranges has been exhibited in several studies. Klimesch et al. (2000) suggested that synchronization of theta and alpha frequencies across distant neural areas is for specific processing of internal mental contexts during cognitive processing. Klimesch et al. (1994, 1999) indicated that theta oscillations represent hippocampal engagement required for retrieving from long-term cell assemblies in episodic memory recalls. Klimesch et al (1997) reported that upper alpha band activity showed maximum sensitivity to encoding process which could differentiate between bad and good semantic memory. They found
significant correlations between upper alpha band measures and semantic memory when semantic processing actually was happening. In a subsequent study Rohm et al. (2000) found that visually presented sentence processing caused greater theta activity whereas upper alpha increased only when there was semantic demand during the processing. Excess beta oscillations have been always looked upon with clinical significance, and hence its neurocognitive importance has not been adequately understood. For example excess beta oscillations have been suggested to show an excitation-inhibition imbalance in the cortex in alcohol dependent subjects (Rangaswami et al. 2002), and it is a commonly known condition in various barbiturate/hypnotic drug induced states. Desynchronization of alpha is always accompanied by an increase in beta activity and therefore it has been considered associated with a cognitive state when greater neural resources are used in the brain. Basar (1999) considered only delta, theta, alpha and gamma oscillations as of any cognitive significance. However beta activity is induced in all conditions when there is a cognitive demand and the activity subsides when the demand is completed. Beta activity has an association with mental motor imageries as found by McFarland et al. (2000) in their study that normal participants could control both mu and beta rhythm using real movement as well as motor imagery. Increase in beta activity was witnessed over the primary motor cortex even during action.
observation (Muthukumaramswamy, Johnson 2004) indicating the possibility of presence of mirror neurons. In a comparative study using Pet and EEG, Nakamura et al. (1999) found that beta power was positively correlated with rCBF in the prefrontal cortices including the anterior cingulate while participants listened to music. Olufsen et al. (2003) found that gamma (30-80 Hz) and beta (12-30 Hz) rhythms occur successively and may have an important role in the maintenance of cell assemblies requiring neural binding. The interdependency between gamma and beta activity while listening to novel auditory stimuli was reported by Haenschel et al. (2000). The role of gamma activity in the 35 – 85 Hz range during retrieval of information, especially visual mental imageries has been exhibited in several studies (Babiloni et al. 2006, 2004; Herrmann et al. 2004; Llinas, Ribary 1993; Engel et al. 2001; Bressler 1990). An increase in the coherence of gamma activity across left frontoparietal areas is an indication of the frontal lobe recruiting neural structures of the parietal areas, during the remembrance of visual mental imageries (Mukundan 2005). The frontal participation is associated with the use and recall of the verbally transcoded information from which the visual mental imagery can be reconstituted, which is accomplished in the posterior regions. Remembrance appears to be an act of recreation of the past, as what is remembered is not mere transcoded information from a registry, but true details with mental imageries and

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accompanying emotions. If one must narrate the activities carried out in at any point the past, one must recall the details of the act. It may also be possible for one to make a narrative of the act without remembering the experiences associated with it. When one is able to remember by recreating the sensory and motor imageries of the experience, it is like reliving the past. In fact, one may transcode what is remembered, all over again, and may throw a new narrative report. Such narrations of the past can become confabulatory and a source of psychological problems (Conway et al. 2003). Over and under encoding can easily cause inclusion of unrelated information and exclusion of relevant components of information respectively in perception and thinking. Absence of verification of such effects because of the absence of their immediate awareness would make the subject accept their remembrance as though reality verified (Mukundan 2007). These studies have mainly considered the evoked and induced changes in the amplitude and power of the different frequency components in a specific time window, and not really the changes in an online continuous paradigm when the activities may or not be actuated by a stimulus and the changes may appear anytime after the stimulus onset/presentation. The true importance is not on the stimulus induced changes, but on the retrieval process that the stimulus may provoke and the changes that may be initiated by the retrieved information. The stimulus may cue and trigger such retrieval only in one.
who has had a specific experience in life. The stimulus does not initiate a recovery process in those who never had the same experience. Brain Electrical Oscillations Signature (BEOS) program monitors and measures both the type of changes if they are present and identifies the process of remembrance if present. A probe in BEOS is not a composition of concealed information as in the P300 paradigm. They are used to trigger remembrance related to the content stated in the probe. The program utilizes a moving window analysis strategy and looks for specific varieties in a stepwise manner and makes inferences or conclusions based on the findings.

**Rationale and significance of the work:**

There is a focused effort by scientists to develop new technologies for deception detection or for identification of individuals who are involved in the perpetration of crime. The traditional polygraph-based techniques emphasized on measuring the emotional effects of having to answer crime-related questions and lying whereas, the newer techniques attempt to measure the neural effects of decision-making while deceiving or concealing the truth. This is achieved by identifying the activation pattern in localized brain areas while one conceals or tells a lie. On the hand, a technique like BEOS profiling attempts to measure the presence of what is termed “experiential knowledge” or the memory related effects of
participation in the crime or associated activities. Instead of identifying localized changes alone in the brain functions, the test is considered to look for changes all over the scalp of the brain from where the electrical activity is recorded. The ultimate goal of these efforts appears to be for using the relevant information thus extracted as evidence in courts of law. The validity of all these techniques remains a matter of constant debate. However, in the meanwhile these techniques must go through their ecological validation and must find a useful place as aids in regular crime investigation.

Presently, BEOS profiling and lie-detection is independently carried out. Further the DFS-TIFAC project has revealed the sensitivity-specificity factors of the BEOS profiling which supports its use in the forensic scenario. There has been no other normative study reported from India until now, though the test is being used in other forensic science laboratories. No such normative study on Polygraph using Guilt Knowledge Test (GKT) test conducted in India is available. Some cases have already utilized data generated from the two tests – polygraph and BEOS, in convicting the accused. Needless to say, these tests have played a significant role in forensic formulation and the corresponding findings have been accepted as corroborative evidence, in support of the primary evidences provided in the case. Already cases were convicted in which the two tests (Polygraph and BEOS) have played significant roles in
forensic formulation and the findings have been accepted as corroborative evidence as the findings are in line with the primary evidences available in the case. Conversely, absence of Experiential Knowledge on BEOS profiling can be highly useful and crucial to use for exonerating innocent suspects. Such scientific tests satiate the much-felt need for accurate and objective techniques as an aid for crime investigation. Due to its high potential for supporting an investigation, there is an urgent need for testing their appropriateness and establishing the specificity of usage in forensic investigation.
Significance of the Work

1. It is proposed that the test carried out in the above project may be developed into a more complex one simulating a crime scenario.

2. It is proposed to introduce more variables such as witness participation, which will necessitate the insertion of a third group of subjects.

3. The linking up of BEOS profiling and Lie-detection will help in linking up brain electrical activity, which is a central measure with the physiological changes, which reflect the autonomic nervous system activity.

4. Since BEOS profiling and Lie-detection findings are complimentary, linking them up can enhance the potency of the tests together.

The above proposals will enhance the understanding and versatility of the BEOS profiling for forensic application.