Throughout the history it has been assumed that lying is accompanied by a change in the body’s physiological activity (Bull, 1988). The theory underlying lie detection is that lying is accompanied by changes in involuntary activities which can be measured by the polygraph (Davis, 1961). When people lie they get measurably nervous about lying thereby leading to increased arousal, which can be assessed in terms of changes in physiological measures such as heart beat, blood pressure, breathing, respiration etc. For example, Kleinmuntz and Szucko (1984) reported that the Chinese forced suspected liars to chew rice powder and then to spit it out. If the resultant powder was dry then the person was judged to have been lying. Beliefs such as this were founded on the premise that lying caused the individual to experience emotion and this would be accompanied by a change in the body’s physiological activity (i.e. a diminution of saliva, the result of a change in the activity of the autonomic nervous system).

The test most widely used for lie detection is known as ‘the polygraph’. It does not detect lying directly but measures various sorts of involuntary bodily activity (heart rate, blood pressure, respiration and palmer sweating) which usually accompany heightened states of emotion. For the test, an instrument is used to provide a continuous write-out of blood pressure, heart rate, respiratory movements, and skin conductance (a measure of sweating) while an examiner asks a series of questions intended to evoke emotional responses which distinguish the guilty from the innocent. In the control question technique the examiner asks a mixture of ‘relevant’ and ‘control’ questions. These are designed with the expectation that a guilty person will experience more emotion when answering the relevant questions (‘Did you murder your wife?’) while an innocent person is likely to find the control questions more disturbing (‘As a child, did you ever steal anything?’). The guilty knowledge technique requires the subject to answer questions or listen to a list of facts which include items only the guilty person would recognize as connected with the investigation. Modern polygraphists, however, rarely make the mistake of believing that lying is accompanied by a special pattern of physiological activity. Instead they
assumed that changes in physiological activity in response to incriminating questions are indicative of lying. Many of them also seem to assume that lying is accompanied by changes in bodily behavior such as foot-wagging, eye blinking etc (Reid & Inbau, 1977). People tell lies and deceive others for many reasons. Most often, lying is a defense mechanism used to avoid trouble with the law, bosses or authority figures. Sometimes, one can tell when someone’s lying, but at other times it may not be so easy. Polygraphs, commonly called "lie detectors," monitor a person's physiological reactions. They do not, as the nickname suggests, detect lies. They can only detect whether deceptive behavior is being displayed.

Several authors have questioned the assumption that innocent participants will be more aroused by comparison items and that guilty participant will be more aroused by relevant items, given that the relevant item will also be of concern to the innocent (Fiedler, Schmid, & Stahl, 2002; Furedy, 1996; Lacono, 2000; Lykken, 1983). In addition, it is unclear how factors apart from truth telling or deception (such as personality, ethnicity, intelligence, anxiety, or mental disorder, to name a few) might influence the outcome. Perhaps more fundamentally, there is no psychological theory that uniquely ties physiological arousal, as measured by the polygraph, to deception. As Saxe, Dougherty and Cross (1985) have pointed out, attempts to explain physiological detection of deception in terms of factors, such as guilt, have met with little success. Thus, even if the assumption of a differential response is true, no convincing psychological explanation has yet been given to explain it.

The lack of a theoretical understanding of how the lie detection works has meant that it is difficult to explain large differences in accuracy reported in different studies. For example, Saxe et al. (1985) reported that correct decisions in ten field studies, using professional examiners and field polygraph techniques to detect deception, ranged from 71% to 99% for guilty suspects and 12.5–94% for innocent suspects. This variability in detection rates was attributed to differences between examiners, subjects, settings, and whether countermeasures were used to pass the polygraph test, but this does not answer the question as to how these variables impacted the results. Similarly, using a sample of 14 mock crime studies, Kircher, Horowitz, and Raskin (1988) also found that accuracy rates were highly variable (chance to 100%). They reported that up to 65% of the variance in accuracy between studies could be attributed to differences in subjects, incentives for passing the
polygraph test, and the methods for determining guilt or innocence. Although they concluded that personal involvement and emotional arousal might explain these discrepancies; the mechanism which connects physiological arousal with psychological constructs like personal involvement, needs to be specified in greater detail.

**Polygraph Machine**

A polygraph instrument is basically a combination of medical devices that are used to monitor physiological changes occurring in the body. Figure 1.1 shows a computerized polygraph machine. As a person is questioned about a certain event or incident, the examiner looks to see how the person's heart rate, blood pressure, respiratory rate and electro-dermal activity (sweatiness, in this case of the fingers) change in comparison to normal levels. Figure 1.2 shows how the various instruments for measuring physiological indices are generally placed on the subjects. Fluctuations in the physiological indices may indicate that the person is being deceptive, but examination results are open to interpretation by the examiner. Examiner looks for the amount of fluctuation in certain physiological activities. A list of physiological activities that are monitored by the polygraph and how they are monitored is as follows:
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Figure 1.1 A computerized polygraph machine

Figure 1.2 A subject with the instruments for measuring the physiological indices.
Respiratory rate: Two rubber tubes filled with air (pneumographs) are placed around the test subject's chest and abdomen. When the chest or abdominal muscles expand, the air inside the tubes is displaced. In an analog polygraph, the displaced air acts on a bellow, an accordion-like device that contracts when the tubes expand. This bellow is attached to a mechanical arm, which is connected to an ink-filled pen that makes marks on the scrolling paper when the subject takes a breath. A digital polygraph also uses the pneumographs, but employs transducers to convert the energy of the displaced air into electronic signals.

Blood Pressure/Heart Rate: A blood-pressure cuff is placed around the subject's upper arm. Tubing runs from the cuff to the polygraph. As blood pumps through the arm it makes a sound; the changes in pressure caused by the sound displace the air in the tubes, which are connected to a bellows, which moves the pen. Again, in digital polygraphs, these signals are converted into electrical signals by transducers.

Galvanic Skin Resistance (GSR) - This is also called electro-dermal activity, and is basically a measure of the sweat on the fingertips. The finger tips are one of the most porous areas on the body and so are good places to look for sweat. The idea is that one sweats more when placed under stress. Fingerplates, called galvanometers, are attached to two of the subject's fingers. These plates measure the skin's ability to conduct electricity. When the skin is hydrated (as with sweat), it conducts electricity much more easily than when it is dry.

The recording for each of the physiological measure is obtained in the form of a graph where increased arousal is indicated by increase in amplitude. A graphical representation of the recordings is shown in Figure 1.3.
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Figure 1.3. A graphical representation of the polygraph recordings

**Accuracy of Polygraph Testing:** Research relating to accuracy of polygraph testing is questionable, as accuracy has been found to be varying markedly across studies. This variability is due to differences in sample size and method of sampling. Bell, Kircher and Bernhardt (2008) found that although respiration measures were more diagnostic for the probable lie test, new physiological measures, such as skin potential excursion and a new respiratory measure, improved the accuracy of the lie detection test such that 86% of innocent participant and 93% of the guilty participants were correctly classified. Another major deterrent to accuracy of polygraph testing is manipulation by the tester.
Reliability and Validity of Polygraphic Lie Detection:
As used by psychologists, reliability refers not to the accuracy of evaluations but to their consistency across time or among examiners. Assessment of any test’s validity is based on the assumption that the test consistency measures the same properties. This consistency, known as reliability, is usually the degree to which a test yields repeatable results. In the context of polygraph lie detection, two sorts of reliability have been investigated i.e. intra individual and inter individual reliability. Intra-examiner reliability refers to the consistency of an individual examiner’s judgments across time. Hunter and Ash (1973) had seven examiners analyze twenty sets of polygraph charts on two occasions, separated by at least a three month interval. Intra examiners reliability, that is, occasion to occasion agreement, ranged from 75% to 90 % for the seven examiners (the average was 85%).

The validity of polygraph testing means, in non technical terms, accuracy of the test in detection deception and truthfulness. The problem of assessing polygraph validity is especially difficult, not only because polygraph tests take a number of forms, but also because validity has different dimensions and can be measured in a number of ways. There are, as a result, a number of different forms of validity associated with polygraph examination depending on the type of polygraph test as well as on its use (e.g., employee screening / investigation of a criminal suspect).

Lie detection

In a polygraph examination, a number of physiological measures (typically respiration, cardiovascular, and sweat gland activity) are recorded while the subject is asked questions relating to the matter under investigation. In the probable lie test, it is assumed that the innocent subject will show more physiological arousal to the probable lie (comparison) questions that ask about past misdeeds and which may have implications in respect of the incident under investigation, whereas the guilty subject will show more arousal to so-called relevant questions that deal with the issue that forms the basis of the investigation. Thus, the decision rules specify that stronger physiological responses to the relevant as opposed to the comparison questions are an indication of deception. A recent review by Raskin and Honts
(2002) reported good accuracy rates in what they considered to be high-quality laboratory studies. For guilty subjects, the percentage correct ranged between 53% and 100%, with a mean of 80–90% depending on whether inconclusive decisions were included. For innocent subjects, the percentage correct ranged between 75% and 90%, with a mean of 84–92%, again depending on whether inconclusive decisions were included. Raskin’s observations are in line with the findings of the National Academy of Sciences (National Research Council, 2002), which concluded that specific-incident polygraph tests, such as those used in mock crimes, result in detection rates that are much better than chance but less than perfect. However, the variability in detection rates reported by Raskin and Honts (2002) and questions surrounding the validity of the lie detection (Ben-Shakhar, 2002; Furedy & Heslegrave, 1988; Kleinmuntz & Szucko, 1984) means that the lie detection has not been fully accepted by the scientific community.

**Lie detection procedure**

For lie detection, various procedures, such as Relevant /Irrelevant Technique (RIT), Control Question Test (CQT), Directed Lie Test (DLT) and Guilty Knowledge Test (GKT) are used.

**The Relevant /Irrelevant Technique (RIT):** One of the oldest polygraph procedures is the Relevant /Irrelevant Technique (RIT), developed by Larson in 1932. In the RIT, two types of questions are asked, crime relevant questions and crime irrelevant questions. Crime relevant questions are related to crime under investigation, such as “Did you steal the money from the company office last night”? All examinees (i.e. employees of the company), both innocent and guilty, will answer ‘no’ to this question otherwise they admit having committed the crime. Irrelevant questions have nothing to do with the crime and the examiners know for sure that the examinee will tell the truth while answering these questions. An example of a crime irrelevant question is “Is today Tuesday”? The examiners then compare the physiological responses to both types of questions. The rationale behind the RIT is that larger responses to relevant crime related questions than to irrelevant questions indicate that the examinee is lying while responding to the crime related questions.
However the premise used in RIT polygraph test is incorrect. A strong physiological response could also occur, i.e. when truthful examinees are afraid of not being believed. Also in the context of a criminal investigation, the question “Did you steal the money”? is likely to be more arousal provoking than the question “Is today Tuesday”? It is therefore, clear that RIT is an inappropriate technique in polygraph testing, and there is agreement among polygraph researchers that such a test should not be used (Honts, 1991; Lykken, 1998; Raskin 1986; Saxe, 1994).

The Control Question Test (CQT): The CQT is the most common technique used in investigations of a specific issue. The CQT was developed to deal with some of the inherent problems in the traditional RIT technique (Reid & Inbau, 1977). The control question test compares responses to relevant questions with responses to control questions. (Elaad, 2003; Lacono & Patric, 1997). This test is often used to determine whether certain criminal suspects should be prosecuted or classified as uninvolved in the crime. Control questions are designed to be arousing for nondeceptive subjects. The questions are designed to cause innocent subjects to be doubtful and concerned about whether they have actually told the truth or told a lie. These questions usually probe for past misdeeds of the same general nature as the crime being investigated but these are transgressions that polygraphist suspect most people have “committed” or considered committing in some form (Reid & Inbau, 1977). An example of a control question might be, “Before the age of 25, did you ever steal anything from a place you worked?” Control questions are designed to cover a long period of time, which may make the subject even more doubtful about the veracity of answers provided.

Control Question technique: In the CQT the person is asked a series of questions, some of which are relevant to the crime (i.e. ‘did you kill Mrs. Smith’)? and cause concern in the person, some are irrelevant (i.e. ‘have you ever engaged in unnatural sexual behaviour’)?; (have you ever stolen anything)? while some are ‘natural’ questions i.e. asking for the person’s age or name. It is assumed that for the innocent person, lying in responses to the control question will cause more of a physiological response than the response to the relevant questions. The rationale behind the CQT is that an innocent person will respond similarity or more to the control questions, but a guilty person (who, of course, will be lying to the relevant questions –hence
the need for using a lie detector) will respond more to the relevant questions. Control question technique has several worthwhile aspects, i.e. since it compares a person’s responses with of his or her own responses it is not affected by the vast differences that exist between people in their physiological reactivity.

Accuracy of CQT—Comparison Question Tests (CQT) are the most commonly used type of psychophysiological deception detection (PDD) tests in law enforcement, forensic practice, and national security screening settings (Honts, Raskin & Kircher, 2008; Raskin & Honts, 2002; Vrij, 2008). A meta-analysis by Honts (1999) suggests that between charts stimulation offers a positive improvement in CQT accuracy. Moreover, a recent study by Offe and Offe (2007) reported that between charts discussions had a positive effect on accuracy, when there was minimal explanation of comparison question in the pretest. When there was a normal pretest discussion of the comparison questions, between charts stimulation produced non-significantly higher accuracy. However, the Offe and Offe study had relatively few subjects and thus had relatively low statistical power to find small effects.

Predictive validity studies of the CQT have been typically conducted by proponents who use this test in practice, and who believe in it. In virtually all published studies, extremely high accuracy rates have been reported. Ignoring inconclusive cases, the CQT was found to correctly identify guilty respondents in 98% of all cases that entered the validity study. For innocent respondents, the corresponding figure is 82% (Raskin et al., 1997). When similar studies were published by opponents or critically minded psychophysiologists, the success rates were somewhat lower (98% for guilty persons and 55% for innocent people). However, the general impression from these statistical figures is that the CQT is a highly accurate diagnostic tool. Although the discrepancy in degree between proponents and opponents is not surprising, the only question seems to be how close the CQT comes to 100% accuracy.

The validity of comparison question polygraph tests is the subject of intense debate among scientists (Honts et al., 2008; Iacono & Lykken, 2008). Although the majority of psychophysiologists and psychologists who work in the area of Psychology and Law express generally positive attitudes concerning the usefulness of polygraph tests for assessment of credibility (Amato & Honts, 1994; Gallup,
1984; Honts, Thurber, Cvencek, & Alloway, 2002), the American Psychological Association expressed serious concerns about their scientific basis and some specific applications (Raskin, 1986). In the last 30 years, there has been a great deal of research, development, and experience with various techniques that employ physiological measures for assessing credibility regarding specific facts, events, or knowledge (Honts et al., 2008).

**Laboratory Studies**- Laboratory research on credibility assessment typically makes subjects deceivers by having them commit a mock crime (e.g. "steal" a watch from an office), and then instructing them to lie about it during a subsequent test. From a scientific viewpoint, random assignment to conditions is highly desirable because it controls the influence of extraneous variables that might confound the results of the experiment (Shadish, Cook & Campbell, 2002). The most accepted type of laboratory study realistically simulates a crime in which some subjects commit an overt transgression, such as a theft (Kircher, Horowitz, & Raskin, 1988). While the guilty subjects enact a realistic crime, the innocent subjects are merely told about the nature of the crime but do not participate in it. All subjects are motivated to produce a truthful outcome, usually by a cash bonus, for passing the test. For example, one such study used prison inmates who were offered a bonus equal to one month's wages if they could produce a truthful outcome (Raskin & Hare, 1978).

**Field Studies**- The major disadvantage of laboratory simulations is the difficulty of completely simulating the real-life situation in which a person suspected of a crime is administered a polygraph test. To verify test accuracy under field conditions, it is necessary to use tests conducted on actual criminal suspects. However, field studies of criminal suspects also have inherent problems. The major problem is obtaining verification of the accuracy of the test outcomes, which can be very difficult in real cases. Two general methods have been used to develop a criterion of guilt and innocence against which to assess the accuracy of field polygraph tests (Raskin, 1986). The best and most common method utilizes confessions to verify the guilt and innocence of the examinees. Law enforcement cases that involve polygraph tests produce rates of confessions in the range of 30% to 80%, but it is not known how these cases compare to those that did not produce confessions (Raskin, 1986).
The Guilty Knowledge Test (GKT): A less controversial method of psychophysiological detection the Guilty Knowledge Test-CIT (Lykken 1959, 1960), more recently referred to as the concealed information test (CIT), (Ambach, Stark, Peper, & Vaitl, 2008; Elaad 2009; Vandenbosch, Verschuere, Crombez, & De Clercq, 2009) is receiving increased research attention (e.g., Gamer, Godert, Keth, Rill, & Vossel, 2008; Gronau, Ben-Shakhar & Cohen, 2005; Rosenfeld, Labkovsky, Winograd, Lui, Vandenboom, & Chedid, 2008; Verschuere, Crombez, De Clercq & Koster, 2004) and is already an accepted criminal procedure in Japan (Hira & Furumitsu 2002; Nakayama 2002). There is a general consensus that the CIT relies on solid scientific ground and on proper control questions (Ben-Shakhar, Bar-Hillel, & Kremnitzer, 2002; Ben-Shakhar & Elaad 2003; Ben-Shakhar & Furedy 1990; Lykken 1974, 1998). The CIT can be applied in criminal interrogations for detection of information that an individual cannot or does not wish to disclose (Lykken 1974, 1998). It uses a series of multiple-choice questions, each having one correct alternative (e.g., a feature of the crime under investigation) and several incorrect (control) alternatives, chosen so that an innocent person would not be able to discriminate them from the correct alternative (Lykken 1998). Typically, if the suspect’s physiological responses to the correct alternative are consistently larger than those to the incorrect alternatives; knowledge about the investigated crime is inferred. As long as information about the criminal event has not leaked out, the probability that an innocent suspect would show consistently larger responses to the correct alternative than to the controls depends only on the number of questions and the number of alternative items per questions. Thus, the CIT can be designed such that maximal protection for the innocent is provided.

The GKT test, when properly carried out does not suffer as much from the problem of arousal evoking relevant questions and fear of not being believed. The GKT test is theoretically sounder and is less disputed amongst scientist than CQT test. Lacono and Patric, (1997) published a survey of scientific opinion about both these type of polygraph testing. The findings revealed that the opinions of both groups of psychologists (CQT and GKT) were very similar, and that they favored the Guilty Knowledge Test (GKT).
Accuracy of GKT- In one early investigation of GKT, Lykken (1959) attempted to demonstrate that the detection of incriminating knowledge about a crime can be done more accurately than the detection of a lie about the crime. In Lykken’s study, 49 male college students were randomly assigned to four categories of guilt in conducting two mock crimes. Subjects either committed a staged “theft,” a staged “murder,” both, or neither. An experimenter then conducted two GKT polygraph examinations with each subject, one for each crime. Each test in Lykken’s study included six questions about details related to the “murder” situation and “theft” situation (e.g., asking the subject to identify an object present in the “murder” room). To make subjects anxious about the accuracy of their responses during the examination, they were told they would be given an electric shock if the examiner felt their responses indicated guilt; in fact, subjects received an electric shock after every question. The relevant alternative in each question was randomly varied among an average of five possibilities. If the question about the relevant detail produced the EDR with the greatest amplitude, it received a score of 2. If it was the second largest in amplitude, it received a 1. A perfect guilty score on each test was 12, and a perfect innocent score was 0. A score of seven or greater was categorized as guilty for the purpose of analysis, and a score of six or less was categorized as innocent. The guilty knowledge test was accurate to a significant degree in identifying subjects who committed both, either, or neither of the crimes. On the basis of this experiment, Lykken argued that GKT, with some refinements, could be applicable in criminal investigations.

Davidson (1968) examined GKT’s validity under conditions that varied motivation level and that he claimed were, in general, more “ego-involving” for subjects. In this study, 48 college students were recruited and assigned randomly to 12 groups of 4. Three of the four were instructed to attempt to commit specific mock murders, and the fourth served as a control. The mock crimes were arranged such that one subject would “commit” the crime, one would try to fail, one was motivated but never had the opportunity, and one (the control) had no knowledge of the crime. Half of the subjects who “committed” the murders received a large amount of money ($25 to $50) and half received a small sum ($10 to $1). The different amounts were presumed to create a different level of motivation in the subjects. The subjects then were examined with the use of GKT. Six multiple-choice questions with five
alternatives were presented to the subjects, and the EDR was recorded. The scoring method followed Lykken’s (1959) exactly (see above). Using a weighted average, 98 percent of the classifications were correct against a chance level of 25 percent. The only error was one false negative.

Bradley and Janisse (1981) tested 192 subjects with GKT after CQT had been conducted in order to study of the influence of threat and demonstrate their accuracy on the polygraph examination. The questions concerned four relevant details. They were scored using the Lykken (1959) method. With EDR data, the GKT classified an average of 74 percent of subjects correctly, and 26 percent incorrectly with 11 false positives and 39 false negatives. With the measure of heart rate change, the GKT categorized 63.5 percent of subjects correctly and 36.5 incorrectly, with 17 false positives and 53 false negatives, neither the degree of threat nor the demonstrated effectiveness of the polygraph test had a significant effect on the discrimination between deceptive and truthful subjects.

The Directed Lie Test: This test tries to detect lying by comparing physiological responses when the subject is told to deliberately lie, to responses when they tell the truth. Example of control questions are “during the first 27 years of life, did you ever tell even one lie? And before age 27, did you ever break even one rule or regulation”? (Raskin & Honts, 2002). Examinees are instructed to answer ‘No’ to these questions. They are also instructed to think about particular situations in which they did tell a lie or break a rule during these (control) denials. The rationale behind the DLT is similar to the rationale behind the CQT. Guilty suspects are thoughts to be mostly concerned with the relevant questions and are expected to show the strongest responses to these questions; innocent suspects are thought to be more concerned with the directed lie questions since they will be concerned that their responses while lying (i.e. to directed lie questions) differ from their responses when telling the truth (i.e. to relevant questions).

The debate about the advantages of CQT v/s GKT for lie detection has risen from decades, since in neuropsychological terms both are “forced choice” paradigms (Lykken, 1991) and the relevant statement /question leads to increased arousal. However, Ogawa, Tsurga and Suzuki (2007) examined effect of arousal level on the physiological responses in a polygraph examination using the Concealed Information Test (CIT). Results suggested that participant’s arousal level has little
effect on differential physiological reactivity on the Concealed Information Test (CIT).

**Limitation of Lie Detection**: Despite the popularity of traditional “Lie Detector” test and numerous report of their success (Honts, Raskin & Kircher ,2005), several limitation have been identified (Raskin, 1989; Lykken, 1998; and National Research Council, 2003). Instead of relying on suspects’ feeling aroused or anxious when deceptively answering crime related questions (i.e. “Did you shoot the drugstore guard on June 23rd :”), GKT, (Lykken, 1959) indexes an examinee’s recognition of crime relevant information. The typical GKT paradigms present a critical probe stimulus alone with several irrelevant items, i.e. “The person who stole the statue would recall its appearance. Was it made of (a) gold, (b) silver, (c) wood, (d) glass, or (e) plastic? Participants are asked to respond “No” after each answer choice is presented. During this process, one or more physiological measures are recorded and differential responsively to probe choices compare to irrelevant alternatives indicates knowledge of the crime.

In lie detection procedures, some smart people (guilty/innocent) use countermeasures to beat the polygraph testing. Use of countermeasures during lie detection by the guilty subjects results in reducing the accuracy of lie detection.

**Countermeasures and Lie Detection**

Polygraph test outcome will often have serious negative consequences for guilty examinees, and they might, therefore try to influence polygraph outcomes and try to produce physiological responses that may lead the examiner to conclude that they are telling the truth. Method to achieve this are called “countermeasures”. Countermeasures are deliberate techniques that some guilty people use in order to beat the polygraph test (Gudjonsson, 1983, 1988). It is possible that an innocent subject may sometime also use deliberate countermeasures to influence the outcome of the test (Clifton, 1991), but there are no data available on this subject population (National Research Council, 2003). Countermeasures are generally employed to increase arousal to control questions (Gudjosson, 1988; Honts & Amato, 2002; Ogawa, Tsuruga & Suzuki, 2007, Vrij, 2000), thereby reducing the possibility of detection.
“The most famous countermeasures test was probably conducted by Floyd ‘Buzz’ Fay, a man who was falsely convicted of murder. He took it on himself to become a polygraph expert during his two and half year of wrongful imprisonment. The convict coached 27 inmates, all of whom confessed to him that they were guilty, on how to beat the control question polygraph test. After 20 minutes of instruction, 23 of 27(85%) were successful in foiling the polygraph examination” (Ford, 1995; Kleinmuntz & Szucko, 1984).

A wide range of potential countermeasures has been suggested by Krapohl (1995), and the effectiveness of some of these countermeasures has been examined empirically. Major classes of countermeasures include using drugs and alcohol to dampen polygraph responses (Cail Sirota & Liberman, 1995), mental countermeasures (e.g., relaxation, production of emotional imagery, mental dissociation, counting backward, hypnotic suggestion and attention focusing techniques) and physical countermeasures (e.g., breath control, behaviors that produce pain before or during questioning, such as biting one’s tongue, or behaviors that produce muscle tension before or during questioning, such as pressing one’s toe to the floor or controlling a variety of muscles in the body) (Honts, Raskin & Kircher, 1994).

Types of Countermeasures: Different type of countermeasures can be grouped under various heading such as physical, mental, hypnosis, biofeedback and drugs. On the basis of research and observational findings the following types of countermeasures have been identified.

Physical countermeasures- Many different physical manipulations can be used to distort the polygraph record but the most common ones consist of inducing either physical pain or muscle tension. Any physical activity which could affect physiological response is a potential problem for interpretation of a polygraph test record, for example, biting one’s tongue in response to the control questions may create sufficient pain or discomfort to elect an artificial physiological response indistinguishable from that of a genuine one. Similarly, pressing the toes against the floor or the thighs against the chair the individual is sitting in, has been shown to be effective techniques under certain circumstances.
Some Laboratory studies (reviewed by office of Technology Assessment, 1983 and Raskin, 1986) have shown that physical countermeasures such as biting ones tongue and pressing the toes against the floor can be effectively utilized by some people in order to defeat the test. Honts and Hodes(1982) found that employing multiple physical countermeasures rather than relying on a single method (biting ones tongue and pressing the toes against the floor at the same time rather than relying on only one countermeasure) improved a subject’s ability to defeat the CQT.

Mental Countermeasures: Another category of countermeasures involves those that get the subject to think differently about the test. Mental countermeasures comprise deliberate attempts by subject to change their pattern of thinking during the polygraph examination in order to defeat the test. There are three broad categories—

- **Artificially producing responses to control questions**: Subjects attempts to artificially produce response to the control questions by eliciting emotionally arousing thoughts.(e.g.- by reflecting back to an erotic or painful experience).

- **Attenuating responses to relevant questions**: Subjects make an effort to attenuate their physiological responses to the relevant questions. They may do this by attempting to calm themselves down when asked the relevant questions.

- **Mental dissociation**: Subjects may deliberately attempts to distract or dissociate themselves away from the arousing quality of the relevant questions. They may do this during a polygraph examination by trying to focus their attention upon some irrelevant objects or thoughts and answer questions ‘automatically’ in a uniform way.

Hypnosis: The effectiveness of hypnosis as countermeasures has been researched in a number of studies. Hypnosis typically involves inducing amnesia for the crime or relevant items. According to Sarbin and Slagle (1979) hypnosis induces decline in skin conductance levels. Training in hypnosis prior to the polygraph test affects the physiological responses, but it appears from the available evidence, that hypnosis is not a strikingly effective countermeasures.

Biofeedback Training: With respect to countermeasure, biofeedback consists of providing subjects with instruction about how to defeat a polygraph test and subsequently giving them an opportunity of practicing a particular countermeasure
before the proper polygraph examination. A research by Corcoran, Lewis and Garver (1978) examined the effect of biofeedback training on suppressing Electro Dermal Response (EDR). They found that both hypnosis and biofeedback groups reduced detection ability after training as compared to a control group. There is no doubt that biofeedback, in its broadest sense, is a potentially effective way of training people to defeat a polygraph test. The training itself appears crucial as merely providing people with information about polygraph techniques and countermeasures is effective in foiling the test results (Honts, Raskin & Kircher, 1984).

*Drugs/Pharmacological Countermeasures:* The main objective of using pharmacological substance as countermeasures is to alter the person’s overall physiological arousal during the polygraph examination so that deceptive answers cannot be physiologically differentiated from truthful ones. Waid, Orne, Cool and Orne (1981) gave subjects 400 mg of the tranquilizer valium and meprobamate and found that it significantly reduced the detection rate on a CIT. In this study, results indicated that meprobamate (Miltown), permitted subjects who were being deceptive to increase their ability to avoid detection in a polygraph examination. One feature of tranquilizers such as meprobamate is that they suppress autonomic activity which may not be accompanied by any observable psychomotor differences. Subjects were all males and divided into three groups: 1) a tranquilizer group; 2) a placebo group; and 3) a control group. Only 3 of the 11 guilty subjects who had taken meprobamate were scored as deceptive.

According to Raskin (1982), a different problem would be encountered by attempts to utilize tranquilizers to defeat an examination employing CQT. The use of such drugs in a CQT polygraph examination would be more likely to yield inconclusive findings, rather than errors, because the drugs would result in no difference between the responses to control and relevant questions. This interpretation is supported by the recent analog study of Gatchel, et al. (1983), which found that the use of propranolol, a beta-blocking drug, resulted in a 32.2 percent inconclusive rate, although the overall error rate was low. Lacono, Boisvenu and Fleming (1984) studied the effect of the tranquilizer valium and stimulant Ritalin in defeating a CIT, and found that ingestion of neither 10 mg of diazepam (Valium”) nor 20 mg of methylphenidate (Ritalin) affected the accuracy of detection. Results in both active
drug conditions were more accurate than when subjects ingested a placebo capsule (containing lactose).

Gudjonsson (1988) have reported that there are three main ways of beating the polygraph test:

(i) Attempting to suppress the physiological reactions to the relevant questions or items, in order to make the difference in responsively between the relevant and control questions minimal. This typically involves mental countermeasures that include: general relaxation or meditation, to distract or dissociate oneself from the anxiety associated with the relevant questions. The advantage of using mental countermeasures is that they are usually more difficult to detect than physical countermeasures.

(ii) Attempting to reduce overall anxiety of reactivity (i.e. to dampen physiological responses) during the assessment.

(iii) Attempting to augment physiological reactions to control or neutral questions or items presented in order to reduce the differentiation between the relevant and control questions. Inflicting physical or mental pain or producing muscle tension when the control items are presented can help to achieve this. It is probably easier for examinees to increase their arousal while answering control questions than to lower their arousal while answering relevant questions. Therefore, countermeasures are generally designed to increase arousal to control questions (Vrij, 2000; Honts & Amato, 2003).

Effectiveness of Countermeasures in Lie Detection: Countermeasures are invariably based on assumptions about the physiological effects of particular mental or physical activities and their implications for the outcomes of polygraph tests. The first step in evaluating countermeasures should be a determination of whether they have their intended effects on the responses measured by the polygraph, followed by a determination of whether these specific changes in physiological responses affect the outcomes of a polygraph test. Countermeasure studies usually omit the step of determining whether countermeasures have their intended physiological effects, making any relationships between countermeasures and polygraph test outcomes
difficult to evaluate. Another omission is the apparent absence of attempts to identify the physiological signatures associated with different countermeasures. It is very likely that specific countermeasures (e.g., inducing pain, thinking exciting thoughts) produce specific patterns of physiological responses (not necessarily limited to those measured by the polygraph) that could be reliably distinguished from each other and from patterns indicating deceptive responses. Polygraph practitioners claim that they can detect countermeasures; this claim would be much more credible if there were known physiological indicators of countermeasure use. A third omission, and perhaps the most important, is the apparent absence of research on the use of countermeasures by individuals who are highly motivated and extensively trained in using countermeasures.

Some laboratory studies (by office of Technology Assessment, 1983 and Raskin, 1986) have shown that physical countermeasures such as biting one’s tongue and pressing the toes against the floor can be effectively utilized by some people in order to defeat the CQT. A series of studies by Honts and his colleagues suggest that training subjects in physical countermeasures or in a combination of physical and mental countermeasures can substantially decrease the likelihood that deceptive subjects will be detected by the polygraph (Honts, 1986; Honts, Raskin & Kircher, 1994; Honts, Hodes & Raskin, 1985; Honts & Kircher, 1987, 1994; Raskin and Kircher, 1990). These studies suggest that physical countermeasures are more effective than mental ones and that a combination of physical and mental countermeasures is probably the most effective. Honts et al. (1987, 1994, and 1996) found that the rate of mistakes made by CQT and GKT polygraphists testing examinees practicing countermeasures ranged between 50 and 70%. Mistakes only lead to false negative outcomes, but not false positive. There is evidence, however, that the countermeasure effect operates particularly through the electrodermal channel (Ben-Shakhar & Dolev, 1996; Elaad & Ben Shakhar, 1991).

Studies of mental countermeasures have also produced inconsistent findings. Kubis (1962) and Wakamatsu (1987) presented data suggesting that some mental countermeasures reduce the accuracy of polygraph tests. Elaad and Ben-Shakhar (1991) present evidence that certain mental countermeasures have relatively weak effects, findings that are confirmed by Ben-Shakhar and Dolev (1996). Timm (1991)
found that the use of post hypnotic suggestion as a countermeasure was ineffective. Studies of the effects of mental countermeasures have failed to develop or test specific hypotheses about why specific countermeasures might work or under which conditions they are most likely to work. These studies have involved very short periods of training and suggest that countermeasures are effective in both comparison question and concealed information test formats. It is possible that the effects of countermeasures are even larger in real-life polygraph examinations than in laboratory experiments, but it is also possible that these experiments overestimate the effectiveness of the measures.

Polygraph examiners commonly claim to be able to detect the use of countermeasures, both through their observations of the examinee’s behavior and through an assessment of the recorded polygraph chart. Some countermeasures, such as the use of psychoactive drugs (e.g., diazepam, commonly known as Valium), have broad behavioral consequences and should be relatively easy to detect (Lacono, Boisvenu, & Fleming, 1984). Whether polygraph examiners can detect more subtle countermeasures or, more importantly, can be trained to detect them, remains an open question. Early empirical work in this area by Honts, Raskin, and Kircher (1987) suggested that countermeasures could be detected, but later work by Honts and his colleagues suggests that polygraph examiners do a poor job in detecting countermeasures (Honts, 1986; Honts, Amato & Gordon, 2001; Honts & Hodes, 1983; Honts, Hodes, & Raskin, 1985; Honts, Raskin, & Kircher, 1994). There have been reports of the use of mechanisms to detect countermeasure in polygraph tests, notably, reports of use of motion sensors in some polygraph equipment to detect muscle tensing (Maschke & Scalabrini, 1992).

Raskin and Kircher (1990) present some evidence that these sorts of detectors can be effective in detecting specific types of countermeasures, but their general validity and utility remain a matter for conjecture. Unfortunately, this work shares the same limitations as the work suggesting that countermeasures have a substantial effect and is based on many of the same studies. There is no evidence that mental countermeasures are detectable by examiners. The available research does not address the issue of training examiners to detect countermeasures. Honts and Amato (2002) suggest that the proportion of subjects
who attempt to use countermeasures could be substantial (Honts, Amato & Gordon, 2001). In particular, they report that many “innocent” examinees in their studies claim to use countermeasures in an effort to produce a favorable outcome in their examinations (the studies are based on self-reports). Even if these self-reports accurately represent the frequency of countermeasure use in the laboratory, it is unwise to conclude that countermeasures are equally prevalent in high-stakes field situations. Because it is possible that countermeasures can increase “failure” rates among non deceptive examinees and because a judgment that an examinee is using countermeasures can have the same practical effect.

Examinees who are highly motivated to “pass” their polygraph tests might engage in a variety of behaviors which they believe will improve their chances, including the use of countermeasures. It is therefore reasonable to expect that the people who engage in countermeasures include, in addition to the critical few who want to avoid being caught in major security violations, people who are concerned that their emotions or anxieties (perhaps about real peccadilloes) might lead to a false positive polygraph result, and people who simply do not want to stake their careers on the results of an imperfect test. Unfortunately, there is no evidence to suggest how many of the people who use countermeasures fall in the latter categories. The proportion may well have increased, though, in the face of widespread claims that countermeasures are effective and undetectable. Of course, the most serious concern about countermeasures is that guilty individuals may use them effectively to cover their guilt. Studies provide little useful evidence on this critical question because the incentives to “beat the polygraph” in the experiments are relatively small ones and the “guilt” is nominal at best. The most troubling possibility is that with a serious investment of time and effort, it might be possible to train a deceptive individual to appear truthful on a polygraph examination by using countermeasures that are very difficult to detect. Given the widespread use of the polygraph in screening for security-sensitive jobs, it is reasonable to expect that foreign intelligence services will attempt to devise and implement methods of assuring that their agents will “pass” the polygraph. It is impossible to tell from the little research that has been done whether training in countermeasures has a good possibility of success or how long such training would take.
The available research does not engender confidence that polygraph test results will be unaffected by the use of countermeasures by people who pose major security threats. In screening employees and applicants for positions in security-related agencies, because the prevalence of spies and saboteurs is so low, almost all the people using countermeasures will not be spies. To the extent that examiners can accurately identify the use of countermeasures, people using them will be detected and will have to be dealt with. Policies for doing so will be complicated by the likelihood that most of those judged to be using countermeasures will in fact be innocent of major security infractions. They will include both individuals who are using countermeasures to avoid being falsely suspected of such infractions and individuals falsely suspected of using countermeasures.

Countermeasures that work in low-stakes laboratory studies might not work, or might work better, in more realistic polygraph settings. Also, different countermeasure strategies might be effective, for example, in defeating screening polygraphs (where the distinction between relevant and comparison questions might not always be obvious) and in defeating the polygraph when used in specific-incident investigations. Studies might also investigate how specific countermeasures relate to question types and to particular physiological indicators, and whether specific countermeasures have reliable effects. Countermeasures training would also be a worthy subject for study. Maschke and Williams (2003) suggest that effective countermeasure strategies can be easily learned and that a small amount of practice is enough to give examinees an excellent chance of “beating” the polygraph. Because the effective application of mental or physical countermeasures on the part of examinees would require skill in distinguishing between relevant and comparison questions, skill in regulating physiological response, and skill in concealing countermeasures from trained examiners, claims that it is easy to train examinees to “beat” both the polygraph and trained examiners require scientific supporting evidence to be credible.

Additional questions for research include whether there are individual differences in learning and retaining countermeasure skills, whether different strategies for countermeasure training have different effects, and whether some strategies work better for some examinees than for others. Research could also address methods of
detecting countermeasures. The available research suggests that detection is difficult, especially for mental countermeasures, but the studies are weak in external validity (e.g., low stakes for examiners and examinees), and they have rarely systematically examined specific strategies for detecting physical or mental countermeasures.

Kircher, Horowitz, and Raskin (1988) reported that polygraph accuracy (measured as Pearson’s r between test results and actual truthfulness or deception) was correlated with three study characteristics across 14 polygraph studies of comparison question tests. The characteristics were examinee population (college students or others), incentive strength (the presence or absence of a tangible consequence of being judged deceptive, for both innocent and guilty examinees), and whether or not the study used field testing techniques that allowed examiners to conduct three or more charts in order to get a conclusive result. Because these characteristics were highly correlated with each other in the 14 studies, and with whether or not the studies were conducted in the authors’ laboratory, it is difficult to attribute the observed associations to any specific characteristic.

**Cognitive aspect of Countermeasures in Lie Detection:** Some studies have demonstrated that certain measures derived from Electroencephalogram (EEG) and Event Related Potentials (ERPs) can be used more successfully in the GKT when detecting use of countermeasures (Allen, Lacono & Danielson, 1992; Boaz et al., 1981; Farewell & Donchin, 1991). The reason might be that Multichannel Physiological Recording (MPR) is mediated by peripheral nervous system. Since deception is a cognitive phenomenon that takes place in the brain, the potential of MPR in a lie detection system would be theoretically inferior to the more proximal, CNS correlates of brain activity that could be obtained by EEG and functional magnetic resonance imaging (fMRI). The development of a theoretical basis for polygraph testing depends on understanding how physiological and psychological processes interact to produce the results seen on polygraph charts when the technique is used in the detection of deception. Because brain activity lies at the heart of this, recent advances in brain imaging, fMRI provide a possible means to explore and better understand the possible psychophysiological correlates of polygraph testing. Recently, Gamer, Bauermann, Stoeter and Vossel (2007) used
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electrodermal responses and fMRI to detect concealed information. Reaction times and SCR amplitudes were found to be linearly related to activity in the cerebellum, the right inferior frontal cortex, and the supplementary motor area. This result provides a first link between behavioral measures, sympathetic arousal, and neural activation patterns during a GKT examination.

Nunez, Casey, Egner, Hare, and Hirsch (2005) found that the right anterior cingulate and right inferior frontal cortices were more active when participants lied about autobiographical, personally-relevant information than when they told the truth, but no differences in brain activation were observed between deceptive and non-deceptive responses to non-autobiographical information. Although personally-relevant information was more emotionally salient, the authors concluded that the small difference in emotional salience between autobiographical and non-autobiographical information was not responsible for the differing patterns of brain activation as other studies that have not focused on emotional material have produced similar patterns of activation when personal relevance was manipulated. Kozel et al. (2004) used the CQT to examine how electrodermal activity (EDA) and brain activation could be used together to detect deception. It appears that the anterior cingulate cortex may modulate physiological responses as measured by the polygraph and may play a role in controlling the cognitive and emotional responses that are produced when participants lie on the polygraph test. The anterior cingulate cortex can be divided into a dorsal area involved in cognitive tasks, and a rostra ventral area more implicated in affective responses and emotional regulation (Bush, Luu, & Posner, 2000; Mohanty et al., 2007). This area of the brain has also been associated with the control of autonomic activity (Luu & Posner, 2003), including heart rate (Critchley et al., 2003) and blood pressure (Gianaros et al., 2005).

Considered from the cognitive perspective deception is a process, which would be initiated when the examinee perceives threatening stimuli. Since perception is a multiple stage processes (Erdelyi, 1974) with consciousness at the final level of processing, it appears probable that use of stimuli which do not reach the conscious level of processing (subliminal) could help in circumventing the use of countermeasures.
Subliminal Perception

Attempts to define the unconscious and to explain unconscious processes have varied from those originally proposed by Freud, to more recent efforts to describe these processes in cognitive terms. At the root of the problem is the lack of a clear definition of "unconscious." The term "subliminal perception" has been used to describe the effects of unconsciously perceived stimuli on conscious thought. The perceptual threshold is defined in traditional psychophysics as the stimulus level necessary for the subject to reliably report the presence of the stimulus 50 percent of the time. It is believed that stimuli which are presented below a subject's perceptual threshold are encoded and stored differently from those stimuli presented above that threshold.

The meaning of the term subliminal perception has changed over the years, and some prefer to use perception without awareness as an alternative that avoids the sometimes contentious issue of limen (threshold). Generally speaking, “Subliminal perception occurs whenever stimuli presented below the threshold or limen for awareness is found to influence thoughts, feelings, or actions” (Merikle, 2000). Because an influence on thoughts, feelings, or actions is relatively easy to measure experimentally, the difficult part about the field is evaluating awareness of a stimulus below the subject's threshold. Central to the issue is the knowledge when a subject is consciously aware of a stimulus, and how this can be reliably ascertained in experiments. Traditionally, the subjects themselves report awareness. While other areas of psychology may disapprove of introspection as a source of data, in the field of subliminal perception this self-report of “awareness” seems to be unavoidable. The inevitable use of the self-report has also lead to much debate over how these self-reports should be interpreted. The dissociation paradigm is the predominant experimental approach used in research on subliminal perception. Perception without awareness is demonstrated only when the subject reports no conscious awareness of the stimulus (null sensitivity) but some other significant effect shows that the stimulus was perceived nevertheless (Merikle & Joordens, 1997) provided that the terms of the dissociation can be reliably stated, this paradigm provides sound demonstration of subliminal perception. As Merikle and Joordens point out, however, the terms of the null sensitivity prove to be a point of disagreement for researchers. Subliminal perception was a topic of hot debate in the mid-1980’s
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(Cheesman & Merikle, 1984; 1986; Fowler, 1986; Holender, 1986; Wolford, 1986; Kihlstrom, Barnhardt & Tataryn, 1992). The discussion was based on the concepts of objective and subjective thresholds (Cheesman & Merikle, 1985). Cheesman and Merikle (1984) identify two classes of threshold measures: subjective, and objective. Within the scope of dissociation, this subjective/objective threshold paradigm shows two different ways to evaluate whether a participant is consciously aware of a stimulus.

Research in the area of subliminal perception was initiated by Pierce and Jastrow's (1884) who was testing the human response to very similar, barely distinguishable stimuli. Pierce and Jastrow devised an experiment in which subjects had to evaluate which of two pressures on skin was greater, along with a reported confidence level. These experiments were not only interesting from a historical viewpoint, but also because they allude to the subjective/objective thresholds (Kihlstrom et al., 1992). Pierce set out to research just-noticeable differences when the difference between stimuli was below a physiological threshold. Two very similar pressures were exerted on the subject's hands, and the subject was forced to choose which of the two pressures was greater. Along with each choice, the subject rated their confidence on a scale of 0-3. Zero confidence denoted “absence of any preference for one answer over its opposite, so that it seemed nonsensical to answer at all” (Pierce and Jastrow). The results indicated a correlation between guesses and the actual proportion of pressures, even when the subjects were guessing (i.e. subliminal). Of the results at zero confidence, subjects guessed the greater pressure correctly in 62%, 70%, and 67% of trials (under different conditions). These results were consistently above 50%, the expected value for guessing. Therefore, the subjects did perceive the stimuli even though they were not aware of them.

Popular interest in this field was spurred by the claims of a marketing researcher, James Vicary (Merikle, 2000). In 1957, Vicary claimed that patrons at a movie theatre were exposed to advertising messages Eat Popcorn and Drink Coca-Cola flashed for 3 millisecond durations and repeated throughout a movie. According to Vicary, patrons were not consciously aware of these hidden messages but responded favorably by significantly increasing their purchases of popcorn and drinks. There
has not been any independent evidence to support the claims, and Vicary himself stated that the research was a fabrication (Merikle, 2000).

As the subjective measure relies on the participants’ self report of the existence of a stimulus i.e. the participants simply indicates whether or not they were aware of the stimulus, it is subject to response bias and may lead the participant to choose against reporting a stimulus when the participant feels ambivalence. As a result, each person may gauge “awareness” using their own terms, leading to inconsistencies among experiments. An objective measure, on the other hand, is obtained when the subject is forced to choose between fixed alternatives or discriminate between several options – even if they believe the options are equivalent. The objective threshold is “the level of detectability where perceptual information is actually discriminated at a chance level” (Kihlstrom, Barnhardt, & Tataryn, 1992). This objective measure provides a lower threshold for conscious awareness, leading to more conservative evaluations of when subliminal perception occurs.

An objective threshold has to be passed for a stimulus to be sensed, that is, to enter the appropriate sensory system. A subjective threshold is the one that has to be passed for a stimulus to enter conscious awareness and/or elicit response. If the objective threshold is not passed, there is no perception. If the objective threshold is passed but the subjective is not, it leads to subliminal perception while if the subjective threshold is passed as well it results in conscious perception. Holender (1986) argued that one could not rely on the subjective threshold as a measure of conscious perception. Instead, Holender said that one could only depend on an objective threshold as a defining criterion. He argued that there are some demonstrable sensory effects of a stimulus which is above the objective threshold. Imagine sitting in front of a computer screen on which a word is briefly shown. It goes so fast that one can only see a flash while the observer do not know which word it was. According to Holender, if one cannot verbally report a stimulus this does not necessarily mean that it did not reach consciousness. Maybe it reached consciousness half a second ago and was forgotten. It should be clear that this sole reliance on the objective threshold proposed by Holender “effectively rules out the
phenomenon of subliminal perception out of existence," as observed by Kihlstrom, Barnhardt & Tataryn (1992).

Therefore, subliminal perception, is perception that passes the objective threshold (i.e., it is discriminated by the senses) but fails to pass the subjective threshold (i.e., it fails to reach conscious awareness, it does not elicit a response) but the question is how can this subjective threshold be determined. It is difficult in an absolute sense. There is no fixed subjective threshold that works for all people under all circumstances. The idea of a fixed threshold has been superseded as a consequence of insights from signal detection theory (Greenwald, Draine & Abrams, 1996). Whether a briefly presented stimulus does reach conscious awareness or not depends on stable individual differences, on current goals and needs and on various contextual effects.

Marcel (1983) reported that while the masked primes were not detected by subjects, the associated primes did facilitate decisions about whether the letter strings were a valid word. Therefore, the stimulus is being perceived without the subject's awareness. Many other studies have used similar methods, confirming Marcel's findings and also demonstrating that “pictures, faces, and spoken words can also facilitate subsequent decisions when they are presented under conditions that make it difficult to discriminate one stimulus from another” (Merikle, 2000). While recognition performance was at chance level, subjects liked the previously seen stimuli over the novel stimuli 60% of the time (Kunst-Wilson & Zajonc, 1980). Because recognition was indeed at chance levels, this experiment provides convincing evidence that a truly subliminal stimulus influences thoughts or feelings. Unlike Pierce and Jastrow's (1884) and Marcel's (1983) experiments, the mere exposure and related experiments use a new dimension, emotional preference, rather than cognition in order to demonstrate perception without awareness.

**Consequences of subliminal stimulation**

*Neurological correlates* - Libet, Alberts, Wright and Feinstein (1967) were presumably the first to provide physiological evidence for subliminal perception. In their experiments, they stimulated the skin of their participants so subtly participants could not consciously report it. Concurrently measured evoked potentials, however, showed changes in the electrical field around the brain. Although their measurements were crude, they did provide unequivocal evidence for brain activity
as a result of perception that escaped conscious awareness. Later, Dehaene et al., (1998) and Whalen et al., (1998) also reported evidence of neurological effects of subliminal stimulation.

**Evaluative and affective effects**- In 1968, Zajonc launched the idea of mere exposure: the more we are exposed to a stimulus, the more we like it. Kunst-Wilson and Zajonc (1980) first demonstrated that even subliminal exposure to a stimulus enhances one’s attitude towards this stimulus. In their experiment, participants were presented with 10 polygons, each five times for only 1 millisecond. Afterwards, participants were presented with pairs of polygons, consisting of an “old” (e.g., previously presented) and a “new” polygon. For each pair, participants had to indicate which one they thought was previously exposed to them and which one they liked most. Participants more often preferred the previously presented polygon to the "new" one, without being able to say which polygon they had been exposed. This subliminal mere exposure effect has been replicated a number of times since (Bornstein, 1992).

**Basic semantic effects**- Debner and Jacoby (1994) obtained evidence for semantic subliminal processing with a particularly convincing paradigm. In their experiments, they presented five-letter words (e.g., “scalp”) on the computer screen subliminally. After a word had appeared, participants were presented with a word stem with three letters of a word (e.g., “sca”). Participants were requested to generate a five-letter word to complete the presented word stem. In some conditions, participants were urged not to choose the word that had just been presented. Relative to a control condition in which the same word stem was presented without earlier exposure to an applicable subliminal word, people who were asked not to use the subliminally presented word use it more often. With this task, evidence was obtained for the semantic processing of a word while at the same time ensuring that this word was not consciously perceived (Marcel, 1983; Merkle, Joordens & Stolz, 1995).

**Empirical Evidence of Subliminal Perception**- The empirical study of subliminal perception started over a hundred years ago when Peirce and Jastrow (1884) showed that participants could discriminate between two objects on the basis of their weights even when the difference in weight was so small that it could not be detected consciously. After choosing between objects, they indicated their confidence on a scale from 0 to 3, with a higher score representing more confidence. On almost all
trials, they chose zero. However, they chose the correct object on more than 60% of the occasions. The minor differences in weight may have escaped consciousness, unconscious processes dealt with them with reasonable accuracy. In addition, they obtained comparable data with pressures that differed slightly in intensity and surfaces that differed slightly in brightness.

Other pioneering work was done by Sidis (1898; described by Merikle and Reingold (1992) and by Pötzl (1917). In Sidis' work, subjects were shown cards containing a single digit or letter, but these cards were so far away that the subject "saw nothing but a dim, blurred spot or dot" (Sidis, 1898). In fact, “the subjects often complained that they could not see anything at all; that even the black, blurred, dim spot often disappeared from their field of vision. However, when Sidis asked the subjects to name the character on the card, their responses were correct more often than would be expected on the basis of pure random guessing, even though many subjects stated “that they might as well shut their eyes and guess”.

Finally, Pötzl (1917) investigated the consequences of subliminal perception on imagery during dreams. He showed participants various pictures for very short durations (10 milliseconds) and predicted that although these pictures could not reach conscious awareness, they would remain active subconsciously long enough to be able to present themselves in dreams. According to Pötzl, some of the images recurred in the dreams of the experimental participants.

Referring to subliminal perception as the processing of stimuli too weak in intensity or too brief in duration to be identified consciously Borgeat, Boissonneault, Chalout, & Elie (1989) recommended the use of disguised stimuli, as certain shadowing tasks, which result in an "audio illusion" (Taylor, 1987 & Taylor 1993). Dixon (1971) prefers the term unconscious perception to describe all cases when responses are governed by stimuli of which the recipient is unaware, while the term subliminal perception is reserved for those cases where the stimulus is below some independently determined limen. Wolman (1973) defines the absolute threshold, or stimulus limen, as the intensity at which a particular sound is just discriminable from silence on a given percentage of trials. Meta-analysis has demonstrated "that subliminal presentation of drive related stimuli produced significantly stronger effects on behavior than supraliminal presentation of the same stimuli" (Bornstein, 1990).
Marcel (1983) conducted research involving another variant of the Stroop color-word interference task. In this study, the target colors were either red or green and the color words used as primes were also either "red" or "green". In this two-color variant of the Stroop task, observers can name a target color faster when it is preceded by the congruent color word than when it is preceded by the incongruent color word, as long as congruent and incongruent trials are equally probable (i.e., 50/50). However, if the probabilities are changed so that incongruent prime-target pairings occur on 80% of the trials and congruent pairings occur on 20% of the trials (i.e., 80/20), then observers name a color faster when it is preceded by the incongruent color word than when it is preceded by the congruent color word (Logan, Zbrodoff & Williamson, 1984).

Subliminal perception and Physiological Response

Considerable evidence is available to support the assertion that subliminal auditory stimuli are capable of inducing behavioral and physiological change. (Dixon & Henley, 1991, Swingle, 1991, Taylor, 1994). Using electrophysiological methods, McCleary and Lazarus (1949) and Lazarus and McCleary (1951) were able to demonstrate that subjects were able to make discriminatory responses, as measured by electrodermal responses (EDRs), to stimuli presented at speeds too rapid for conscious recognition. These researchers presented five-letter nonsense syllables to subjects, flashed at speeds ranging from 6 ms to one second, on a screen placed seven feet from the subject. Lazarus and McCleary found that the GSR responses were greater in magnitude following the presentation of syllables previously paired with shock, independent of whether or not these syllables had been correctly identified. Lazarus and McCleary assumed that the GSR, being mediated by the autonomic nervous system, was sensitive to both conscious and unconscious perceptual processes. Therefore, they concluded that subliminal perception, defined as perception below the threshold for identification had been demonstrated. Chun and Sarbin (1968) believe that verbal skin resistance measures appear more similar to the resistance measures reported by Lazarus and McCleary (1951).

Yet other studies (Dixon 1971, 1981) have shown that the human brain by its electrical response responds to the meaning of words presented to the ears during sleep. It is interesting to note that even in the deepest sleep and without awakening the subject, such words may also evoke dreams that are relevant to their meaning. Borgeat and Goulet (1983), showed a significant effect of "activation subliminal
suggestions" on physiological measures of heart rate, EMG, and EDR during and following a stressing task. During the experimental task, subjects were exposed to auditory 25-dB activating and deactivating suggestions masked by a 40-dB white noise signal. For the deactivating subliminal auditory messages, suggestions of heaviness and warmth on the various parts of the body, and suggestions of subjective calm, relaxation, and sleepiness were employed. The subliminal activating suggestions suggested muscle energy and activity in the same parts of the body and urge and readiness for some action to be accomplished in the future. Similar results were obtained by Borgeat, Elie, Chalout, Chabout, and Louis (1985) using a selective attention (auditory attend/non-attend) paradigm on measures of EDR, EMG, and heart rate.

One of the most extensively researched examples of subliminal perception occurs in connection with the fact that the awareness threshold for threatening words or pictures may be significantly higher or lower than that for more neutral material. Experiments which involved the simultaneous recording of EEGs (brain rhythms), heart rate and perceptual thresholds suggest that, prior to awareness of a visual stimulus which is gradually increasing in brightness, the brain may analyses the latter's meaning and, as a result, modify its own level of arousal to hasten or retard awareness of the information that it carries. In one study (Corteen & Wood 1972), people were asked to report a stream of prose presented to one ear while words of which they remained unaware were presented to the other ear. It was found that those 'subliminal' words (on the unattended-to ear), which had previously been associated with electric shock, produced an emotional response (i.e. a change in skin resistance due to sweating) without interfering with the attention task of 'shadowing' prose on the other ear. In another experiment (Henley & Dixon 1974) imagery evoked by music presented to one ear, above the conscious threshold, was shaped by subliminal words to the other ear. Considered together, these two sets of data suggest that, at a preconscious level of processing, the brain can 'decide' whether or not information on a subsidiary or unattended-to channel should be kept isolated from, or used to facilitate, responses evoked by material to which the recipient is devoting his conscious attention.

More recently, Masling, Bornstein, Poynton, Reed, and Katkin (1991) used an arousing experimental message (NO ONE LOVES ME) and a neutral control message (NO ONE LIFTS IT). Subjects exposed to the short duration (4 ms)
arousing message showed a significant increase in EDR when compared to controls. These results support Silverman's hypothesis that drive-related stimuli presented below awareness thresholds produce significant effects on behavior.

Neurophysiological research has indicated that the receipt and onward transmission of sensory information, initiated by external stimuli, depends upon the classical sensory pathways linking peripheral receptors with their cortical projections. Awareness of this sensory traffic perceptual experience relies upon sufficient contribution from the ascending fibers of the reticular activating system, that dense network of cells which arises in the brain stem and then spreads upwards and outwards to infiltrate the cortex. If the reticular system is blocked by surgery or drugs, the arrival of sensory information at the cortex still occurs but the owner of the cortex remains oblivious of the fact. This finding is of considerable significance for proponents of subliminal perception and accords with data from research by Libet et al., (1967). Recording from the exposed brains of fully conscious human subjects, they were able to detect electrical potentials initiated by tactile stimuli of which their subjects remained totally unaware.

The different approaches followed in studies of subliminal perception indicate that evidence favoring subliminal perception is often found when perceptual awareness is defined in terms of subjective criteria. In the very earliest studies of subliminal perception, subjective criteria were used, and it was established that the observers could respond consistently at a better than chance level of accuracy even when they thought that their responses were only guesses (Miller 1939; Sidis 1898; Williams 1938). Thus, if perceptual awareness is measured in terms of subjective criteria, then subliminal perception is valid and an easily-demonstrated phenomenon.

**Subliminal stimuli as deterrent to countermeasures in Lie Detection**

Research in the area of lie detection indicates that the major deterrent to accuracy, specifically identification of guilty, is the use of countermeasures. As lying is a conscious process which is initiated on detection of the relevant stimuli, probability of lying (subsequent use of countermeasures) could be reduced by use of stimuli which do not reach the level of conscious awareness (subliminal stimuli). Research has shown that subliminal stimuli which do not elicit conscious awareness produce physiological as well as cortical activation. Thus, use of subliminal stimuli
could go a long way in reducing the probability of use of countermeasures in lie detection. Recent countermeasure studies (Rosenfeld, Labkovsky, Winograd, Lui, Vandenboom, and Chedid, 2008) have shown that subjects can be trained to make concealed responses (e.g., wiggling the toe) to the non meaningful items, which significantly increased P300 response (a specific brief electrical wave in a person's electroencephalogram (EEG) which is a measure of the way the brain pays attention and discriminates between potentially important and non-important stimuli.) to the irrelevant stimuli and therefore, no difference is found between guilty and irrelevant stimulus conditions. This makes it virtually impossible to distinguish probe and irrelevant P300s, whose differences would otherwise be usually diagnostic for deception. Earlier it was felt that this kind of paradigm was immune to the influence of countermeasures.

An obviously important requirement of physiological and cortical based methods for identifying deception is that such methods be resistant to subjects’ attempts to defeat them, that is, with countermeasures. It is expected that the subliminal presentation of key test stimuli, subliminally processed uniquely by guilty subjects, will affect physiological and cortical arousal responses to the supraliminally presented stimuli in such a way as to allow discrimination of guilty versus innocent subjects.

Thus, it is probable that use of subliminal stimuli in lie detection would make the procedure immune to countermeasure use. If a key stimulus is presented subliminally, subjects would not be able to apply specific countermeasures to it because it would not be consciously perceived. Support for this contention is available from research where the priming of semantically related and unrelated words was found to modulate the amplitude and duration of ERP components (Besson, Kutas, & Van Petten, 1992).

With this background, review of researches related to lie detection and subliminal perception was conducted. The review has been presented in the next chapter.